Project Profile for Material Change to an Exempted Designated Project under S 5 (10) of the Environmental Impact Assessment Ordinance for Application for Approval to Apply Directly for an Environmental Permit

1. INTRODUCTION

Before the first new gas-fired unit of Lamma Extension is commissioned in 2004, the Hongkong Electric Company Limited (HEC) is planning to increase the existing generating capacity to meet the maximum load demand in 2002. This is in accordance with HEC's generation development plan based on the latest forecast of maximum load growth.

After careful consideration on the technical, economic, environmental as well as timing factors pertinent to the best choice for increasing generating output to meet the projected demand in 2002, HEC proposes to upgrade two of the existing gas turbine plants currently under simple cycle operation in Lamma Power Station to a combined cycle unit by recovering the waste heat energy in the flue gas to produce steam for additional generation of electricity before the commissioning of the gas-fired power station at Lamma Extension in 2004.

The proposed conversion scheme involves upgrading of the existing gas turbines and is regarded as a material change to an exempted designated project (the existing Lamma Power Station) according to the *Environmental Impact Assessment Ordinance*. An EIA study was conducted for the existing Lamma Power Station (see *Reference 1* in *Section 20*), however, the EIA report only addressed the environmental impacts associated with the generating capacity upto 2000.

A recently completed EIA study for Lamma Extension (see *Reference 2* in *Section 20*) in February 1999 are of more relevance to this project. This EIA Report includes findings on wind tunnel modelling, water quality assessment, marine ecology and fishery impacts for the Lamma Extension which are of direct relevance to this Project. The said EIA Report has concluded that no unacceptable or insurmountable impacts are expected provided the recommended mitigation measures are adopted and implemented. These mitigation measures are however mainly related to the dredging work for site formation and installation of the submarine gas pipeline which are not directly related to this conversion project.

This Project Profile serves to address the environmental impact arising from construction and operation of the proposed conversion for application for permission to apply directly for environmental permit.

2. BASIC INFORMATION

2.1 PROJECT TITLE

Conversion of Two Existing Gas Turbines into a Combined Cycle Unit

2.2 PURPOSE AND NATURE OF THE PROJECT

Six oil-firing gas turbines (GT2 to GT7), each of 125MW nominal capacity, are at present installed at HEC's Lamma Power Station for peak lopping and emergency operation. The proposed conversion will include the installation of a steam-cycle bottoming system comprising mainly two heat recovery steam generators and a steam turbine-generator at the back end of GT5 and GT7 to form a combined cycle unit. The additional steam-cycle bottoming system will produce an extra output of 115MW by solely utilising the waste heat from the gas turbine exhaust gas.

2.3 NAME OF PROJECT PROPONENT

The Hongkong Electric Company Limited (HEC).

2.4 LOCATION OF PROJECT

Figure 2.4a shows the location of the proposed conversion project. Making use of the open area between the existing gas turbines at the south western corner of Lamma Power Station, a steam-cycle bottoming system will be installed to recover the waste heat from the exhaust gas of GT5 and GT7 so as to form a combined cycle unit with a gross output of 365MW.

2.5 NAME AND TELEPHONE NUMBERS OF CONTACT PERSONS

Mrs. Juliana Ma, Public Affairs Manager
Tel. No. 2843 3268

Mr. Andrew Lu, Deputy Public Affairs Manager
Tel. No. 2843 3287

2.6 PROPOSED ADDITION, MODIFICATION AND ALTERATION

As part of the conversion, GT5 and GT7 will be modified to utilise natural gas, in addition to the current capacity to utilise light fuel oil. Once natural gas is available for Lamma Extension, a tee-off pipeline will be constructed to supply natural gas from Lamma Extension to the proposed conversion unit. Since Lamma Extension will be connected physically to the existing power station, the said tee-off pipeline will be run on land either above-ground or inside pipe trench.

At present, the waste heat in the hot exhaust gas from the existing simple-cycle gas turbines is directly discharged to the atmosphere without utilization. The proposed conversion is to install a steam-cycle bottoming system to recover the waste heat from GT5 and GT7 by the heat recovery steam generator (HRSG) to produce steam which in turn drives a steam turbine-generator for secondary electricity generation. The exhaust gas after passing through the HRSG will be discharged to the atmosphere through the existing GT stacks of 80m high. Cooling water required for the steam-cycle bottoming system will be supplied from additional C.W. pumps and returned to the existing No. 1 C.W. outfall for discharge to the sea. *Figure 2.6a* shows the layout of the additional equipment to be installed for the proposed conversion which includes:

- 2 numbers of heat recovery steam generators;
- 1 steam turbine building to house the steam turbine and the auxiliaries;
- generator and unit transformers; and
- 2 numbers of additional C.W. pumps.

As a result of the additional power output generated by the steam cycle, there will be substantial gain in the overall thermal efficiency from about 30% (in simple cycle GT) to 46%. A schematic representation of the conversion unit is shown in *Figure 2.6b.*

2.7 PROPOSED PROGRAMME

Based on the lead time required for design and construction, the targeted completion date for the proposed conversion is as follows:

Commencement of building construction	September 2000
Commencement of plant erection	August 2001
Commercial operation of plant	July 2002
Conversion to Natural Gas firing	End 2004

3. POSSIBLE IMPACT ON THE ENVIRONMENT

3.1 SCOPING OF ENVIRONMENTAL ISSUES

Table 3.1a identifies the potential environmental impacts which may arise from the construction and operation of the proposed conversion of gas turbine into combined cycle unit.

Table 3.1a Potential Sources of Environmental Impacts

Potential Impact	Construction Phase	Operation Phase
Gaseous Emissions	✓	✓
Dust	✓	×
Odour	×	×
Noise	✓	✓
Night-time Operations	×	×
Traffic Generation	×	×
Liquid Effluents, Discharges, or Contaminated Runoff	✓	✓
Generation of Waste or By-products	✓	×
Manufacturing, Storage, Use, Handling, Transport, or Disposal of Dangerous Goods, Hazardous Materials or Wastes	✓	✓
Risk of accidents which would result in pollution or hazard	×	✓
Disposal of Spoil Material, including potentially Contaminated Materials	✓	×
Disruption of Water Movement or Bottom Sediment	×	×
Unsightly Visual Appearance	×	×
Cultural & Heritage	×	×
Ecological Impacts:		
- Terrestrial	×	×
- Marine	×	✓

Notes:
✓ = Possible, × = Not Expected

4 GASEOUS EMISSIONS

4.1 EMISSION DURING CONSTRUCTION PHASE

Although the emissions from construction equipment has the potential to cause air quality impacts, the number of construction equipment to be used during the construction phase is small due to the relatively small size of the project and the nearest Air Sensitive Receivers are located over 800m from the proposed site and separated by other industrial activities at Lamma Power Station, no adverse air quality impacts during the construction impact is envisaged.

4.2 EMISSION CHARACTERISTICS DURING OPERATIONAL PHASE

The proposed conversion is to effectively recover the waste heat energy in the exhaust flue gas of existing GT5 and GT7, which would otherwise be discharged to the atmosphere. No additional fuel will be burnt and the HRSG is of the unfired design solely for recovering the heat energy from the gas turbine exhaust gas for steam production. Hence, emissions from the gas turbines are the only sources of pollutants before and after the conversion. As the gas turbines after the conversion will also be modified to burn natural gas instead of oil firing, the conversion will result in large reduction of the emission levels as indicated in *Table 4.2a.*

Table 4.2a Emission Characteristics before and after GT5 and GT7 Conversion (at Source)

	Before Conversion (Oil-firing) (Current Specified Process Licence)	After Conversion (Gas-firing)
Sulphur Dioxide, mg/Nm^3	290	10
Nitrogen Oxides, mg/Nm^3 (expressed as NO_2)	185	90
Particulates, mg/Nm^3	12	5
Min Efflux Temp, ^oC	390	80
Min Efflux Velocity, m/s	32	15

Note:
The concentrations of the air pollutants are expressed at 0^oC, 101.325 kilopascals pressure and 15% O_2 dry condition.

4.3 MAXIMUM HOURLY GROUND LEVEL CONCENTRATIONS

A separate wind tunnel modelling was conducted during the EIA study for Lamma Extension to predict the cumulative ground level concentrations (glcs) at the air sensitive receivers (ASRs) arising from Lamma Power Station alone (ie without the Lamma Extension) with the conversion in place. Results of the wind tunnel modelling are presented in *Annex A* for reference.

Based on the loading schedule as per *Table 4.3a*, the hourly average concentrations predicted at various ASRs for SO_2 and NO_2 during the maximum outputs with and without the conversion are summarised in *Table 4.3b*. The results indicated that the predicted SO_2 and NO_2 glcs would not exceed the respective AQOs at the ASRs.

Table 4.3a Loading Schedule with and without Conversion for the worst scenario of Maximum Output (Unit: MW)

	L8	**L7**	**L6**	**L5**	**L4**	**L2**	**L1**	**L3**	**GT5/7**	**GTs**	**Total**
Without Conversion	350	350	350	350	350	250	250	250	0	435	2935
With Conversion	350	350	350	350	350	250	250	250	365	185	3050

Table 4.3b Predicted Cumulative Hourly SO_2 and NO_2 glcs (μg/m3)

Pollutant	**Without Conversion (@ 2935MW)**	**With Conversion (Oil-firing) (@ 3050MW)**	**With Conversion (Gas-firing) (@ 3050MW)**	**AQO**
Sulphur Dioxide	69 - 788	58 - 796	51 - 697	800
Nitrogen Dioxide	52 - 262	52 - 293	51 - 264	300

GT5 and GT7 after conversion will initially be burning light oil until gas is available. Under the worst case modelling scenario of maximum output of 3,050MW, the predicted cumulative glcs as indicated in *Table 4.3b* are all within AQO limits using 0.2% S fuel. The predicted glcs will be reduced significantly under gas-firing situation.

4.4 GREENHOUSE GAS EMISSION

In addition to reduction of SO_2 and NO_2 emissions, the conversion will also result in reduction of CO_2 emission due to higher plant efficiency (46% vs 30%) and the change from oil-firing to gas-firing of conversion of GT5 and GT7 to combined cycle unit. *Table 4.4a* shows the per kWh CO_2 emission from the conversion unit compared with the simple cycle oil-fired gas turbines.

Table 4.4a Comparison of the per kWh CO_2 Emissions

	GT5/7 Conversion (Gas-firing)	GT5/7 Conversion (Oil-firing)	Oil -firing GTs
CO_2 emission (kg/kWh)	0.39	0.55	0.81

5. DUST

Minimal site formation work is expected as the proposed HRSG will be located on formed ground and with the proper implementation of mitigation measures, no adverse construction dust impacts is envisaged.

When the GT5and GT7 utilise natural gas as fuel, the particulates emissions are expected to reduce by almost 60% (see *Table 4.2a*), and hence there will be an environmental improvement from the conversion of the gas turbines to a combined cycle unit.

6. ODOUR

No odour impact is envisaged during both the construction and operation phase of the proposed project.

7. NOISE

7.1 NOISE SENSITIVE RECEIVERS

Settlement on the northern end of Lamma Island (mostly one to three storey residential buildings) is largely concentrated around the harbour at Yung Shue Wan and the adjacent villages of Yung Shue Long, Sha Po, Ko Long, Wang Long and Tai Wan San Tsuen. These residences are shielded from plant noise to varying degrees by the intervening hill (Kam Lo Hom) which defines the plant's northern boundary.

Owing to the complex terrain and the history of noise concerns expressed within the community, four representative residential locations have been identified as the NSRs as shown in *Table 7.1a.*

Table 7.1a Locations of NSRs

NSR No.	Location	Distance to the Construction Site (m)
NSR 1	Long Tsai Tsuen / Hung Shing Ye	1150
NSR 2	Ko Long	850
NSR 3	North Slope above Yung Shue Wan Harbour	1300
NSR 4	School in Tai Wan San Tsuen	1200

7.2 CONSTRUCTION PHASE

A construction noise assessment (See *Annex B*) has been conducted to predict the construction noise impact from anticipated construction equipment. The predicted construction noise impacts at the noise sensitive receivers (NSRs) are present in *Table 7.2a.*

Table 7.2a Predicted Construction Noise Levels at nearby NSRs (Daytime, 0700 to 1900 hours)

Construction Period (mm/yy)	NSR 1 Criterion 75 dB(A)	NSR 2 Criterion 75 dB(A)	NSR 3 Criterion 75 dB(A)	NSR 4 Criterion 65 dB(A)
09/2000-09/2000	46	49	44	45
10/2000-10/2000	48	52	47	48
11/2000-04/2001	50	53	48	49
05/2001-06/2001	48	52	47	48
07/2001-08/2001	49	52	47	48
09/2001-12/2001	47	50	45	46
01/2002-06/2002	40	43	38	39

All predicted noise levels are within the relevant criteria during construction phase. No adverse and residual noise impact during the 22 months of construction phase is envisaged at the residences and school.

7.3 OPERATIONAL PHASE

Noise impact from the conversion unit during operational phase has been undertaken and presented in *Table 7.3a*. Calculation details are shown in *Annex B*. Whereas the measured background noise level was 51.7 dB(A) under free field condition, the background noise level with 3 dB(A) facade correction should be 55 dB(A) which is equivalent to the ANL stipulated in EIAO-TM.

Table 7.3a Predicated Noise Levels from GT Conversion Unit in Operational Phase

NSR No.	Location	Noise Level, dB(A)
NSR 1	Long Tsai Tsuen / Hung Sing Ye	41
NSR 2	Ko Long	44
NSR 3	North Slope above Yung Shue Wan Harbour	39
NSR 4	School in Tai Wan San	40

Although noise levels from the conversion unit itself are well below the 55 criterion, cumulative noise impact from the GT conversion unit and existing power station has been calculated in accordance with the above results. As given in the Lamma Extension EIA report, the maximum potential noise impact for the existing plant can conservatively be estimated by the monitored data. Predicted cumulative noise levels in operational phase have been shown in *Table 7.3b*.

Table 7.3b Cumulative Noise Levels in Operational Phase

NSR No.	Location	Existing plant, dB(A)	Conversion unit, dB(A)	Overall Noise Level, dB(A)
NSR 1	Long Tsai Tsuen / Hung Sing Ye	55	41	55
NSR 2	Ko Long	55	44	55
NSR 3	North Slope above Yung Shue Wan Harbour	55	39	55
NSR 4	School in Tai Wan San	55	40	55

The overall results show that existing noise environment at the NSRs will not be worsened by the GT conversion unit. Predicted noise level at NSR 2 due to the GT conversion unit was about 11 dB(A) below the background level and 16 dB(A) less than the 60 dB(A) daytime criterion. In addition, the conversion unit is designed, under normal conditions, for peak lopping at daytime in summer months only, noise contribution from the conversion unit to the prevailing background level is, therefore, limited to the daytime during summer only.

As aforementioned, predicted cumulative noise level for Lamma Power Station is 55 dB(A) at NSR which is 5 dB(A) less than 60 dB(A) day time criterion. Noise exceedance at NSRs in operational phase is hence not envisaged. The overall change in term of noise level at the NSRs would be insignificant when the conversion unit is in operation.

8. NIGHT-TIME OPERATION

No night-time operations is anticipated for the construction nor operation phase during normal conditions of the proposed conversion of gas turbines.

9. TRAFFIC GENERATION

No land base traffic will be generated as the proposed site is located on Lamma Island. No additional fuel (light oil) will be required to be delivered to the site as the proposed conversion will not require additional fuel but utilise the waste heat generated from the gas turbines.

No adverse traffic impact is envisaged.

10. LIQUID EFFLUENTS, DISCHARGES, OR CONTAMINATED RUNOFF

10.1 CONSTRUCTION PHASE

As the proposed site is located on formed land, minimal site runoff is expected and no adverse construction water quality is anticipated.

10.2 OPERATIONAL PHASE

An assessment of the impacts on water quality, marine ecology and fisheries of the discharge of cooling water from the proposed conversion of oil fired gas turbines to combined cycle operation at the existing power station has been carried out (see *Annex C*). Discharges of cooling water were simulated using a thermal discharge model.

The water quality assessment predicted that the small increase in flowrate (3%) following the conversion of the two oil fired gas turbines to combined cycle operation at the existing Lamma Power Station would only marginally affect the size of the thermal plume and residual chlorine discharge compared with the existing operating strategy. It is considered unlikely that the small increase will significantly increase the formation of foam. If, however, foam formation becomes a problem, it may be controlled through measure to contain the foam to the immediate vicinity of the outfall. It was concluded that the conversion would be environmentally acceptable in terms of water quality impacts and as such no mitigation measures were specified.

11. GENERATION OF WASTE AND BY-PRODUCTS

During the construction of the proposed conversion, Construction and Demolition (C&D) Materials will be generated. Industrial wastes such as packaging materials will also arise. Provided that these wastes are properly segregated, recycled as far as possible, and disposed of, no adverse construction waste impacts are envisaged.

12. MANUFACTURING, STORAGE, USE, HANDLING, TRANSPORT, OR DISPOSAL OF DANGEROUS GOODS, HAZARDOUS MATERIALS OR WASTES

All fuel oils will be handled in accordance with the current practices at Lamma Power Station. No additional fuel oil will be used as the HRSG utilised the waste heat from the existing gas turbines.

All the gas installations will be constructed and operated in full compliance with the *Gas Safety (Gas Supply) Regulation* as per the conditions imposed on the Lamma Extension by the authority.

13. RISK OF ACCIDENTS WHICH WOULD RESULT IN POLLUTION OR HAZARD

All the gas installations will be constructed and operated in full compliance with the *Gas Safety (Gas Supply) Regulation*. Since the conversion unit will be on oil-firing initially until the first unit of Lamma Extension is commissioned and gas is available from the Shenzhen LNG Terminal, the gas firing facilities for the conversion unit will be retrofitted at a later date when relevant Government approvals under the *Gas Safety (Gas Supply) Regulation* have been sought accordingly.

14. DISPOSAL OF SPOIL MATERIALS

Minimal amount of excavated materials will be generated for the site formation of the HRSG unit. No adverse environmental impacts is envisaged for the disposal of spoil materials.

15. DISRUPTION OF WATER MOVEMENT OR BOTTOM SEDIMENT

As no reclamation will be required, no impacts to hydrodynamics and disruption of bottom sediment are anticipated.

16. VISUAL & LANDSCAPE

The existing GT5 and GT7 area and hence the proposed conversion unit is situated in the existing power station, thus no direct impact on the existing land form and coastal morphology of Lamma Island. The GT5 and GT7 conversion unit will be well surrounded by the existing station facilities with a low landscape quality. The new heat recovery steam generator and the steam turbine compound are small masses of blocks and have relatively low visual characters (maximum E&M structure at 35m level and maximum building structure at 20m level). Views from many of the more populated areas on Lamma Island will be obstructed by the Po Lo Tsui headland. By adopting appropriate colour scheme to the new structures, any visual impact as a result of the conversion work would be well absorbed by the established character of the power station. The proposed conversion unit will be well absorbed by the existing installations at Lamma Power Station (see *Annex D*).

The proposed GT5 and GT7 conversion is not expected to pose any adverse visual and landscape impact to the existing environment.

17 CULTURAL & HERITAGE

As the proposed conversion is located on reclaimed land within the existing power station compound, no cultural & heritage impact is envisaged.

18. ECOLOGICAL IMPACTS

18.1 TERRESTRIAL ECOLOGY

As the proposed conversion is located on reclaimed land within the existing power station compound, no terrestrial ecological impact is envisaged.

18.2 MARINE ECOLOGY

An assessment of potential marine ecology and fisheries impacts was made based on the thermal modelling results (see *Annex C*). Baseline data from the recently completed EIA of a 1,800MW Gas-Fired Power Station at Lamma Extension was used to characterise the marine ecology & fisheries resources in the vicinity of the power station. The assessment concluded that no adverse impacts to both marine ecology and fisheries would be expected.

19. DESCRIPTION OF MITIGATION MEASURES

Based on the above assessment, the construction and operation of the proposed conversion plant will not result in any adverse environmental impacts with the implementation of the following mitigation measures:

- Implement good site management practices for construction waste management, effluent discharge and general noise mitigation such as:

  - All debris and materials will be covered or stored in a sheltered debris collection area. Dust control measures such as water spraying on roads and dusty areas, covering of lorries by impervious sheets and controlling of the falling height of fill materials, etc. will be implemented in accordance with *APCO*.

  - General noise mitigation measures (ref *NCO*) will be employed at work site throughout the construction phase such as selection of quiet Powered Mechanical Equipment (PMEs). Mitigation against general construction noise will be provided during Sundays and public holidays, either at source with portable noise barriers, or by rescheduling of some PMEs to less sensitive time periods.

  - Construction waste will be properly stored at site and windblown litter and dust will be minimised during transportation by either covering trucks or transporting wastes in enclosed containers. Waste will be disposed of at licensed sites and disposal permit will be obtained from appropriate authorities, if required, in accordance with the Waste Disposal Ordinance. Should chemical waste be produced, it will be handled in accordance with the relevant regulation.

- Effluent discharge from construction activities will conform to relevant ProPECC Note requirements and comply with the Water Pollution Control Ordinance (WPCO).

- Use light oil of 0.2% sulphur content for oil-firing of the conversion unit.
- Use of acoustic enclosures around major noise sources.

20. USE OF PREVIOUSLY APPROVED EIA REPORTS

This Project Profile has made reference to the following EIA Reports:

<u>Reference 1</u>

Title:	The Hongkong Electric Company Limited Environmental Impact Assessment of Units L7 and L8 Lamma Power Station - Final Initial Assessment Report	
Reference Number:	EIA - 012 / BC	
Time of Approval:	May 1992	
Approval by:	Director of Environmental Protection	
Environmental Aspects Addressed:	Air quality Water quality Noise Waste management Landscape and visual	Marine Ecology Terrestrial Ecology Social-Economic Impacts Maritime Transport EM&A

<u>Reference 2</u>

Title:	The Hongkong Electric Company Limited - Environmental Impact Assessment of a 1,800MW Gas-Fired Power Station at Lamma Extension (8 February 1999)	
Reference Number:	AEIAR-010 / 1999	
Time of Approval:	5th May 1999	
Approval by:	Director of Environmental Protection	
Environmental Aspects Addressed:	Air quality Water quality Noise Waste management Land contamination	Ecology Fisheries Landscape and visual Hazard to life

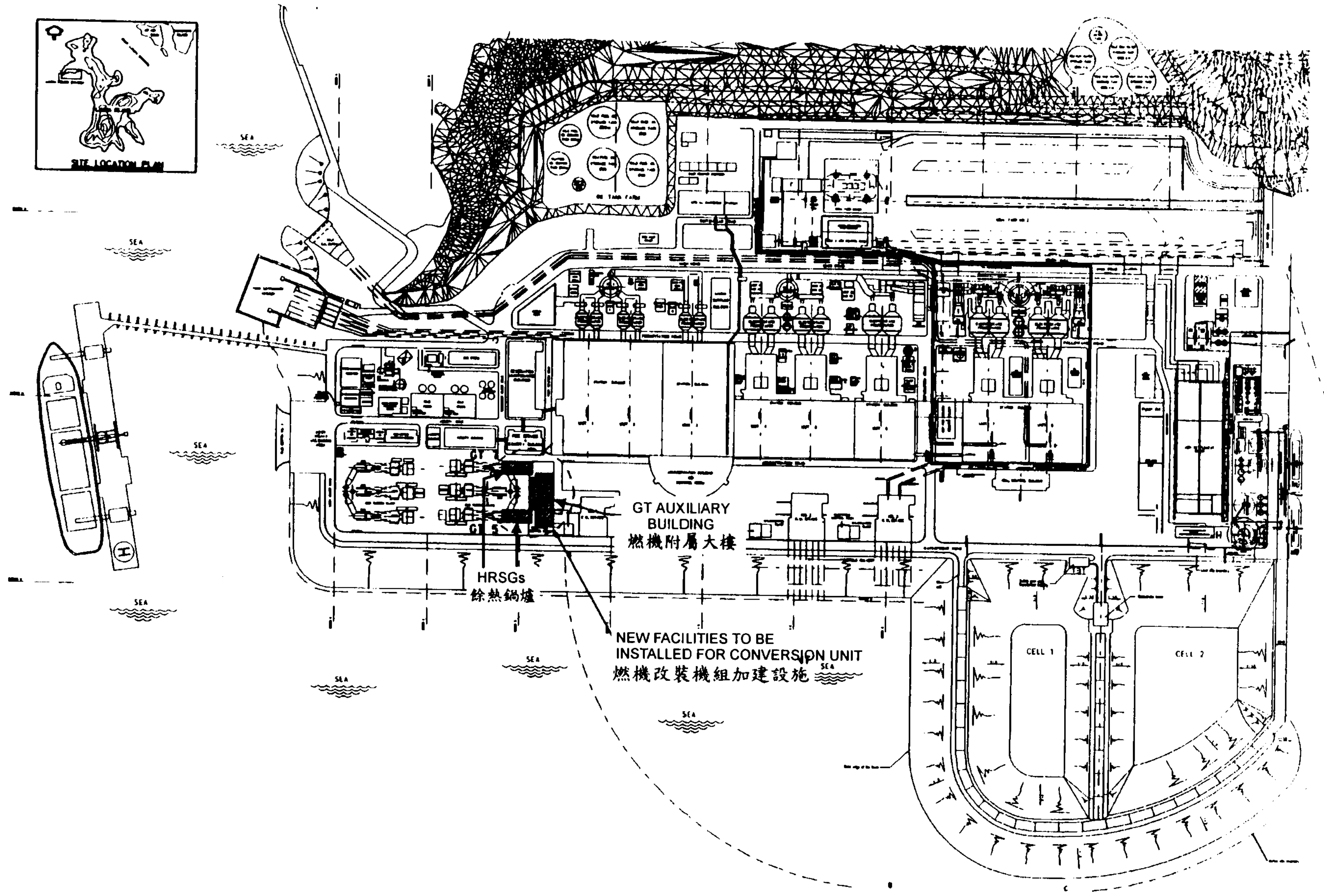

FIGURE 2.4a
圖 2.4a

LOCATION OF PROPOSED NEW FACILITIES FOR CONVERSION UNIT
燃機改裝機組新加設施位置圖

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DATE: 06/03/00

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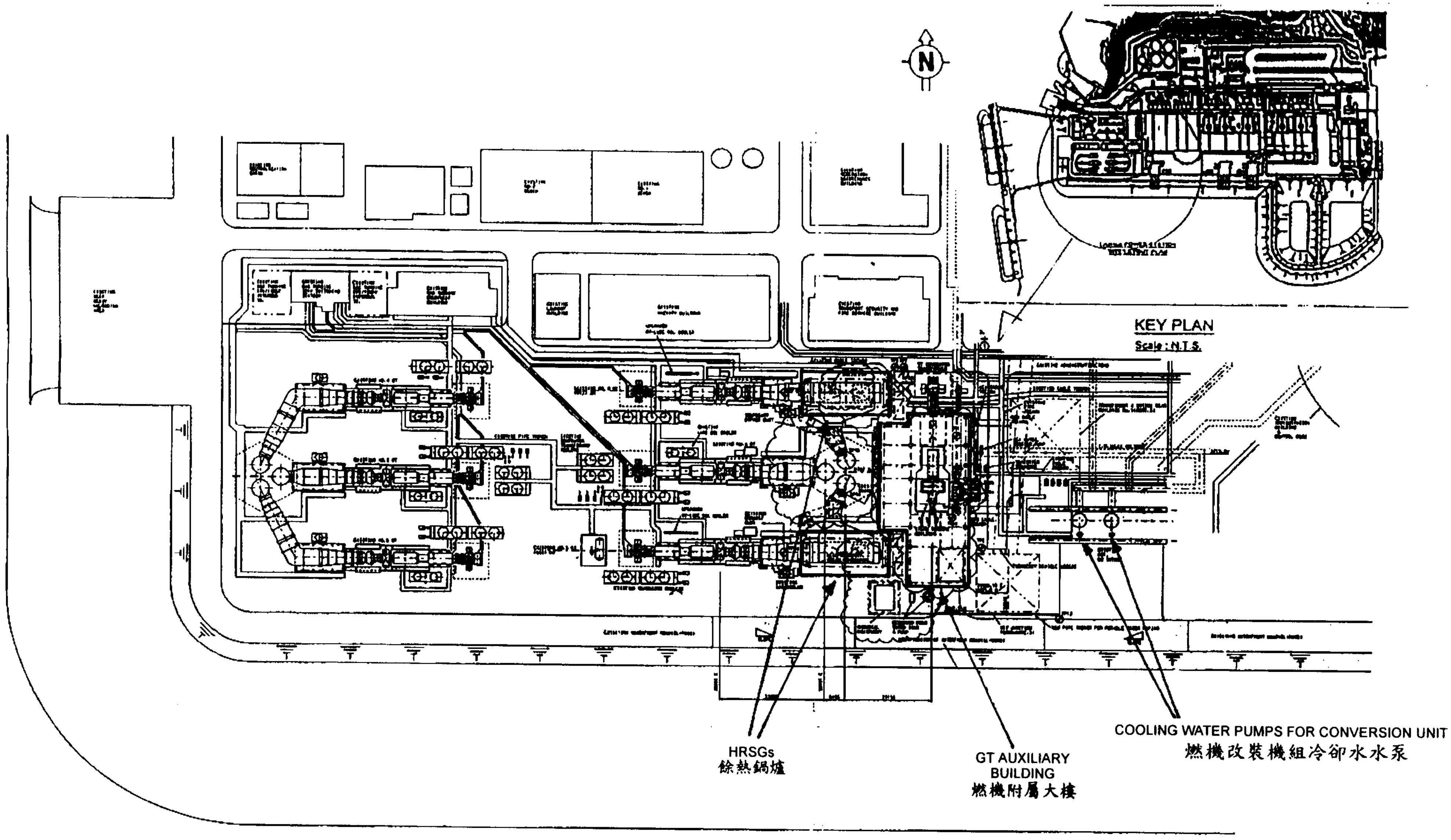

FIGURE 2.6a
圖 2. 6a

LAYOUT OF THE ADDITIONAL EQUIPMENT TO BE INSTALLED FOR CONVERSION UNIT
燃機改裝機組加裝設備佈置圖

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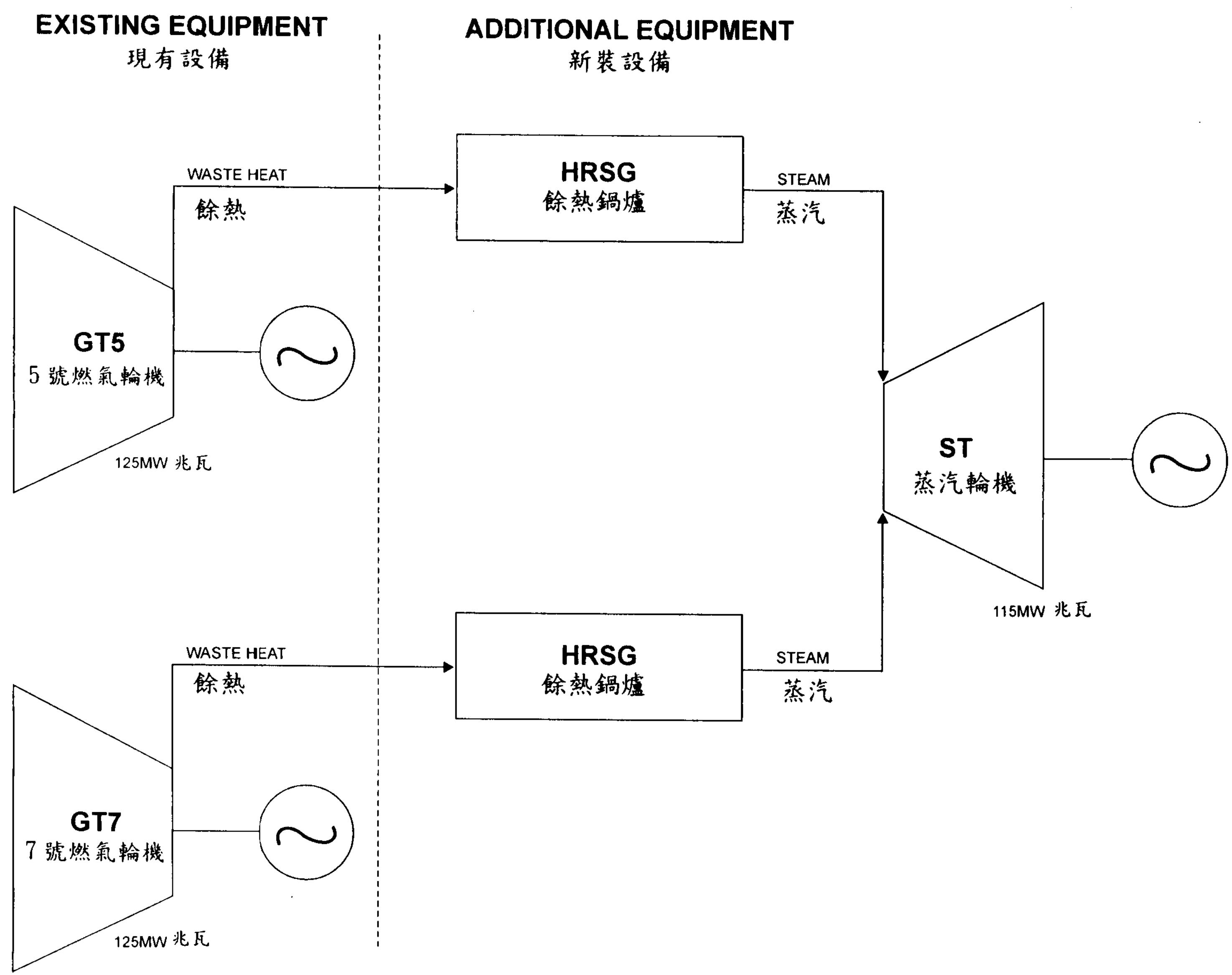

FIGURE 2.6b
圖 2.6b

SCHEMATIC DIAGRAM OF THE COMBINED CYCLE CONVERSION PLANT
聯合循環改裝機組示意圖

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DATE: 28/02/00

Environmental Resources Management
ERM

Annex A

Results of Wind Tunnel Modelling

A1 AIR QUALITY ASSESSMENT

A1.1 INTRODUCTION

This Annex presents key findings of the wind tunnel simulation for the proposed conversion scheme at Lamma Power Station by making use of the wind tunnel modelling results of the Lamma Extension EIA Study.

The wind tunnel project of Lamma Extension was performed by RWDI Inc. of Canada, a specialist consultant employed by the EIA project leader ERM-HK Ltd. to evaluate the air quality impacts due to SO_2 and NO_x emission at HEC power station peak load operations. The scope of RWDI's work involved a scale model testing in a Boundary Layer Wind Tunnel to quantify the dispersion of pollutant emissions from the proposed Lamma Extension as well as the existing Lamma Power Station. The objectives of this modelling study was to determine the minimum stack height in Lamma Extension to ensure compliance with Hong Kong Air Quality Objectives (AQO).

An 1:1000 scale model of the Lamma Extension, the existing power station and all surrounding terrain was used. The spatial scope of the wind tunnel covered areas defined as the near-field of the power station. Specifically, it includes an area within approximately 9.3 km of the proposed power station. Figure A1-1a depicts the spatial scope of the wind tunnel study.

A1.2 BASELINE CONDITIONS

Both EPD and HEC have established a network of air quality monitoring station for SO_2 and NO_x in Hong Kong. Monitoring results are available in the form of hourly, daily and annually ground level concentrations (glcs).

Based on the evaluation of the background air quality data in the EIA Report of the Lamma Extension, it is proposed to adopt following hourly concentrations as the background for predicting air quality in the wind tunnel test:

Table 1.2a Background Concentration of SO_2 and NO_2

Average Time / Pollutant (1)	SO_2 (μgm^{-3})			NO_2 (μgm^{-3})		
	AQO	Urban	Rural	AQO	Urban	Rural
1 Hour	800	33	23	300	80	49

Note
(1) Measured at 298K and 101.325kPa.

A1.3 AIR SENSITIVE RECEIVERS

According to the EIAO-TM, domestic premises, hotel, hostel, hospital, clinic, nursery, temporary housing accommodation, school, educational institution, office, factory, shop, shopping centre, place of public worship, library, court of law, sports stadium or performing arts centre are classified as Air Sensitive Receivers (ASRs).

The location of identified representative 69 nos. of ASRs are shown in *Figure A1.3a*.

A1.4 *MODELLING SCENARIOS*

The following scenarios associated with the proposed conversion scheme were studied:

Scenario 1 - Baseline scenario with existing Lamma Power Station operating at a maximum output of 2935 MW without the conversion in place as the worst scenario before commissioning of the 1st gas-fired unit at Lamma Extension;

Scenario 2 - Lamma Power Station operating at a maximum output of 3050 MW with the conversion in place assuming the conversion unit on gas-firing; and

Scenario 3 - Same as Scenario 2 but with the conversion in place assuming the conversion unit on oil-firing.

In the wind tunnel modelling study for Lamma Extension project, the ground level concentrations were calculated from the ratio of emission concentration to measured concentration of tracer gas at ASRs, and the actual load of the generating units. By applying the same principle, the air quality impacts with the conversion scheme were estimated from the previous wind tunnel modelling results. LGO with 0.5% sulphur content is assumed for the assessment except for the conversion unit in Scenario 3 which is assumed to burn 0.2% sulphur content LGO.

A1.5 *PREDICTED AIR QUALITY IMPACTS*

The results are summarised in following *Table A1.5a*:

Table 1.5a ***Summary of the Predicted Pollutant Concentration in 2003***

Scenarios / Hourly Concentration of Pollutant	**SO_2 (μgm^{-3})** AQO = 800	**NO_2 (μgm^{-3})** AQO = 300
Scenario 1	69 - 788	52 - 262
Scenario 2	51 - 697	51 - 264
Scenario 3	58 - 796	52 - 293

A1.6 *CONCLUSION*

From the prediction of ground level concentration in above *Section A1.5*, it is observed that the net and cumulative impacts arising from operation of the conversion unit will not result in any predicted exceedances of the relevant AQOs for SO_2 and NO_2 at ASRs in the near-field of the power station.

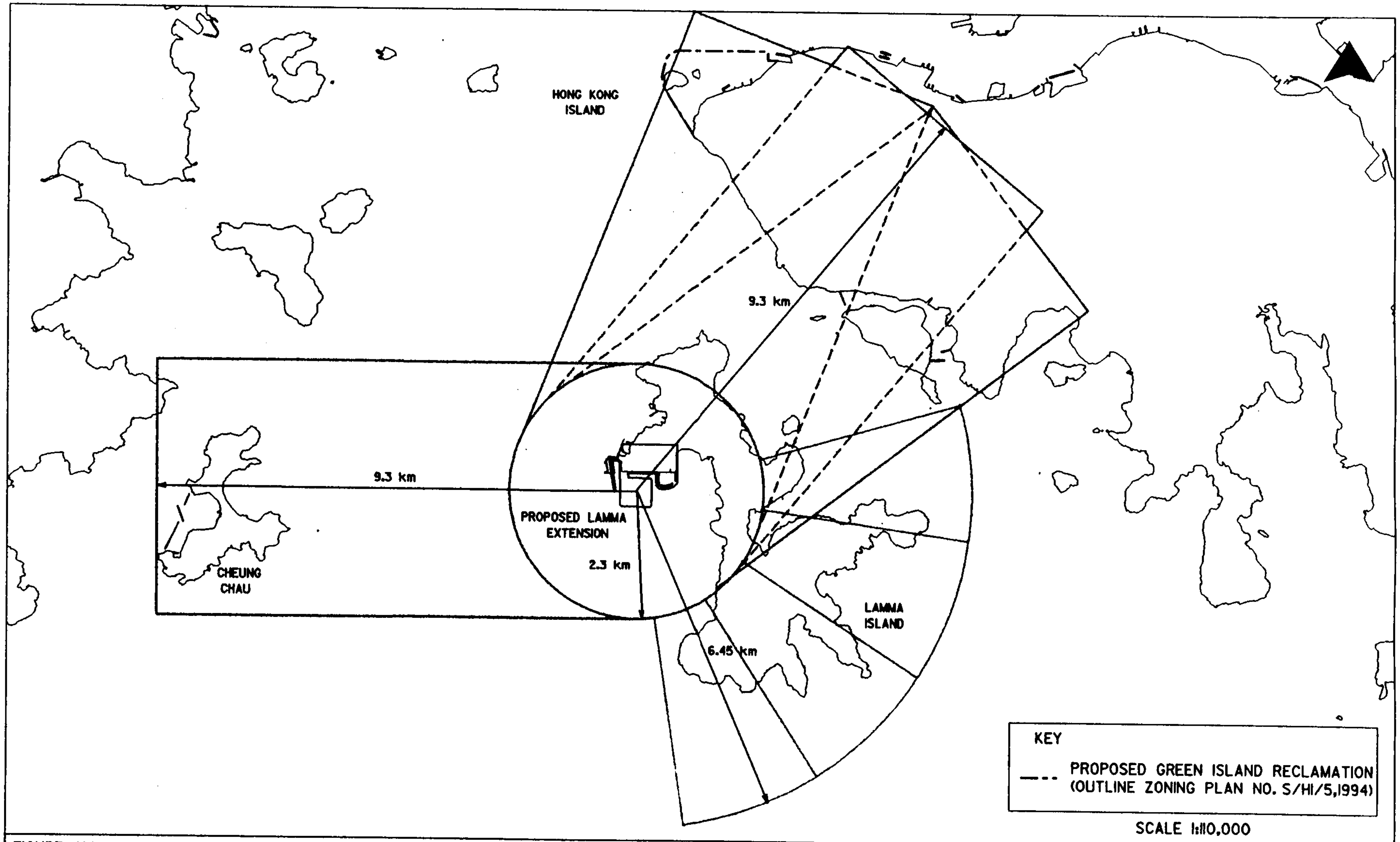

FIGURE AI.1a

SPATIAL SCOPE OF WIND TUNNEL STUDY

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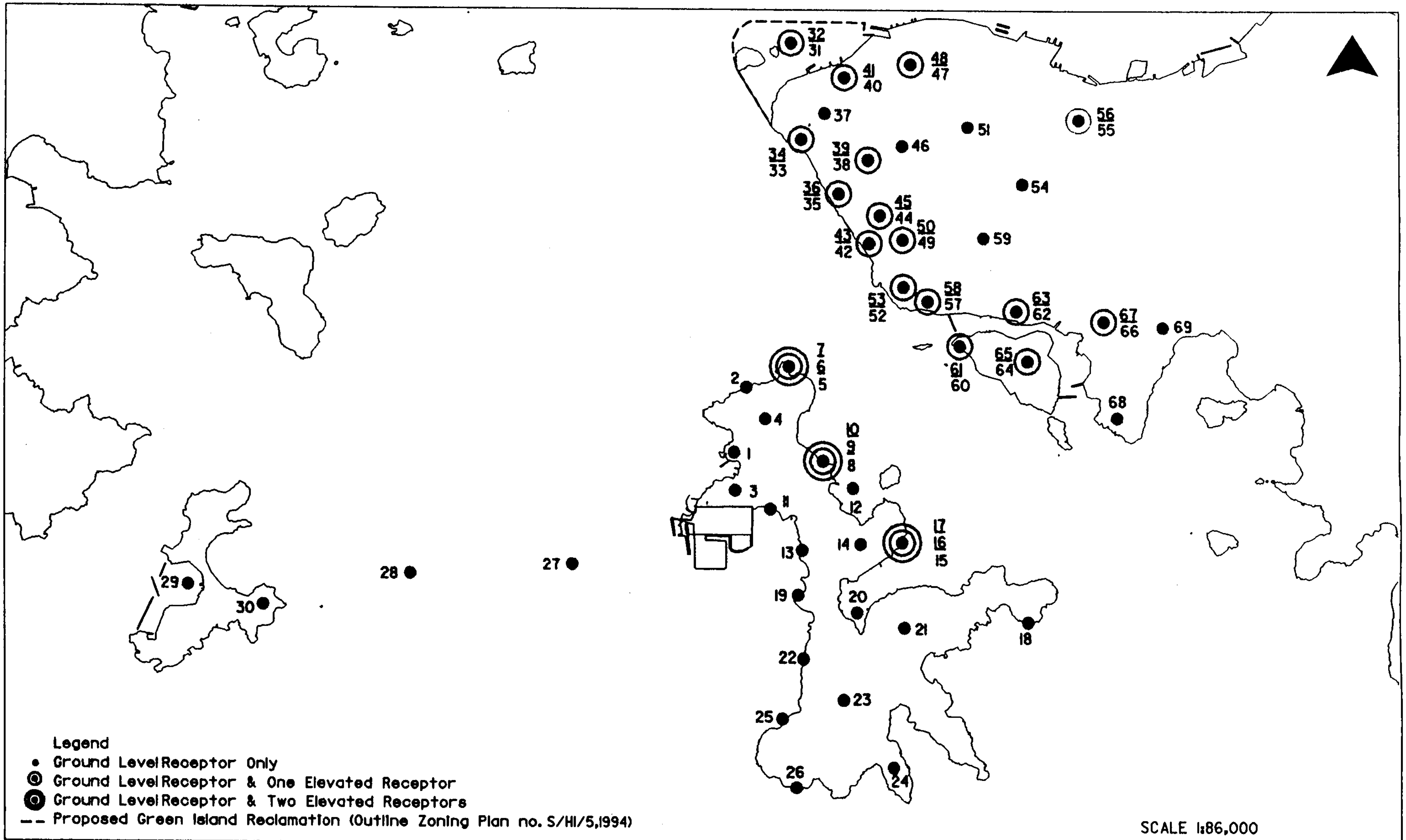

FIGURE A1.3a

WIND TUNNEL MEASUREMENT LOCATIONS

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GT Conversion Pollutant Emission - SO2 (Scenario 1 - Without GT Conversion)

System Peak Load (MW) 2935

LGO Sulphur Content 0.5%

Receptor	Wind Tunnel Data Scenario 1 GT2-7 MW 294	Scenario 2 CC MW 244	Predicted Data Source D1 GT2-7 MW 435	Source D2 CC MW 0	D1 + D2	Receptor	Predicted Data A	B	C	GLC - ug/m3 A+B+C+D1+D2	Bkgrd	Distance Correction	GLC W/Bkgrd
1	164	197	243	0	243	1	0	0	0	243	23	1.00	266
2	124	177	183	0	183	2	3	1	1	188	23	1.00	211
3	61	124	90	0	90	3	0	0	0	90	23	1.00	113
4	235	321	348	0	348	4	0	9	0	357	23	1.00	380
5	177	263	262	0	262	5	8	0	0	270	23	1.00	293
6	163	241	241	0	241	6	29	9	2	281	23	1.00	304
7	167	249	247	0	247	7	128	66	2	443	23	1.00	466
8	186	273	275	0	275	8	1	5	1	282	23	1.00	305
9	188	258	278	0	278	9	18	22	1	317	23	1.00	340
10	281	306	416	0	416	10	65	93	8	582	23	1.00	605
11	89	179	132	0	132	11	0	8	0	140	23	1.00	163
12	107	162	158	0	158	12	4	4	0	166	23	1.00	189
13	22	14	33	0	33	13	12	1	0	46	23	1.00	69
14	52	56	77	0	77	14	4	0	0	81	23	1.00	104
15	62	89	92	0	92	15	11	27	1	131	23	1.00	154
16	66	67	98	0	98	16	22	16	3	139	23	1.00	162
17	79	91	117	0	117	17	36	34	4	191	23	1.00	214
18	38	93	56	0	56	18	42	39	5	142	23	1.00	165
19	57	58	84	0	84	19	1	4	0	89	23	1.00	112
20	90	112	133	0	133	20	4	1	0	138	23	1.00	161
21	45	165	67	0	67	21	82	16	2	167	23	1.00	190
22	0	53	0	0	0	22	10	103	22	135	23	1.00	158
23	0	0	0	0	0	23	18	165	51	234	23	1.00	257
24	0	0	0	0	0	24	106	308	51	465	23	1.00	488
25	20	29	30	0	30	25	84	176	5	275	23	1.00	298
26	29	236	43	0	43	26	137	128	15	323	23	1.00	346
27	257	308	380	0	380	27	15	14	2	411	23	1.00	434
28	162	274	240	0	240	28	133	116	12	501	23	1.00	524
29	116	181	175	0	175	29	301	282	27	765	23	1.00	788
30	28	141	41	0	41	30	149	178	19	387	23	1.00	410
31	21	140	31	0	31	31	50	83	9	173	33	1.00	206
32	17	38	25	0	25	32	56	92	10	183	33	1.00	216
33	68	134	101	0	101	33	23	20	2	146	23	1.00	169
34	77	152	114	0	114	34	40	34	4	192	23	1.00	215
35	65	106	96	0	96	35	128	110	11	343	23	1.00	366
36	67	113	99	0	99	36	155	135	14	403	23	1.00	426
37	80	159	118	0	118	37	53	46	5	222	23	1.00	245
38	100	150	148	0	148	38	76	66	7	297	23	1.00	320
39	41	128	61	0	61	39	70	68	7	206	23	1.00	229
40	11	111	16	0	16	40	127	124	13	280	33	1.00	313
41	24	91	36	0	36	41	54	47	5	142	33	1.00	175
42	89	133	132	0	132	42	136	119	12	399	23	1.00	422
43	63	95	93	0	93	43	99	87	9	288	23	1.00	311
44	40	217	59	0	59	44	52	45	5	161	23	1.00	184
45	54	210	80	0	80	45	113	98	10	301	23	1.00	324
46	66	103	101	0	101	46	142	124	13	380	23	1.00	403
47	40	67	59	0	59	47	79	69	7	214	33	1.00	247
48	39	66	58	0	58	48	67	58	6	189	33	1.00	222
49	78	163	115	0	115	49	29	25	3	172	23	1.00	195
50	85	168	126	0	126	50	76	67	7	276	23	1.00	299
51	48	69	71	0	71	51	126	110	12	319	23	1.00	342
52	90	144	133	0	133	52	51	44	5	233	23	1.00	256
53	102	172	151	0	151	53	80	69	7	307	23	1.00	330
54	57	123	84	0	84	54	281	245	26	636	23	1.00	659
55	23	48	34	0	34	55	77	67	7	185	33	1.00	218
56	31	52	46	0	46	56	99	86	9	240	33	1.00	273
57	79	182	117	0	117	57	84	73	8	282	23	1.00	305
58	62	142	92	0	92	58	102	89	9	292	23	1.00	315
59	58	133	86	0	86	59	113	99	10	308	23	1.00	331
60	131	211	194	0	194	60	83	73	14	364	23	1.00	387
61	84	136	124	0	124	61	149	130	16	419	23	1.00	442
62	90	146	133	0	133	62	98	85	13	329	23	1.00	352
63	99	159	146	0	146	63	68	59	12	285	23	1.00	308
64	147	183	218	0	218	64	145	127	13	503	23	1.00	526
65	149	183	220	0	220	65	123	107	11	461	23	1.00	484
66	84	106	124	0	124	66	171	149	16	460	23	1.00	483
67	79	98	117	0	117	67	136	118	12	383	23	1.00	406
68	110	174	163	0	163	68	46	40	4	253	23	1.00	276
69	87	83	129	0	129	69	204	178	19	530	23	1.00	553
					416					765	Max		788
											Min		69
											HKAQO		800

Table A1-5a Predicted SO2 GLC for Scenario 1

System Peak Load (MW) 2935 LGO S Content 0.5%

Receptor	Predicted Data Source D1 GTs MW 435 LGO	Source D2 CC MW 0 N/A	Source A+B+C L1-L8 MW 2500 COAL	Background	Results SO2 GLC ug/m3
1	243	0	0	23	266
2	183	0	5	23	211
3	90	0	0	23	113
4	348	0	9	23	380
5	262	0	8	23	293
6	241	0	40	23	304
7	247	0	196	23	466
8	275	0	7	23	305
9	278	0	39	23	340
10	416	0	166	23	605
11	132	0	8	23	163
12	158	0	8	23	189
13	33	0	13	23	69
14	77	0	4	23	104
15	92	0	39	23	154
16	98	0	41	23	162
17	117	0	74	23	214
18	56	0	86	23	165
19	84	0	5	23	112
20	133	0	5	23	161
21	67	0	100	23	190
22	0	0	135	23	158
23	0	0	234	23	257
24	0	0	465	23	488
25	30	0	245	23	298
26	43	0	280	23	346
27	380	0	31	23	434
28	240	0	261	23	524
29	175	0	590	23	788
30	41	0	346	23	410
31	31	0	142	33	206
32	25	0	158	33	216
33	101	0	45	23	169
34	114	0	78	23	215
35	96	0	247	23	366
36	99	0	304	23	426
37	118	0	104	23	245
38	148	0	149	23	320
39	61	0	145	23	229
40	16	0	264	33	313
41	36	0	106	33	175
42	132	0	267	23	422
43	93	0	195	23	311
44	59	0	102	23	184
45	80	0	221	23	324
46	101	0	279	23	403
47	59	0	155	33	247
48	58	0	131	33	222
49	115	0	57	23	195
50	126	0	150	23	299
51	71	0	248	23	342
52	133	0	100	23	256
53	151	0	156	23	330
54	84	0	552	23	659
55	34	0	151	33	218
56	46	0	194	33	273
57	117	0	165	23	305
58	92	0	200	23	315
59	86	0	222	23	331
60	194	0	170	23	387
61	124	0	295	23	442
62	133	0	196	23	352
63	146	0	139	23	308
64	218	0	285	23	526
65	220	0	241	23	484
66	124	0	336	23	483
67	117	0	266	23	406
68	163	0	90	23	276
69	129	0	401	23	553
				Max	788
				Min	69
				HKAQO	800

GT Conversion Pollutant Emission - NOx (Scenario 1 - Without GT Conversion)
System Peak Load (MW) 2935
LGO Sulphur Content 0.5%

Receptor	Wind Tunnel Data Scenario 1 GT2-7 MW 294	Scenario 2 CC MW 244	Predicted Data Source D1 GT2-7 MW 435	Source D2 CC MW 0	D1 + D2	Receptor	Predicted Data A	B	C	GLC - ug/m3 A+B+C+D1+D2	Bkgrd	Distance Correction	GLC W/Bkgrd
1	21	20	31	0	31	1	0	0	0	31	49	0.52	65
2	16	18	24	0	24	2	0	0	0	24	49	0.81	68
3	8	13	12	0	12	3	0	0	0	12	49	0.38	53
4	30	33	44	0	44	4	0	1	0	45	49	0.71	81
5	23	27	34	0	34	5	1	0	0	35	49	0.96	83
6	21	25	31	0	31	6	4	1	1	37	49	0.93	83
7	21	26	31	0	31	7	16	10	1	58	49	0.96	105
8	24	28	36	0	36	8	0	1	0	37	49	0.72	75
9	24	27	36	0	36	9	2	3	0	41	49	0.76	80
10	36	32	53	0	53	10	8	14	3	78	49	0.72	105
11	11	18	16	0	16	11	0	1	0	17	49	0.42	56
12	14	17	21	0	21	12	1	1	0	23	49	0.69	65
13	3	2	4	0	4	13	2	0	0	6	49	0.40	52
14	7	6	10	0	10	14	0	0	0	10	49	0.71	56
15	8	7	12	0	12	15	1	4	0	17	49	1.00	66
16	8	7	12	0	12	16	3	3	1	19	49	0.93	67
17	10	9	15	0	15	17	5	5	2	27	49	0.91	73
18	1	4	1	0	1	18	5	9	3	18	49	1.44	76
19	7	6	10	0	10	19	0	1	0	11	49	0.50	55
20	11	12	16	0	16	20	0	0	0	16	49	0.82	62
21	6	7	9	0	9	21	10	2	1	22	49	1.00	71
22	0	0	0	0	0	22	1	16	9	26	49	0.69	67
23	0	0	0	0	0	23	2	26	21	49	49	0.92	94
24	0	0	0	0	0	24	13	48	21	82	49	1.23	150
25	3	3	4	0	4	25	8	27	2	41	49	0.83	83
26	4	4	6	0	6	26	17	20	6	49	49	1.09	102
27	33	32	49	0	49	27	2	2	1	54	49	0.61	82
28	21	26	31	0	31	28	17	18	5	71	49	1.25	138
29	15	19	22	0	22	29	38	41	11	112	49	1.90	262
30	4	7	6	0	6	30	19	28	8	61	49	1.88	151
31	3	5	4	0	4	31	6	13	4	27	80	1.92	133
32	2	4	3	0	3	32	7	14	4	28	80	1.93	134
33	9	14	13	0	13	33	3	3	1	20	49	1.69	83
34	10	16	15	0	15	34	5	5	1	26	49	1.76	94
35	8	11	12	0	12	35	16	17	5	50	49	1.54	126
36	9	12	13	0	13	36	20	21	6	60	49	1.52	141
37	10	16	15	0	15	37	7	7	2	31	49	1.77	103
38	13	16	19	0	19	38	10	10	3	42	49	1.64	118
39	2	2	3	0	3	39	11	12	3	29	49	1.81	96
40	1	1	1	0	1	40	16	19	5	41	80	1.88	158
41	3	9	4	0	4	41	7	7	2	20	80	1.84	118
42	11	14	16	0	16	42	17	18	5	56	49	1.47	132
43	8	10	12	0	12	43	12	13	4	41	49	1.49	110
44	5	22	7	0	7	44	6	7	2	22	49	1.55	84
45	7	8	10	0	10	45	14	15	4	43	49	1.56	116
46	9	11	13	0	13	46	18	19	5	55	49	1.75	146
47	5	7	7	0	7	47	10	11	3	31	80	1.93	141
48	5	7	7	0	7	48	8	9	3	27	80	1.92	133
49	10	17	15	0	15	49	4	4	1	24	49	1.47	84
50	11	11	16	0	16	50	10	10	3	39	49	1.50	108
51	6	7	9	0	9	51	16	17	5	47	49	1.84	135
52	11	15	16	0	16	52	6	7	2	31	49	1.46	95
53	13	18	19	0	19	53	10	11	3	43	49	1.41	110
54	7	13	10	0	10	54	35	38	11	94	49	1.81	220
55	3	5	4	0	4	55	10	10	3	27	80	2.00	135
56	4	5	6	0	6	56	12	13	4	35	80	2.00	150
57	10	19	15	0	15	57	11	11	3	40	49	1.40	105
58	8	13	12	0	12	58	13	14	4	43	49	1.36	107
59	7	14	10	0	10	59	14	15	4	43	49	1.70	123
60	17	22	25	0	25	60	10	11	6	52	49	1.39	121
61	11	14	16	0	16	61	19	20	7	62	49	1.37	134
62	11	15	16	0	16	62	12	13	6	47	49	1.60	124
63	13	16	19	0	19	63	9	9	5	42	49	1.53	114
64	19	19	28	0	28	64	18	20	5	71	49	1.52	157
65	19	19	28	0	28	65	15	17	5	65	49	1.52	148
66	11	11	16	0	16	66	21	23	6	66	49	1.79	167
67	10	10	15	0	15	67	17	18	5	55	49	1.80	148
68	14	18	21	0	21	68	6	6	2	35	49	1.68	107
69	11	9	16	0	16	69	26	28	8	78	49	1.65	194
					53					112	Max		262
											Min		52
											HKAQO		300

Table A1-5b Predicted NO2 GLC for Scenario 1

System Peak Load (MW) 2935 LGO S Content 0.5%

Receptor	Predicted Data Source D1 GTs MW 435 LGO	Source D2 CC MW 0 N/A	Source A+B+C L1-L8 MW 2500 COAL	Background	Results NO2 GLC ug/m3
1	31	0	0	49	65
2	24	0	0	49	68
3	12	0	0	49	53
4	44	0	1	49	81
5	34	0	1	49	83
6	31	0	6	49	83
7	31	0	27	49	105
8	36	0	1	49	75
9	36	0	5	49	80
10	53	0	25	49	105
11	16	0	1	49	56
12	21	0	2	49	65
13	4	0	2	49	52
14	10	0	0	49	56
15	12	0	5	49	66
16	12	0	7	49	67
17	15	0	12	49	73
18	1	0	17	49	76
19	10	0	1	49	55
20	16	0	0	49	62
21	9	0	13	49	71
22	0	0	26	49	67
23	0	0	49	49	94
24	0	0	82	49	150
25	4	0	37	49	83
26	6	0	43	49	102
27	49	0	5	49	82
28	31	0	40	49	138
29	22	0	90	49	262
30	6	0	55	49	151
31	4	0	23	80	133
32	3	0	25	80	134
33	13	0	7	49	83
34	15	0	11	49	94
35	12	0	38	49	126
36	13	0	47	49	141
37	15	0	16	49	103
38	19	0	23	49	118
39	3	0	26	49	96
40	1	0	40	80	158
41	4	0	16	80	118
42	16	0	40	49	132
43	12	0	29	49	110
44	7	0	15	49	84
45	10	0	33	49	116
46	13	0	42	49	146
47	7	0	24	80	141
48	7	0	20	80	133
49	15	0	9	49	84
50	16	0	23	49	108
51	9	0	38	49	135
52	16	0	15	49	95
53	19	0	24	49	110
54	10	0	84	49	220
55	4	0	23	80	135
56	6	0	29	80	150
57	15	0	25	49	105
58	12	0	31	49	107
59	10	0	33	49	123
60	25	0	27	49	121
61	16	0	46	49	134
62	16	0	31	49	124
63	19	0	23	49	114
64	28	0	43	49	157
65	28	0	37	49	148
66	16	0	50	49	167
67	15	0	40	49	148
68	21	0	14	49	107
69	16	0	62	49	194
				Max	262
				Min	52
				HKAQO	300

GT Conversion Pollutant Emission - SO2 (Scenario 2 - After GT Conversion - Conversion Unit Gas & GTs LGO Option)
System Peak Load (MW) 3050
LGO Sulphur Content 0.5%

Receptor	Wind Tunnel Data Scenario 1 GT2-7 MW 294	Scenario 2 CC MW 244	Predicted Data Source D1 GT2-7 MW 185	Source D2 CC MW 365	D1 + D2	Receptor	Predicted Data A	B	C	GLC - ug/m3 A+B+C+D1+D2	Bkgrd	Distance Correction	GLC W/Bkgrd
1	164	7	103	10	113	1	0	0	0	113	23	1.00	136
2	124	6	78	9	87	2	3	1	1	92	23	1.00	115
3	61	4	38	6	45	3	0	0	0	45	23	1.00	68
4	235	11	148	17	164	4	0	9	0	173	23	1.00	196
5	177	9	111	14	125	5	8	0	0	133	23	1.00	156
6	163	8	103	12	115	6	29	9	2	155	23	1.00	178
7	167	9	105	13	118	7	128	86	2	314	23	1.00	337
8	186	9	117	14	131	8	1	5	1	138	23	1.00	161
9	188	9	118	13	132	9	16	22	1	171	23	1.00	194
10	281	11	177	16	193	10	65	93	8	359	23	1.00	382
11	89	6	56	9	65	11	0	8	0	73	23	1.00	96
12	107	6	67	8	76	12	4	4	0	84	23	1.00	107
13	22	0	14	1	15	13	12	1	0	28	23	1.00	51
14	52	2	33	3	36	14	4	0	0	40	23	1.00	63
15	62	2	39	4	43	15	11	27	1	82	23	1.00	105
16	68	2	42	3	45	16	22	16	3	86	23	1.00	109
17	79	3	50	5	54	17	36	34	4	128	23	1.00	151
18	38	3	24	5	29	18	42	39	5	115	23	1.00	138
19	57	2	36	3	39	19	1	4	0	44	23	1.00	67
20	90	4	57	6	62	20	4	1	0	67	23	1.00	90
21	45	6	28	9	37	21	82	16	2	137	23	1.00	160
22	0	2	0	3	3	22	10	103	22	138	23	1.00	161
23	0	0	0	0	0	23	18	165	51	234	23	1.00	257
24	0	0	0	0	0	24	106	308	51	465	23	1.00	488
25	20	1	13	1	14	25	64	176	5	259	23	1.00	282
26	29	8	18	12	30	26	137	128	15	310	23	1.00	333
27	257	11	162	16	178	27	15	14	2	209	23	1.00	232
28	162	9	102	14	116	28	133	116	12	377	23	1.00	400
29	118	6	74	9	84	29	301	262	27	674	23	1.00	697
30	28	5	18	7	25	30	149	178	19	371	23	1.00	394
31	21	5	13	7	20	31	50	83	9	162	33	1.00	195
32	17	1	11	2	13	32	56	92	10	171	33	1.00	204
33	68	5	43	7	50	33	23	20	2	95	23	1.00	118
34	77	5	48	8	56	34	40	34	4	134	23	1.00	157
35	65	4	41	6	46	35	126	110	11	293	23	1.00	316
36	67	4	42	6	48	36	155	135	14	352	23	1.00	375
37	80	5	50	8	59	37	53	46	5	163	23	1.00	186
38	100	5	63	8	71	38	76	66	7	220	23	1.00	243
39	41	4	26	7	32	39	70	68	7	177	23	1.00	200
40	11	4	7	6	13	40	127	124	13	277	33	1.00	310
41	24	3	15	5	20	41	54	47	5	126	33	1.00	159
42	89	5	56	7	63	42	136	119	12	330	23	1.00	353
43	63	3	40	5	45	43	99	87	9	240	23	1.00	263
44	40	7	25	11	36	44	52	46	5	138	23	1.00	161
45	54	7	34	11	45	45	113	98	10	266	23	1.00	289
46	68	4	43	5	48	46	142	124	13	327	23	1.00	350
47	40	2	25	3	29	47	79	69	7	184	33	1.00	217
48	39	2	25	3	28	48	67	58	6	159	33	1.00	192
49	78	6	49	8	57	49	29	25	3	114	23	1.00	137
50	85	6	53	9	62	50	76	67	7	212	23	1.00	235
51	48	2	30	4	34	51	126	110	12	282	23	1.00	305
52	90	5	57	7	64	52	51	44	5	164	23	1.00	187
53	102	6	64	9	73	53	80	69	7	229	23	1.00	252
54	57	4	36	6	42	54	281	245	26	594	23	1.00	617
55	23	2	14	2	17	55	77	67	7	168	33	1.00	201
56	31	2	20	3	22	56	99	86	9	216	33	1.00	249
57	79	6	50	9	59	57	84	73	8	224	23	1.00	247
58	62	5	39	7	46	58	102	89	9	246	23	1.00	269
59	58	5	36	7	43	59	113	99	10	265	23	1.00	288
60	131	7	82	11	93	60	83	73	14	263	23	1.00	286
61	84	5	53	7	60	61	149	130	16	355	23	1.00	378
62	90	5	57	7	64	62	98	85	13	260	23	1.00	283
63	99	5	62	8	70	63	68	59	12	209	23	1.00	232
64	147	6	93	9	102	64	145	127	13	387	23	1.00	410
65	149	6	94	9	103	65	123	107	11	344	23	1.00	367
66	84	4	53	5	58	66	171	149	16	394	23	1.00	417
67	79	3	50	5	55	67	136	118	12	321	23	1.00	344
68	110	6	69	9	78	68	46	40	4	168	23	1.00	191
69	87	3	55	4	59	69	204	178	19	460	23	1.00	483
					193					674	Max		697
											Min		51
											HKAQO		800

Table A1-5c Predicted SO2 GLC for Scenario 2

System Peak Load (MW) 3050 LGO S Content 0.5%

Receptor	Predicted Data Source D1 GTs MW 185 LGO	Source D2 CC MW 365 GAS	Source A+B+C L1-L8 MW 2500 COAL	Background	Results SO2 GLC ug/m3
1	103	10	0	23	136
2	78	9	5	23	115
3	38	6	0	23	68
4	148	17	9	23	196
5	111	14	8	23	156
6	103	12	40	23	178
7	105	13	196	23	337
8	117	14	7	23	161
9	118	13	39	23	194
10	177	16	166	23	382
11	56	9	8	23	96
12	67	8	8	23	107
13	14	1	13	23	51
14	33	3	4	23	63
15	39	4	39	23	105
16	42	3	41	23	109
17	50	5	74	23	151
18	24	5	86	23	138
19	36	3	5	23	67
20	57	6	5	23	90
21	28	9	100	23	160
22	0	3	135	23	161
23	0	0	234	23	257
24	0	0	465	23	488
25	13	1	245	23	282
26	18	12	260	23	333
27	162	16	31	23	232
28	102	14	261	23	400
29	74	9	590	23	697
30	18	7	346	23	394
31	13	7	142	33	195
32	11	2	158	33	204
33	43	7	45	23	118
34	48	8	78	23	157
35	41	6	247	23	316
36	42	6	304	23	375
37	50	8	104	23	186
38	63	8	149	23	243
39	26	7	145	23	200
40	7	6	264	33	310
41	15	5	106	33	159
42	56	7	267	23	353
43	40	5	195	23	263
44	25	11	102	23	161
45	34	11	221	23	289
46	43	5	279	23	350
47	25	3	155	33	217
48	25	3	131	33	192
49	49	8	57	23	137
50	53	9	150	23	235
51	30	4	248	23	305
52	57	7	100	23	187
53	64	9	156	23	252
54	36	6	552	23	617
55	14	2	151	33	201
56	20	3	194	33	249
57	50	9	165	23	247
58	39	7	200	23	269
59	36	7	222	23	288
60	82	11	170	23	286
61	53	7	295	23	378
62	57	7	196	23	283
63	62	8	139	23	232
64	93	9	285	23	410
65	94	9	241	23	367
66	53	5	336	23	417
67	50	5	266	23	344
68	69	9	90	23	191
69	55	4	401	23	483
				Max	697
				Min	51
				HKAQO	800

GT Conversion Pollutant Emission - NOx (Scenario 2 - After GT Conversion - Conversion Unit Gas & GTs LGO Option)
System Peak Load (MW) 3050
LGO Sulphur Content 0.5%

Receptor	Wind Tunnel Data Scenario 1 GT2-7 MW 294	Scenario 2 CC MW 244	Predicted Data Source D1 GT2-7 MW 185	Source D2 CC MW 365	D1 + D2	Receptor	Predicted Data A	B	C	GLC - ug/m3 A+B+C+D1+D2	Bkgrd	Distance Correction	GLC W/Bkgrd
1	21	10	13	15	28	1	0	0	0	28	49	0.52	64
2	16	9	10	13	23	2	0	0	0	23	49	0.81	68
3	8	6	5	9	14	3	0	0	0	14	49	0.38	54
4	30	16	19	24	43	4	0	1	0	44	49	0.71	80
5	23	13	14	20	34	5	1	0	0	35	49	0.96	83
6	21	12	13	18	31	6	4	1	1	37	49	0.93	84
7	21	13	13	19	32	7	16	10	1	59	49	0.96	106
8	24	14	15	20	35	8	0	1	0	36	49	0.72	75
9	24	13	15	20	35	9	2	3	0	40	49	0.76	79
10	38	16	23	23	46	10	8	14	3	71	49	0.72	100
11	11	9	7	13	20	11	0	1	0	21	49	0.42	58
12	14	8	9	12	21	12	1	1	0	23	49	0.69	65
13	3	1	2	1	3	13	2	0	0	5	49	0.40	51
14	7	3	4	4	9	14	0	0	0	9	49	0.71	55
15	8	3	5	5	10	15	1	4	1	16	49	1.00	65
16	8	3	5	5	10	16	3	3	1	17	49	0.93	65
17	10	4	6	7	13	17	5	5	2	25	49	0.91	72
18	1	2	1	3	4	18	5	9	3	21	49	1.44	79
19	7	3	4	4	9	19	0	1	0	10	49	0.50	54
20	11	6	7	9	16	20	0	0	0	16	49	0.82	62
21	6	3	4	5	9	21	10	2	1	22	49	1.00	71
22	0	0	0	0	0	22	1	16	9	26	49	0.69	67
23	0	0	0	0	0	23	2	26	21	49	49	0.92	94
24	0	0	0	0	0	24	13	48	21	82	49	1.23	150
25	3	1	2	2	4	25	8	27	2	41	49	0.83	83
26	4	2	3	3	5	26	17	20	6	48	49	1.09	102
27	33	16	21	23	44	27	2	2	1	49	49	0.61	79
28	21	14	13	20	34	28	17	18	5	74	49	1.25	141
29	15	9	9	14	23	29	38	41	11	113	49	1.90	264
30	4	3	3	5	8	30	19	26	8	63	49	1.68	154
31	3	2	2	4	6	31	6	13	4	29	80	1.92	135
32	2	2	1	3	4	32	7	14	4	29	80	1.93	136
33	9	7	6	10	16	33	3	3	1	23	49	1.69	88
34	10	8	6	12	18	34	5	5	1	29	49	1.76	100
35	8	5	5	8	13	35	16	17	5	51	49	1.54	128
36	9	6	6	9	14	36	20	21	6	61	49	1.52	142
37	10	8	6	12	18	37	7	7	2	34	49	1.77	109
38	13	8	8	12	20	38	10	10	3	43	49	1.64	119
39	2	1	1	1	3	39	11	12	3	29	49	1.61	95
40	1	0	1	1	1	40	16	19	5	41	80	1.88	158
41	3	4	2	7	8	41	7	7	2	24	80	1.84	125
42	11	7	7	10	17	42	17	18	5	57	49	1.47	133
43	8	5	5	7	12	43	12	13	4	41	49	1.49	110
44	5	11	3	16	19	44	6	7	2	34	49	1.55	102
45	7	4	4	6	10	45	14	15	4	43	49	1.55	116
46	9	5	6	8	14	46	18	19	5	56	49	1.75	146
47	5	3	3	5	8	47	10	11	3	32	80	1.93	142
48	5	3	3	5	8	48	8	9	3	28	80	1.92	134
49	10	8	6	12	19	49	4	4	1	28	49	1.47	90
50	11	5	7	8	15	50	10	10	3	38	49	1.50	106
51	6	3	4	5	9	51	16	17	5	47	49	1.84	135
52	11	7	7	11	18	52	6	7	2	33	49	1.46	97
53	13	9	8	13	21	53	10	11	3	45	49	1.41	113
54	7	6	4	9	14	54	36	38	11	98	49	1.81	226
55	3	2	2	4	6	55	10	10	3	29	80	2.00	137
56	4	2	3	4	6	56	12	13	4	35	80	2.00	150
57	10	9	6	14	20	57	11	11	3	45	49	1.40	112
58	8	6	5	9	14	58	13	14	4	45	49	1.36	111
59	7	7	4	10	15	59	14	15	4	48	49	1.70	130
60	17	11	11	16	27	60	10	11	6	54	49	1.39	123
61	11	7	7	10	17	61	19	20	7	63	49	1.37	135
62	11	7	7	11	18	62	12	13	6	49	49	1.60	127
63	13	8	8	12	20	63	9	9	5	43	49	1.53	114
64	19	9	12	14	26	64	18	20	5	69	49	1.52	153
65	19	9	12	14	26	65	15	17	5	63	49	1.52	144
66	11	5	7	8	15	66	21	23	6	65	49	1.79	166
67	10	5	6	7	14	67	17	18	5	54	49	1.80	145
68	14	9	9	13	22	68	6	6	2	36	49	1.88	109
69	11	4	7	7	13	69	26	28	8	75	49	1.85	189
					46					113	Max		264
											Min		51
											HKAQO		300

Table A1-5d Predicted NO2 GLC for Scenario 2

System Peak Load (MW) 3050 LGO S Content 0.5%

Receptor	Predicted Data Source D1 GTs MW 185 LGO	Source D2 CC MW 365 GAS	Source A+B+C L1-L8 MW 2500 COAL	Background	Results NO2 GLC ug/m3
1	13	15	0	49	64
2	10	13	0	49	68
3	5	9	0	49	54
4	19	24	1	49	80
5	14	20	1	49	83
6	13	18	6	49	84
7	13	19	27	49	106
8	15	20	1	49	75
9	15	20	5	49	79
10	23	23	25	49	100
11	7	13	1	49	58
12	9	12	2	49	65
13	2	1	2	49	51
14	4	4	0	49	55
15	5	5	6	49	65
16	5	5	7	49	65
17	6	7	12	49	72
18	1	3	17	49	79
19	4	4	1	49	54
20	7	9	0	49	62
21	4	5	13	49	71
22	0	0	26	49	67
23	0	0	49	49	94
24	0	0	82	49	150
25	2	2	37	49	83
26	3	3	43	49	102
27	21	23	5	49	79
28	13	20	40	49	141
29	9	14	90	49	264
30	3	5	55	49	154
31	2	4	23	80	135
32	1	3	25	80	136
33	6	10	7	49	88
34	6	12	11	49	100
35	5	8	38	49	128
36	6	9	47	49	142
37	6	12	16	49	109
38	8	12	23	49	119
39	1	1	26	49	95
40	1	1	40	80	158
41	2	7	16	80	125
42	7	10	40	49	133
43	5	7	29	49	110
44	3	16	15	49	102
45	4	6	33	49	116
46	6	8	42	49	146
47	3	5	24	80	142
48	3	5	20	80	134
49	6	12	9	49	90
50	7	8	23	49	106
51	4	5	38	49	135
52	7	11	15	49	97
53	8	13	24	49	113
54	4	9	84	49	226
55	2	4	23	80	137
56	3	4	29	80	150
57	6	14	25	49	112
58	5	9	31	49	111
59	4	10	33	49	130
60	11	16	27	49	123
61	7	10	46	49	135
62	7	11	31	49	127
63	8	12	23	49	114
64	12	14	43	49	153
65	12	14	37	49	144
66	7	8	50	49	165
67	6	7	40	49	145
68	9	13	14	49	109
69	7	7	62	49	189
				Max	264
				Min	51
				HKAQO	300

GT Conversion Pollutant Emission - SO2 (Scenario 3 - After GT Conversion - LGO Option)

System Peak Load (MW) 3050

LGO Sulphur Content 0.20% CC; 0.50% GT

Receptor	Wind Tunnel Data Scenario 1 GT2-7 MW 294	Scenario 2 CC MW 244	Predicted Data Source D1 GT2-7 MW 185	Source D2 CC MW 365	D1 + D2	Receptor	Scenario 1 A	B	C	GLC - ug/m3 A+B+C+D1+D2	Bkgrd	Distance Correction	GLC W/Bkgrd
1	164	197	103	118	221	1	0	0	0	221	23	1.00	244
2	124	177	78	106	184	2	3	1	1	189	23	1.00	212
3	61	124	38	74	113	3	0	0	0	113	23	1.00	136
4	235	321	148	192	340	4	0	9	0	349	23	1.00	372
5	177	263	111	157	268	5	8	0	0	277	23	1.00	300
6	163	241	103	144	247	6	29	9	2	287	23	1.00	310
7	167	249	105	149	254	7	128	66	2	450	23	1.00	473
8	186	273	117	163	280	8	1	5	1	287	23	1.00	310
9	188	258	118	154	273	9	16	22	1	312	23	1.00	335
10	261	306	177	183	360	10	65	93	8	526	23	1.00	549
11	89	179	56	107	163	11	0	8	0	171	23	1.00	194
12	107	162	67	97	164	12	4	4	0	172	23	1.00	195
13	22	14	14	8	22	13	12	1	0	35	23	1.00	58
14	52	56	33	34	66	14	4	0	0	70	23	1.00	93
15	62	69	39	41	80	15	11	27	1	119	23	1.00	142
16	66	67	42	40	82	16	22	16	3	123	23	1.00	146
17	79	91	50	54	104	17	36	34	4	178	23	1.00	201
18	38	93	24	56	80	18	42	39	5	166	23	1.00	189
19	57	58	36	35	71	19	1	4	0	76	23	1.00	99
20	90	112	57	67	124	20	4	1	0	129	23	1.00	152
21	45	165	28	99	127	21	82	16	2	227	23	1.00	250
22	0	53	0	32	32	22	10	103	22	167	23	1.00	190
23	0	0	0	0	0	23	18	165	51	234	23	1.00	257
24	0	0	0	0	0	24	106	308	51	465	23	1.00	488
25	20	29	13	17	30	25	64	176	5	275	23	1.00	298
26	29	236	18	141	159	26	137	128	15	439	23	1.00	462
27	257	306	162	184	346	27	15	14	2	377	23	1.00	400
28	162	274	102	164	266	28	133	116	12	527	23	1.00	550
29	118	181	74	108	183	29	301	262	27	773	23	1.00	796
30	28	141	18	84	102	30	149	178	19	448	23	1.00	471
31	21	140	13	84	97	31	50	83	9	239	33	1.00	272
32	17	38	11	23	33	32	56	92	10	191	33	1.00	224
33	68	134	43	80	123	33	23	20	2	168	23	1.00	191
34	77	152	48	91	139	34	40	34	4	217	23	1.00	240
35	65	108	41	65	106	35	126	110	11	353	23	1.00	376
36	67	113	42	68	110	36	155	135	14	414	23	1.00	437
37	80	159	50	95	145	37	53	46	5	249	23	1.00	272
38	100	150	63	90	153	38	76	66	7	302	23	1.00	325
39	41	128	26	77	102	39	70	68	7	247	23	1.00	270
40	11	111	7	66	73	40	127	124	13	337	33	1.00	370
41	24	91	15	54	70	41	54	47	5	176	33	1.00	209
42	89	133	56	80	136	42	136	119	12	403	23	1.00	426
43	63	95	40	57	96	43	99	87	9	291	23	1.00	314
44	40	217	25	130	155	44	52	45	5	257	23	1.00	280
45	54	210	34	126	160	45	113	98	10	381	23	1.00	404
46	68	103	43	62	104	46	142	124	13	383	23	1.00	406
47	40	87	25	40	65	47	79	69	7	220	33	1.00	253
48	39	66	25	39	64	48	67	58	6	195	33	1.00	228
49	78	163	49	98	147	49	29	25	3	204	23	1.00	227
50	85	168	53	101	154	50	76	67	7	304	23	1.00	327
51	48	69	30	41	71	51	126	110	12	319	23	1.00	342
52	90	144	57	86	143	52	51	44	5	243	23	1.00	266
53	102	172	64	103	167	53	80	69	7	323	23	1.00	346
54	57	123	36	74	109	54	281	245	26	661	23	1.00	684
55	23	48	14	29	43	55	77	67	7	194	33	1.00	227
56	31	52	20	31	51	56	99	86	9	245	33	1.00	278
57	79	182	50	109	159	57	84	73	8	324	23	1.00	347
58	62	142	39	85	124	58	102	89	9	324	23	1.00	347
59	58	133	36	80	116	59	113	99	10	338	23	1.00	361
60	131	211	82	126	209	60	83	73	14	379	23	1.00	402
61	84	136	53	81	134	61	149	130	16	429	23	1.00	452
62	90	145	57	87	143	62	98	85	13	339	23	1.00	362
63	99	159	62	95	157	63	68	59	12	296	23	1.00	319
64	147	183	93	110	202	64	145	127	13	487	23	1.00	510
65	149	183	94	110	203	65	123	107	11	444	23	1.00	467
66	84	106	53	63	116	66	171	149	16	452	23	1.00	475
67	79	98	50	59	108	67	136	118	12	374	23	1.00	397
68	110	174	69	104	173	68	46	40	4	263	23	1.00	286
69	87	83	55	50	104	69	204	178	19	505	23	1.00	528
					360					773	Max		796
											Min		58
											HKAQO		800

Table A1-5e Predicted SO2 GLC for Scenario 3

System Peak Load (MW) 3050

LGO S Content CC 0.20%; GT 0.50%

Receptor	Predicted Data Source D1 GTs MW 185 0.50%LGO	Source D2 CC MW 365 0.20%LGO	Source A+B+C L1-L8 MW 2500 COAL	Background	Results SO2 GLC ug/m3
1	103	118	0	23	244
2	78	106	5	23	212
3	38	74	0	23	136
4	148	192	9	23	372
5	111	157	8	23	300
6	103	144	40	23	310
7	105	149	196	23	473
8	117	163	7	23	310
9	118	154	39	23	335
10	177	183	166	23	549
11	56	107	8	23	194
12	67	97	8	23	195
13	14	8	13	23	58
14	33	34	4	23	93
15	39	41	39	23	142
16	42	40	41	23	146
17	50	54	74	23	201
18	24	56	86	23	189
19	36	35	5	23	99
20	57	67	5	23	152
21	28	99	100	23	250
22	0	32	135	23	190
23	0	0	234	23	257
24	0	0	465	23	488
25	13	17	245	23	298
26	18	141	280	23	462
27	162	184	31	23	400
28	102	164	261	23	550
29	74	108	590	23	796
30	18	84	346	23	471
31	13	84	142	33	272
32	11	23	158	33	224
33	43	80	45	23	191
34	48	91	78	23	240
35	41	65	247	23	376
36	42	68	304	23	437
37	50	95	104	23	272
38	63	90	149	23	325
39	26	77	145	23	270
40	7	66	264	33	370
41	15	54	106	33	209
42	56	80	267	23	426
43	40	57	195	23	314
44	25	130	102	23	280
45	34	126	221	23	404
46	43	62	279	23	406
47	25	40	155	33	253
48	25	39	131	33	228
49	49	98	57	23	227
50	53	101	150	23	327
51	30	41	248	23	342
52	57	86	100	23	266
53	64	103	156	23	346
54	36	74	552	23	684
55	14	29	151	33	227
56	20	31	194	33	278
57	50	109	165	23	347
58	39	85	200	23	347
59	36	80	222	23	361
60	82	126	170	23	402
61	53	81	295	23	452
62	57	87	196	23	362
63	62	95	139	23	319
64	93	110	285	23	510
65	94	110	241	23	467
66	53	63	336	23	475
67	50	59	266	23	397
68	69	104	90	23	286
69	55	50	401	23	528
				Max	796
				Min	58
				HKAQO	800

GT Conversion Pollutant Emission - NOx (Scenario 3 - After GT Conversion - LGO Option)

System Peak Load (MW) 3050

LGO Sulphur Content 0.20% CC, 0.50% GT

NOx 154 / 150

Receptor	Wind Tunnel Data Scenario 1 GT2-7 MW 294	Scenario 2 CC MW 244	Predicted Data Source D1 GT2-7 MW 185	Source D2 CC MW 365	D1 + D2	Receptor	Scenario 1 A	B	C	GLC - ug/m3 A+B+C+D1+D2	Bkgrd	Distance Correction	GLC W/Bkgrd
1	21	20	13	31	44	1	0	0	0	44	49	0.52	72
2	16	18	10	28	38	2	0	0	0	38	49	0.81	80
3	8	13	5	20	25	3	0	0	0	25	49	0.36	58
4	30	33	19	51	70	4	0	1	0	71	49	0.71	99
5	23	27	14	41	56	5	1	0	0	57	49	0.96	104
6	21	25	13	38	52	6	4	1	1	58	49	0.93	102
7	21	28	13	40	53	7	16	10	1	80	49	0.96	126
8	24	28	15	43	56	8	0	1	0	59	49	0.72	92
9	24	27	15	41	57	9	2	3	0	62	49	0.76	96
10	36	32	23	49	72	10	8	14	3	97	49	0.72	119
11	11	18	7	28	35	11	0	1	0	36	49	0.42	64
12	14	17	9	26	35	12	1	1	0	37	49	0.69	74
13	3	2	2	3	5	13	2	0	0	7	49	0.40	52
14	7	6	4	9	14	14	0	0	0	14	49	0.71	59
15	8	7	5	11	16	15	1	4	1	22	49	1.00	71
16	8	7	5	11	16	16	3	3	1	23	49	0.93	70
17	10	9	6	14	20	17	5	5	2	32	49	0.91	78
18	1	4	1	6	7	18	5	9	3	24	49	1.44	83
19	7	8	4	9	14	19	0	1	0	15	49	0.50	56
20	11	12	7	18	25	20	0	0	0	25	49	0.82	70
21	6	7	4	11	15	21	10	2	1	26	49	1.00	77
22	0	0	0	0	0	22	1	16	9	26	49	0.69	67
23	0	0	0	0	0	23	2	26	21	49	49	0.92	94
24	0	0	0	0	0	24	13	48	21	82	49	1.23	150
25	3	3	2	5	6	25	8	27	2	43	49	0.83	85
26	4	4	3	6	9	26	17	20	6	52	49	1.09	105
27	33	32	21	49	70	27	2	2	1	75	49	0.61	94
28	21	28	13	43	56	28	17	18	5	96	49	1.25	169
29	15	19	9	29	39	29	38	41	11	129	49	1.90	293
30	4	7	3	11	13	30	19	26	8	66	49	1.68	164
31	3	5	2	8	10	31	6	13	4	33	80	1.92	143
32	2	4	1	6	7	32	7	14	4	32	80	1.93	142
33	9	14	6	22	27	33	3	3	1	34	49	1.69	107
34	10	16	6	25	31	34	5	5	1	42	49	1.76	123
35	8	11	5	17	22	35	16	17	5	60	49	1.54	141
36	9	12	6	18	24	36	20	21	6	71	49	1.52	157
37	10	16	6	25	31	37	7	7	2	47	49	1.77	132
38	13	16	8	25	33	38	10	10	3	56	49	1.64	140
39	2	2	1	3	4	39	11	12	3	30	49	1.61	98
40	1	1	1	2	2	40	16	19	5	42	80	1.88	159
41	3	9	2	14	16	41	7	7	2	32	80	1.84	138
42	11	14	7	22	28	42	17	18	5	68	49	1.47	150
43	8	10	5	15	20	43	12	13	4	49	49	1.49	122
44	5	22	3	34	37	44	6	7	2	52	49	1.55	129
45	7	8	4	12	17	45	14	15	4	50	49	1.55	126
46	9	11	6	17	23	46	16	19	5	65	49	1.75	162
47	5	7	3	11	14	47	10	11	3	38	80	1.93	153
48	5	7	3	11	14	48	8	9	3	34	80	1.92	145
49	10	17	6	26	32	49	4	4	1	41	49	1.47	110
50	11	11	7	17	24	50	10	10	3	47	49	1.50	119
51	6	7	4	11	15	51	16	17	5	53	49	1.64	146
52	11	15	7	23	30	52	6	7	2	45	49	1.46	115
53	13	18	8	28	36	53	10	11	3	60	49	1.41	133
54	7	13	4	20	24	54	35	36	11	106	49	1.81	245
55	3	5	2	8	10	55	10	10	3	33	80	2.00	145
56	4	5	3	8	10	56	12	13	4	39	80	2.00	158
57	10	19	6	29	36	57	11	11	3	60	49	1.40	134
58	8	13	5	20	25	58	13	14	4	56	49	1.36	125
59	7	14	4	22	26	59	14	15	4	59	49	1.70	149
60	17	22	11	34	44	60	10	11	6	71	49	1.39	148
61	11	14	7	22	28	61	19	20	7	74	49	1.37	151
62	11	15	7	23	30	62	12	13	6	61	49	1.60	146
63	13	16	8	25	33	63	9	9	5	56	49	1.53	134
64	19	19	12	29	41	64	18	20	5	84	49	1.52	177
65	19	19	12	29	41	65	15	17	5	78	49	1.52	168
66	11	11	7	17	24	66	21	23	6	74	49	1.79	181
67	10	10	6	15	22	67	17	18	5	62	49	1.80	160
68	14	16	9	28	36	68	8	6	2	50	49	1.68	134
69	11	9	7	14	21	69	26	28	6	83	49	1.85	202
					72					129	Max		293
											Min		52
											HKAQO		300

Table A1-51 Predicted NO2 GLC for Scenario 3

System Peak Load (MW) 3050

LGO S Content CC 0.20%, GT 0.50%

Receptor	Predicted Data Source D1 GTs MW 185 0.50%LGO	Source D2 CC MW 365 0.20%LGO	Source A+B+C L1-L8 MW 2500 COAL	Background	Results NO2 GLC ug/m3
1	13	31	0	49	72
2	10	28	0	49	80
3	5	20	0	49	58
4	19	51	1	49	99
5	14	41	1	49	104
6	13	38	6	49	102
7	13	40	27	49	126
8	15	43	1	49	92
9	15	41	5	49	96
10	23	49	25	49	119
11	7	28	1	49	64
12	9	26	2	49	74
13	2	3	2	49	52
14	4	9	0	49	59
15	5	11	6	49	71
16	5	11	7	49	70
17	6	14	12	49	78
18	1	6	17	49	83
19	4	9	1	49	56
20	7	18	0	49	70
21	4	11	13	49	77
22	0	0	26	49	67
23	0	0	49	49	94
24	0	0	82	49	150
25	2	5	37	49	85
26	3	6	43	49	105
27	21	49	5	49	94
28	13	43	40	49	169
29	9	29	90	49	293
30	3	11	55	49	164
31	2	8	23	80	143
32	1	6	25	80	142
33	6	22	7	49	107
34	6	25	11	49	123
35	5	17	38	49	141
36	6	18	47	49	157
37	6	25	16	49	132
38	8	25	23	49	140
39	1	3	26	49	98
40	1	2	40	80	159
41	2	14	16	80	138
42	7	22	40	49	150
43	5	15	29	49	122
44	3	34	15	49	129
45	4	12	33	49	126
46	6	17	42	49	162
47	3	11	24	80	153
48	3	11	20	80	145
49	6	26	9	49	110
50	7	17	23	49	119
51	4	11	38	49	146
52	7	23	15	49	115
53	8	28	24	49	133
54	4	20	84	49	245
55	2	8	23	80	145
56	3	8	29	80	158
57	6	29	25	49	134
58	5	20	31	49	125
59	4	22	33	49	149
60	11	34	27	49	148
61	7	22	46	49	151
62	7	23	31	49	146
63	8	25	23	49	134
64	12	29	43	49	177
65	12	29	37	49	168
66	7	17	50	49	181
67	6	15	40	49	160
68	9	28	14	49	134
69	7	14	62	49	202
				Max	293
				Min	52
				HKAQO	300

Annex B

Noise Assessment

B1 *INTRODUCTION*

This Appendix describes and evaluates the potential noise impacts arising from the construction and operational phases of the proposed conversion unit at Lamma Power Station which under normal conditions is designed for peak lopping at daytime only.

The assessment contains a description of the existing noise environment in the vicinity of the proposed Gas Turbine 5 (GT5) and Gas Turbine 7 (GT7) conversion work, relevant noise legislation and standards, methodology used to predict the noise impacts and the predicted noise levels at construction and operational phases at nearby Noise Sensitive Receivers (NSRs).

B2 *ENVIRONMENTAL LEGISLATION AND STANDARDS*

B2.1 *THE RELEVANT ORDINANCES AND THE TECHNICAL MEMORANDA*

The principal legislation on the control of plant construction and operational noise is the *Noise Control Ordinance* (NCO). Various Technical Memoranda (TMs), which stipulate control approaches and criteria, have been issued under the NCO. For planning and early identification of potential environmental issues, the *Environmental Impact Assessment Ordinance* (EIAO) is the principal legislation. Relevant study methodology and assessment criteria for construction and operation noise are given in the *Technical Memorandum on Environmental Impact Assessment Process* (EIAO-TM).

Noise assessment carried out during the planning phase under the EIAO does not constitute an exemption from the NCO requirements. The NCO will be enforced based on future conditions such as the effect of prevailing influencing factors and the exact location of receivers and sources.

B2.2 *CONSTRUCTION NOISE CRITERIA*

General Construction Work

Noise arising from general construction works during normal working hours (ie 0700 to 1900 hours on any day not being a Sunday or public holiday) at the openable windows of buildings is governed by the EIAO-TM. Since the construction works would be undertaken during the daytime (normal working hours) in weekdays only, the criteria stipulated in the EIAO-TM will be considered appropriate in this assessment. *Table B2.2a* summarises the noise criteria of general construction work. The Area Sensitive Rating (ASR) is assumed to be "A" and the nearest sensitive receivers are assumed to be the domestic premises.

Table B2.2a *Acceptable Noise Level for General Construction Work (ANL, dB(A))*

Time Period	ANL	Remarks
0700 to 1900 hours on any day not being a Sunday or general holiday	75/70[(i)] /65[(ii)]	EIAO ($L_{eq, 30\ min}$)

Notes : (i) For educational institutions
(ii) For educational institutions duration examination

B2.3 *OPERATIONAL NOISE CRITERIA*

The EIAO-TM specifies that noise from fixed sources under planning should be 5 dB(A) below the ANL in the *Technical Memorandum for the Assessment of Noise from Places Other Than Domestic Premises* (IND-TM) or equivalent to the prevailing background noise level. As the GT conversion unit will be for emergency standby and peak lopping during day time of summer months only, the potential noise impact due to the GT conversion unit shall not exceed 55 dB(A) or prevailing background, whichever is lower during the day time as ASR for Lamma Island is "A". Taking the above into consideration, the ANL at NSRs as prescribed in EIAO-TM is presented in *Table B2.3a*.

Table B2.1a ***Acceptable Noise Level of GT Conversion Unit during Operational Phase (ANL, $L_{eq, 30\ min}$ dB(A)) under EIAO-TM***

Time Period	ANL
0700 to 2300 hours on any day	55 dB(A) or background

Once the GT conversion unit is in operation, the noise impact will be subject to the control of the NCO. The cumulative noise impact of the conversion unit and existing generating units will be assessed against the NCO-TM limits. *Table B2.3b* summarises the limit of the combined operational noise from Lamma Power Station including the GT conversion unit.

Table B2.3b ***Acceptable Noise Level of Lamma Power Station including GT Conversion Unit during Operational Phase (ANL, $L_{eq, 30\ min}$ dB(A)) under NCO-TM***

Time Period	ANL
0700 to 2300 hours on any day	60 dB(A)

B3 ***DESCRIPTION OF EXISTING ENVIRONMENT***

B3.1 *EXISTING ENVIRONMENT*

Lamma Island is a lightly populated area without a conventional road system. A limited number of small petrol or diesel-powered carts are used to transport materials but there is no vehicular traffic. As a result, ambient (baseline) noise levels are quite low and, at least over that portion of the island surrounding the present HEC plant, are dominated by noise from local village activities, natural sources (wind and waves) and the power station.

B3.2 *Baseline Noise Monitoring*

HEC has for many years had a permanent noise monitoring station established near the police station at Hung Shing Ye. This site was selected to be representative of those residences to the east and northeast of the existing power plant which have been and will remain directly exposed (with no terrain shielding) to operational noise from the existing power station. In addition, regular manned monitoring of noise levels at Tai Wan To was conducted throughout 1997. Based on the results of baseline noise measurement made in the Lamma Extension Environmental Impact Assessment (EIA) report, the day time free field background noise in Hung Shing Ye and Tai Wan To was about $L_{eq\,(30mins)}$ 55.4 dB(A) and 51.7 dB(A) respectively. The measurement locations were close to the existing residential area and had similar landuse and orientation from the Lamma Power Station. The noise environment at Hung Shing Ye and Tai Wan To should be similar. The difference in noise levels at these location indicated the effect of sporadic extraneous sources present typically in the environment.

B4 *NOISE ASSESSMENT*

B4.1 *Identification of Existing Noise Sensitive Receivers*

Settlement on the northern end of Lamma Island (mostly one to three storey residential buildings) is largely concentrated around the harbour at Yung Shue Wan and the adjacent villages of Yung Shue Long, Sha Po, Ko Long, Wang Long and Tai Wan San Tsuen. These residences are shielded from plant noise to varying degrees by the intervening hill (Kam Lo Hom) which defines the plant's northern boundary.

Owing to the complex terrain and the history of noise concerns expressed within the community, four representative residential locations have been identified as the NSRs as shown in *Table B4.1a*.

Table B4.1a Locations of NSRs

NSR No.	Location	Distance to the Construction Site (m)
NSR 1	Long Tsai Tsuen / Hung Shing Ye	1150
NSR 2	Ko Long	850
NSR 3	North Slope above Yung Shue Wan Harbour	1300
NSR 4	School in Tai Wan San Tsuen	1200

B4.2 *Identification of Noise Impacts*

Construction Phase

Potential source of noise during construction phase is the use of Powered Mechanical Equipment (PME) on site for each activity during different construction stages. According to the project schedule, the construction programme would span about 22 months, beginning in September 2000 and ending in June 2002 with completion of the GT conversion unit. Throughout this period many phases of construction will be carried out simultaneously so that their noise emissions would be additive. *Table B4.2a* lists the various major phases of the construction programme and indicates their projected start and finish dates.

Table B4.2a *Schedule for Major Construction Activities*

Activity	Hours/Day	Start	Finish
Superstructure	12	9/2000	12/2001
Inlet & Outlet Culvert	12	10/2000	08/2001
Transformer & Switchgear Bldg No. 1	12	11/2000	04/2001
Electrical & Mechanical Work	12	07/2001	06/2002

Operational Phase

Noise sources associated with the proposed GT conversion unit include the following :

- gas turbine, turbine intake and exhaust systems
- steam turbine
- electricity generator
- heat recovery steam generator
- transformers
- fire pumps, water pumps, air compressors, electric motors and ventilation fans
- control valves, associated pipe-work and steam discharges

In order to limit the noise exposure of personnel on site, most of the major noise sources in continuous operation will be located within the buildings and a number of noisy sources will also be housed in individual acoustic enclosure.

It is a standard practice during the design stage of such plant to specify individual noise limits for all significant equipment or overall noise level of the plant. These limits are considered practically achievable for the majority of noise sources, particularly those located externally.

B4.3 ASSESSMENT METHODOLOGY

Construction Noise

The assessment of noise impact form the associated construction works for the development of GT conversion unit was undertaken based on the procedure outline in the GW-TM. In general, the procedure to undertake a construction noise assessment is as follows:

- locate representative NSRs that may be affected by the works;

- determine plant teams for corresponding construction activities, based on available information or agreed plant inventories;
- assign sound power level (SWL) to the PME proposed based on the GW-TM or other sources;
- calculate the correction factors based on the distance between the NSRs and the notional noise source position of the work sites;
- apply corrections such as potential screening effect and acoustic reflection, if any, in the calculations; and
- predict construction noise level at NSRs.

The total SWL associated with each activity has been established based on the given plant inventory as list in *Table B4.3a*.

Table B4.3a ***Plant Inventory to be Employed in the Construction Phase***

	CNP	SWL	No.	Corrected SWL
Superstructure (structural concrete)				
Heavy Duty Crane	BS5228	110	1	100
Mobile Crane	CNP048	112	2	115
Generator	CNP101	108	2	111
Air-compressor	CNP001	110	2	113
Truck	CNP067	117	2	120
Concrete Lorry Mixer	CNP044	109	4	115
Vibratory Poker	CNP170	113	4	119
Concrete Pump	CNP047	109	2	112
Breaker (Hand-held)	CNP026	114	1	114
Inlet & Outlet Culvert				
Excavator	CNP081	112	1	112
Air-compressor	CNP001	100	2	103
Breaker (Hand-held)	CNP026	114	2	117
Crane Lorry	BS5228	116	1	116
Submersible Water Pump	CNP283	85	2	88
Dump Truck	CNP067	117	1	117
Concrete Lorry Mixer	CNP044	109	2	112
Vibratory Poker	CNP170	113	4	119
Transformer & Switchgear Bldg No. 1				
Mobile Crane	CNP048	112	1	112
Generator	CNP101	108	1	108
Air-compressor	CNP001	100	1	100
Concrete Lorry Mixer	CNP044	109	2	112
Truck	CNP067	117	1	117
Vibratory Poker	CNP170	113	4	119
Concrete Pump	CNP047	109	1	109
Breaker (Hand-held)	CNP026	114	1	114
E&M Construction Work				
Heavy Duty Crane	BS5228	110	1	110
Light Mobile Crane	BS5228	107	2	110
Generator	CNP101	108	1	108
Air-compressor	CNP001	100	2	103
Truck	CNP067	117	1	117

Operational Noise

The operational noise impact assessment has followed the procedure as stated in the IND-TM. The steps for assessing the operational noise impact are presented as below:

- locate representative NSRs that may be affected by plant;
- determine the ANL by considering if there is any influencing factor, e.g. major road or industrial estate, in the vicinity of NSRs;
- determine ASR and subsequent ANL;
- find out the SWL of noise sources;
- calculate the correction factors;
- apply corrections such as potential screening effect and acoustic reflection, if any, in the calculations according to standard acoustical principles and practices; and
- predict construction noise level at NSRs..

According to the previous records of performance test carried out for GT5 and GT7, the overall sound power level or SWL of each gas turbine unit was about 116 dB(A). Based on the design criteria incorporated in the technical specification, the SWL of the newly supplied equipment will be equal or less than 112 dB(A). Hence the overall SWL of the GT conversion unit will be 119.8 dB(A).

In view of the fact that the conversion unit will be located behind main station building and intervening hill (Kam Lo Hom), which can effectively screen the noise from the GT conversion unit and block the direct line of sight to the nearby NSRs, 10 dB(A) barrier attenuation was thus applied to the predicted noise levels.

B4.4 EVALUATION OF NOISE IMPACTS

Construction Phase

The predicted noise levels at the nearby NSRs are presented at *Table B4.4a*. Construction noise calculation is revealed in *Attachment A*. Ko Long (NSR 2) and School in Tai Wan San Tsuen (NSR 4) are most noise sensitive among the NSRs inasmuch as NSR 2 is located closest to the site while NSR 4, a school, is subject to a more stringent criterion.

Table B4.4a Predicted Construction Noise Levels at nearby NSRs (Daytime, 0700 to 1900 hours)

Construction Period (mm/yy)	NSR 1 Criterion 75 dB(A)	NSR 2 Criterion 75 dB(A)	NSR 3 Criterion 75 dB(A)	NSR 4 Criterion 65 dB(A)
09/2000-09/2000	46	49	44	45
10/2000-10/2000	48	52	47	48
11/2000-04/2001	50	53	48	49
05/2001-06/2001	48	52	47	48
07/2001-08/2001	49	52	47	48
09/2001-12/2001	47	50	45	46
01/2002-06/2002	40	43	38	39

The results indicate that a maximum of 53 dB(A) was predicted at NSR 2 during 11/2000 to 04/2000. Noise impact from construction activities has been identified during this period. The screening effect from the existing power station and terrain, air absorption and distance attenuation have drastically reduced the noise level at NSR 2 to 22 dB(A) below the 75 dB(A) daytime construction noise criterion during that period.

A maximum of 49 dB(A) was predicted at NSR 4 during the period of 11/2000 to 04/2001. Owing to the more stringent criterion applicable to the educational institute, 65 dB(A) was considered as criterion for NSR 4 during examination period which reflected the worst case scenario. The maximum predicted noise level at NSR 4 was 16 dB(A) below the 65 dB(A) criterion.

All predicted noise levels are within the relevant criteria during construction phase. No adverse and residual noise impact during the 22 months of construction phase is envisaged at the residences and school.

Operational Phase

Noise impact from the conversion unit in operational phase has been undertaken and presented in *Table B4.4b*. Calculation details are shown in *Attachment B*. Whereas the measured background noise level was 51.7 dB(A) under free field condition, the background noise level with 3 dB(A) facade correction should be 55 dB(A) approximatelywhich is equivalent to the ANL stipulated in EIAO-TM.

Table B4.4b Predicated Noise Levels from GT Conversion Unit in Operational Phase

NSR No.	Location	Noise Level, dB(A)
NSR 1	Long Tsai Tsuen / Hung Sing Ye	41
NSR 2	Ko Long	44
NSR 3	North Slope above Yung Shue Wan Harbour	39
NSR 4	School in Tai Wan San Tsuen	40

Although noise levels from the conversion unit itself are well below the 55 dB(A) criterion, cumulative noise impact from the GT conversion unit and existing power station has been calculated in accordance with the above results. As given in the Lamma Extension EIA report, the maximum potential noise impact for the existing plant can conservatively be estimated by the monitored data. Predicted cumulative noise levels in operational phase have been shown in *Table B4.4c*.

Table B4.4c Cumulative Noise Levels in Operational Phase

NSR No.	Location	Existing plant, dB(A)	Conversion unit, dB(A)	Overall Noise Level, dB(A)
NSR 1	Long Tsai Tsuen / Hung Sing Ye	55	41	55
NSR 2	Ko Long	55	44	55
NSR 3	North Slope above Yung Shue Wan Harbour	55	39	55
NSR 4	School in Tai Wan San Tsuen	55	40	55

The overall results show that existing noise environment at the NSRs will not be worsened by the GT conversion unit. Predicted noise level at NSR 2 due to the GT conversion unit was about 11 dB(A) below the background level and 16 dB(A) less than the 60 dB(A) daytime criterion. In addition, the conversion unit is designed, under normal conditions, for peak lopping at daytime in summer months only, noise contribution from the conversion unit to the prevailing background level is, therefore, limited to the daytime during summer only.

As aforementioned, predicted cumulative noise level for Lamma Power Station is 55 dB(A) at NSR which is 5 dB(A) less than 60 dB(A) day time criterion. Noise exceedance at NSRs in operational phase inasmuch as the operation of power plant is hence not envisaged. The overall change in term of noise level at the NSRs would be insignificant when the conversion unit is in operation.

B4.5 Environmental Monitoring and Audit

There is no construction and operational noise exceedance anticipated. The noise generated from the construction and operational activities will be closely monitored by the well-established noise monitoring network at Lamma Power Station. The current noise monitoring and alarming system consists of 5 permanent monitoring stations located at the boundary of Lamma Power Station and will provide early indication of any possible exceedance of statutory noise limits at the nearby noise sensitive receivers.

B5 CONCLUSION

In view of a combination of the large setback distance between the site and surrounding community, the presence of building structure inside the power station and terrain shielding to the north and east of the site, adverse construction and operational noise impacts at the NSRs are unlikely.

The existing noise monitoring reports submitted to EPD under the EM&A Programme for Lamma Power Station Unit 7/8 Operation will well cover the monitoring of the construction and operational noise incurred from the GT conversion project. No additional noise monitoring is recommended.

Attachment A - Conversion Unit Construction Noise Data Sheet

1. Superstructure

	Duration	No. of Plant	Plant ref.	SWL	Corrected SWL			
Heavy Duty Crane	12	1	BS5228	110	110	1E+11	10/2000	12/2001
Mobile Crane	12	2	CNP048	112	115	3.1698E+11	10/2000	12/2001
Generator	12	2	CNP101	108	111	1.2619E+11	10/2000	12/2001
Air-compressor	12	2	CNP001	100	103	2E+10	10/2000	12/2001
Truck	12	2	CNP067	117	120	1.0024E+12	10/2000	12/2001
Concrete Lorry Mixer	12	4	CNP044	109	115	3.1773E+11	10/2000	12/2001
Vibratory Poker	12	4	CNP170	113	119	7.981E+11	10/2000	12/2001
Concrete Pump	12	2	CNP047	109	112	1.5887E+11	10/2000	12/2001
Breaker (Hand-held)	12	1	CNP026	114	114	2.5119E+11	10/2000	12/2001
Total SWL				Gen Work	124.9			

2. Inlet & Outlet Culvert

Excavator	12	1	CNP081	112	112	1.5849E+11	10/2000	08/2001
Air-compressor	12	2	CNP001	100	103	2E+10	10/2000	08/2001
Breaker (Hand-held)	12	2	CNP026	114	117	5.0238E+11	10/2000	08/2001
Crane Lorry	12	1	BS5228	116	116	3.9811E+11	10/2000	08/2001
Submersible Water Pump	12	2	CNP283	85	88	632455532	10/2000	08/2001
Dump Truck	12	1	CNP067	117	117	5.0119E+11	10/2000	08/2001
Concrete Lorry Mixer	12	2	CNP044	109	112	1.5887E+11	10/2000	08/2001
Vibratory Poker	12	4	CNP170	113	119	7.981E+11	10/2000	08/2001
Total SWL				Gen Work	124.0			

3. Tx & Switchgear Building No. 1

Superstructure								
Mobile Crane	12	1	CNP048	112	112	1.5849E+11	11/2000	04/2001
Generator	12	1	CNP101	108	108	6.3096E+10	11/2000	04/2001
Air-compressor	12	1	CNP001	100	100	1E+10	11/2000	04/2001
Concrete Lorry Mixer	12	2	CNP044	109	112	1.5887E+11	11/2000	04/2001
Truck	12	1	CNP067	117	117	5.0119E+11	11/2000	04/2001
Vibratory Poker	12	4	CNP170	113	119	7.981E+11	11/2000	04/2001
Concrete Pump	12	1	CNP047	109	109	7.9433E+10	11/2000	04/2001
Breaker (Hand-held)	8	1	CNP026	114	114	2.5119E+11	11/2000	04/2001
Sub-total SWL				Gen Work	123.1			

4. E&M Construction Work

Heavy Duty Crane	12	1	BS5228	110	110	1E+11	01/2001	06/2002
Light Mobile Crane	12	2	BS5228	107	110	1.0024E+11	01/2001	06/2002
Generator	12	1	CNP101	108	108	6.3096E+10	01/2001	06/2002
Air-compressor	12	2	CNP001	100	103	2E+10	01/2001	06/2002
Truck	12	1	CNP067	117	117	5.0119E+11	01/2001	06/2002
Sub-total SWL				Gen Work	118.9			

Max Construction Noise Level at NSR (0700-1900)

	General Const Work	NSR1	NSR2	NSSR3	NSR4
Max SWL		124.9	124.9	124.9	124.9
Distance	m	1150	850	1300	1200
Attenuation	dBA	-69.20	-66.57	-70.26	-69.57
Atm Absorption	dB/km	2.7	2.7	2.7	2.7
Attenuation	dBA	-3.11	-2.30	-3.51	-3.24
Screening Effect [1]	dBA	-10	-10	-10	-10
Facade Effect	dBA	3	3	3	3
Total Corrections	dBA	-79.3	-75.9	-80.8	-79.8
SPL	**dBA**	**45.6**	**49.0**	**44.1**	**45.1**
EIAO TM	dBA	75	75	75	65

[1] Screening effect is due to the substantial structure of the main power station building, thus -10 dB(A) was applied

Period	NSR1	NSR2	NSR3	NSR4
	SWL			
09/2000-09/2000	124.9	124.9	124.9	124.9
10/2000-10/2000	127.5	127.5	127.5	127.5
11/2000-12/2000	128.8	128.8	128.8	128.8
01/2001-04/2001	129.3	129.3	129.3	129.3
05/2001-08/2001	128.1	128.1	128.1	128.1
09/2001-12/2001	125.9	125.9	125.9	125.9
01/2002-06/2002	118.9	118.9	118.9	118.9
	CNL			
09/2000-09/2000	45.6	49.0	44.1	45.1
10/2000-10/2000	48.2	51.6	46.7	47.7
11/2000-12/2000	49.5	53.0	48.1	49.0
01/2001-04/2001	50.0	53.4	48.5	49.5
05/2001-08/2001	48.8	52.2	47.3	48.3
09/2001-12/2001	46.6	50.0	45.1	46.1
01/2002-06/2002	39.6	43.1	38.2	39.1

Attachment B - Conversion Unit Operational Noise Data Sheet

SWL Level at the Source

Existing GT Unit	dBA	119	7.9433E+11
New Equipment luding HRSGs, ST, etc)	dBA	112	1.5849E+11
Total SWL	dBA	119.8	

Max Operational Noise Level at NSR - Conversion Unit Only

		0700-2300hr NSR1	NSR2	NSR3	NSR4
Max SWL		119.8	119.8	119.8	119.8
Min Distance	m	1150	850	1300	1200
Attenuation	dBA	-69.20	-66.57	-70.26	-69.57
Atm Absorption	dB/km	2.7	2.7	2.7	2.7
Attenuation	dBA	-3.11	-2.30	-3.51	-3.24
Barrier Effect	dBA	-10	-10	-10	-10
Facade Effect	dBA	3	3	3	3
Total Corrections	dBA	-79.3	-75.9	-80.8	-79.8
SPL	**dBA**	**40.5**	**43.9**	**39.0**	**40.0**

Max Operational Noise Level at NSR - Overall Noise Level (SPL)

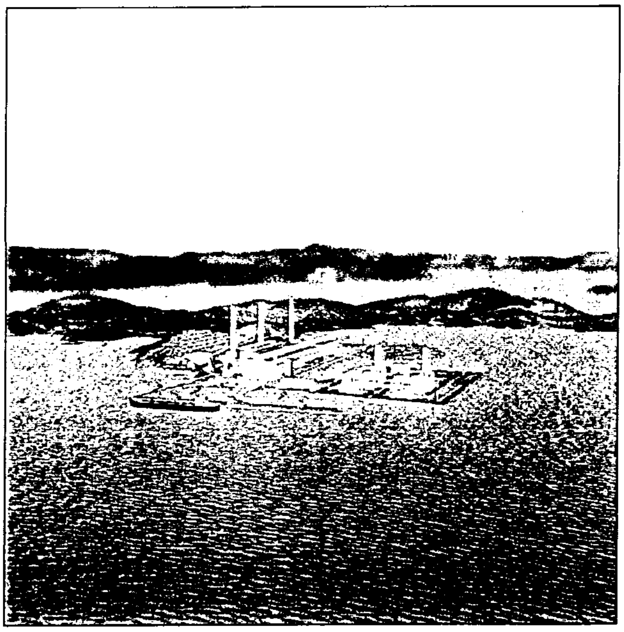
		NSR1	NSR2	NSR3	NSR4
Conversion Unit	dBA	40.5	43.9	39.0	40.0
Existing Lamma P/S	dBA	54.7	54.7	54.7	54.7
SPL	**dBA**	**54.9**	**55.0**	**54.8**	**54.8**

Annex C

Assessment of Water Quality, Marine Ecology and Fisheries Impacts

FINAL REPORT

The Hongkong Electric Co Ltd



Lamma Power Station - Conversion of Gas Turbine Nos. 5 & 7 to Combined Cycle Plant: *Assessment of Water Quality, Marine Ecology and Fisheries Impacts*

13 December 1999

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Kowloon, Hong Kong
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FINAL REPORT

The Hongkong Electric Co Ltd

Lamma Power Station - Conversion of Gas Turbine Nos.5 & 7 to Combined Cycle Plant: *Assessment of Water Quality, Marine Ecology and Fisheries Impacts*

13 December 1999

Reference C1992

For and on behalf of
Environmental Resources Management

Approved by: Shelley Clarke

Signed: Shelley Clarke

Position: Technical Director

Date: 13 December 1999

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ANNEX A — *THERMAL DISCHARGE MODELLING RESULTS FOR SCENARIO 1 - EXISTING LAMMA POWER STATION*

ANNEX B — *THERMAL DISCHARGE MODELLING RESULTS FOR SCENARIO 2 - LAMMA POWER STATION AFTER CONVERSION OF THE TWO GAS FIRED UNITS TO COMBINED CYCLE OPERATION*

1 BACKGROUND

1.1 INTRODUCTION

At the existing Hongkong Electric Company Ltd (HEC) Lamma Power Station there are eight coal fired units, three 250MW units and five 350MW units, and six 125MW oil fired gas turbines. HEC propose to convert two of the oil fired gas turbines to combined cycle operation by the year 2003. This will be prior to the construction of the Lamma Extension, which is scheduled for completion in 2004, although the reclamation for the Lamma Extension will have been completed by 2003. The Lamma Extension will be an 1,800MW facility, consisting of six 300MW gas fired turbines and will be operated as a combined cycle plant with the existing power station. An Environmental Impact Assessment (EIA) of the Lamma Extension was completed in February 1999, and reference to that earlier EIA has been made in this Study.

In October 1999 HEC commissioned ERM to carry out an assessment of the impacts on water quality, marine ecology and fisheries of the cooling water discharges from the proposed conversion of the two oil fired gas turbines at the existing Lamma Power Station to combined cycle operation. The conversion of the gas fired units to combined cycle operation will result in changes to the heat rejection rates (flow rate and temperature of the cooling water discharge), compared with the existing power station, which will change the thermal plumes in the receiving waters. In addition, there will be small changes in the discharge of residual chlorine resulting from the changes to the flow rates of the cooling water. The conversion will have no other impacts on water quality, as it will not involve additional construction work or changes in other discharges from the power station. The assessment was primarily carried out using a thermal discharge model set up by Delft Hydraulics as part of the EIA of the Lamma Extension[1]. An assessment of the acceptability of the thermal discharges has been made based on the results from the modelling. A qualitative assessment of changes to the discharge of residual chlorine has been made based on data on the existing and future discharge rates.

1.2 OBJECTIVES OF THE STUDY

The objective of the Study is to predict the nature and extent of environmental impacts due to the discharge of cooling water following the conversion of the two oil fired gas turbines at the existing Lamma Power Station to combined cycle operation. Mitigation measures in the form of design modifications and operational controls are recommended where necessary.

(1) ERM (1999). Environmental Impact Assessment of a 1,800MW Gas-Fired Power Station at Lamma Extension. Final Report to the Hongkong Electric Co Ltd, February 1999.

1.3 *STRUCTURE OF THE REPORT*

This report is structured as follows:

- *Section 2 - Assessment of Water Quality Impacts* assesses the impacts on water quality of the proposed conversion of the two gas fired units to combined cycle operation;
- *Section 3 - Assessment of Marine Ecology Impacts* assesses the impacts on marine ecology of the proposed conversion of the two gas fired units to combined cycle operation;
- *Section 4 - Assessment of Fisheries Impacts* assesses the impacts on fisheries of the proposed conversion of the two gas fired units to combined cycle operation; and,
- *Section 5 - Summary and Conclusions* presents a summary of the assessment and the main conclusions of the Study.

2 ASSESSMENT OF WATER QUALITY IMPACTS

2.1 ASSESSMENT METHODOLOGY

A thermal discharge model has been used to simulate the discharge of cooling water from the proposed conversion of two oil fired gas turbines at the existing Lamma Power Station to combined cycle operation. This is the same model as was used in the earlier EIA of the proposed Lamma Extension[2]. The model has been used to simulate two scenarios for the discharge of cooling water as follows:

- Scenario 1 - the thermal discharge from the existing Lamma Power Station in 2003, which represents the discharges without the conversion of the oil fired gas turbines to combined cycle; and

- Scenario 2 - the thermal discharge from the Lamma Power Station assuming the conversion of two oil fired gas turbines to combined cycle operation occurs.

The thermal discharge rates used for Scenarios 1 and 2 are shown in *Tables 2.1a* and *2.1b*, respectively. Data in *Tables 2.1a* and *2.1b* were provided by HEC, based on their estimation of the likely operation of the existing power station in 2003 and the operation of the power station with the conversion. In the tables it can be seen that the discharge rates fluctuate throughout the day as a function of power demand. The temperature of the thermal discharge was calculated from the data on heat rejection rate and discharge rate. The data in *Tables 2.1a* and *2.1b* show that the average discharge rate for Scenario 2 is higher than that for Scenario 1, while the average temperature rise at the point of discharge is similar.

(2) ERM (1999). *Op cit.*

Table 2.1a ***Heat Rejection and Discharge Rates for Scenario 1 (Source: HEC)***

Hour	Heat Rejection Rate (Gcal h^{-1})	Discharge Rate (m^3 $hour^{-1}$)	Temperature Rise at Point of Discharge (°C)
0	1,792.6	278,000	6.4
1	1,576.4	278,000	5.7
2	1,480.8	278,000	5.3
3	1,429.1	278,000	5.1
4	1,392.5	278,000	5.0
5	1,380.8	278,000	5.0
6	1,405.4	278,000	5.0
7	1,632.9	278,000	5.9
8	2,130.8	315,400	6.7
9	2,486.9	352,800	7.0
10	2,590.7	352,800	7.3
11	2,590.7	352,800	7.3
12	2,590.7	352,800	7.3
13	2,590.7	352,800	7.3
14	2,590.7	352,800	7.3
15	2,590.7	352,800	7.3
16	2,590.7	352,800	7.3
17	2,590.7	352,800	7.3
18	2,584.5	352,800	7.3
19	2,541.9	352,800	7.2
20	2,457.5	352,800	6.9
21	2,413.0	352,800	6.8
22	2,279.5	352,800	6.4
23	2,053.3	315,400	6.5
Average	2,156.8	324,750	6.5

Table 2.1b *Heat Rejection and Discharge Rates for Scenario 2 (Source: HEC)*

Hour	Heat Rejection Rate (Gcal h^{-1})	Discharge Rate (m^3 $hour^{-1}$)	Temperature Rise at Point of Discharge (°C)
0	1,792.6	278,000	6.4
1	1,576.4	278,000	5.7
2	1,480.8	278,000	5.3
3	1,429.1	278,000	5.1
4	1,392.5	278,000	5.0
5	1,380.8	278,000	5.0
6	1,405.4	278,000	5.0
7	1,632.9	278,000	5.9
8	2,130.8	315,400	6.7
9	2,511.8	371,800	6.7
10	2,711.6	371,800	7.3
11	2,720.1	371,800	7.3
12	2,724.0	371,800	7.3
13	2,727.4	371,800	7.3
14	2,729.6	371,800	7.3
15	2,738.1	371,800	7.3
16	2,722.3	371,800	7.3
17	2,716.1	371,800	7.3
18	2,705.4	371,800	7.3
19	2,634.9	371,800	7.1
20	2,482.6	371,800	6.7
21	2,413.0	352,800	6.8
22	2,279.5	352,800	6.4
23	2,053.3	315,400	6.5
Average	2,212.1	334,250	6.5

In the modelling it was assumed that the thermal discharge from the power station following the conversion of the gas fired units to combined cycle operation would be through the existing outfalls, the locations of which are shown in *Figure 2.1a*. This figure also shows the thermal discharge model grid and the representations of the land forms which are planned to be present in 2003. As part of the studies for the EIA of the Lamma Extension, the initial buoyant rise of the thermal discharges from the existing power station was investigated. It was predicted that the heated water around the discharge point would remain in the upper 30% of the water column, which was represented by the upper three model layers. For this Study the same approach was used and the thermal discharges were input into the upper three model layers.

Both scenarios have been simulated for wet season conditions, which were found to represent the worst case in terms of thermal impacts for the EIA of the Lamma Extension. The thermal discharge model was run for a representative 15 day spring-neap tidal cycle. A background temperature of 28°C was used, which is representative of wet season conditions.

In 2003 the reclamation for the Lamma Extension will have been constructed but the new power station will not be operational. The layout of the reclamation for the new power station, as represented in the hydrodynamic model, is shown in *Figure 2.1a*. This scenario had been modelled in the Lamma Extension EIA and thus flow data from the Delft 3D hydrodynamic model was available and applied to these additional thermal simulations.

The Lamma Power Station uses sodium hypochlorite dosing, produced through the electrolysis of sea water, as an anti-fouling agent. Sodium hypochlorite dosing produces residual chlorine which limits marine growth within the cooling water system. In the previous EIA for the Lamma Power Station Extension the discharge of residual chlorine from the existing power station was simulated using a computer model of the dispersion and decay of the residual chlorine[3]. For this study reference will be made to the previous modelling results. The flow rate of the cooling water discharge following the conversion will be compared with that which was simulated for the existing power station in the previous EIA and changes in the behaviour of the residual chlorine plume identified and assessed.

2.2 IDENTIFICATION OF IMPACTS

Impacts from thermal discharges are caused by increases in temperature in the receiving waters above the ambient values. The Water Quality Objectives (WQOs) for the Southern Water Control Zone, within which the Lamma Power Station is situated, state that the variation in temperature from human activity should not exceed 2°C. However, it is likely that this level will be exceeded within a certain distance of the Lamma Power Station outfall. The assessment of the impacts caused by the discharge from the Lamma Power Station involved determining the size of the area within which the 2°C limit is exceeded and the location of this zone of exceedence. This area of exceedence is termed a 'mixing zone' if it does not include any sensitive receivers and is limited in size. Sensitive receivers have been defined in the vicinity of the Lamma Power Station and are shown on *Figure 2.2a*. These are the same sensitive receivers as those used in the EIA for the Lamma Extension.

For the two scenarios it was found that the buoyancy of the thermal plumes coupled with the near surface discharge meant that there was no temperature elevation in the lower part of the water column. The results from the thermal plume model have been assessed for the top 40% of the water column, which corresponds to the upper four layers in the model. Although the surface discharge is initially input to the top three layers, some vertical mixing will occur despite the buoyancy of the thermal plume and the surface discharge, and so four layers of the model were assessed to account for this mixing.

Residual chlorine in the marine environment is harmful to marine organisms if concentration levels exceed a certain value. In the previous EIA it was

(3) ERM (1999). *Op cit.*

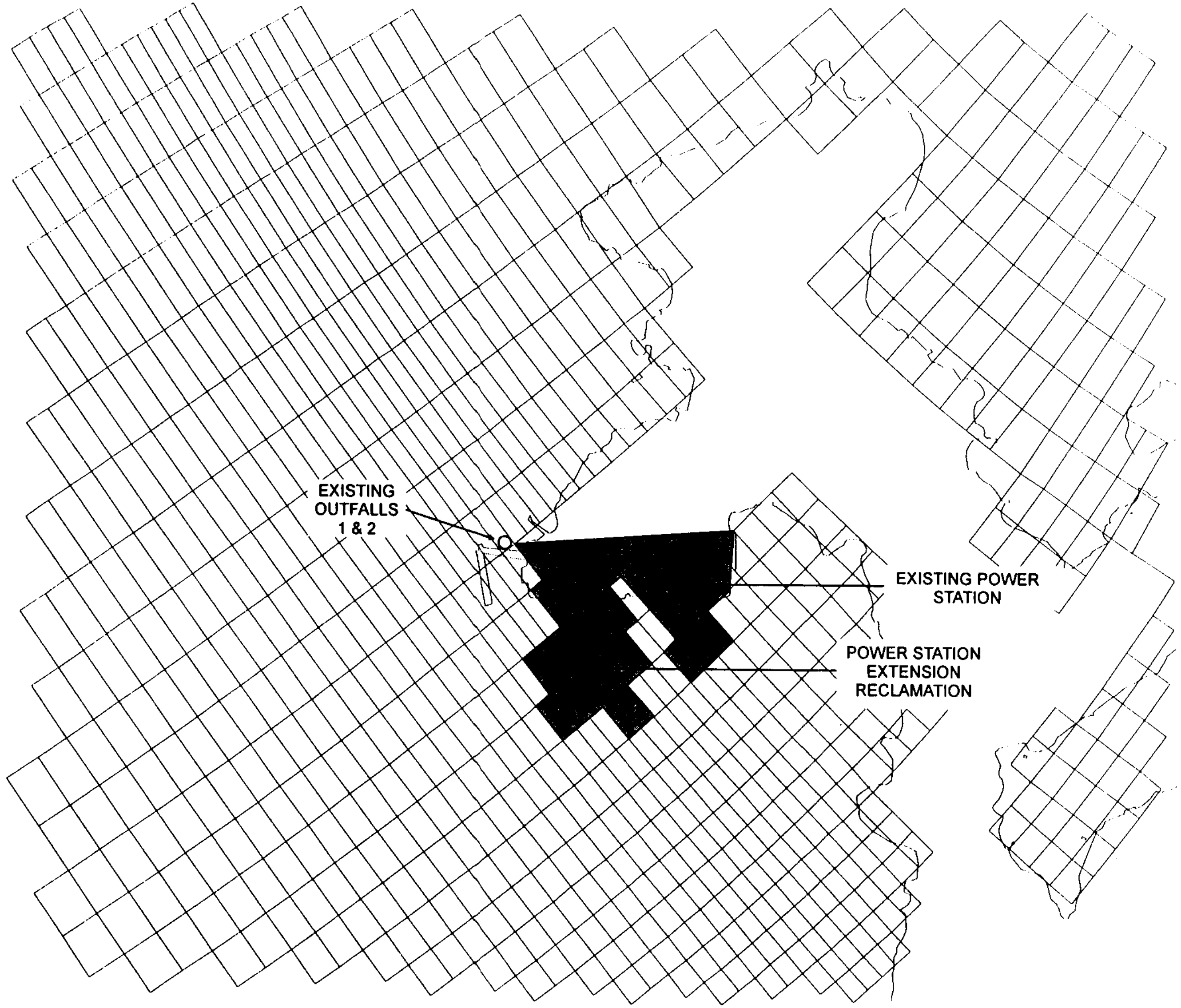

FIGURE 2.1a

LOCATION OF EXISTING OUTFALL AND THE RECLAMATION LAYOUT IN 2003

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DATE: 11/05/99

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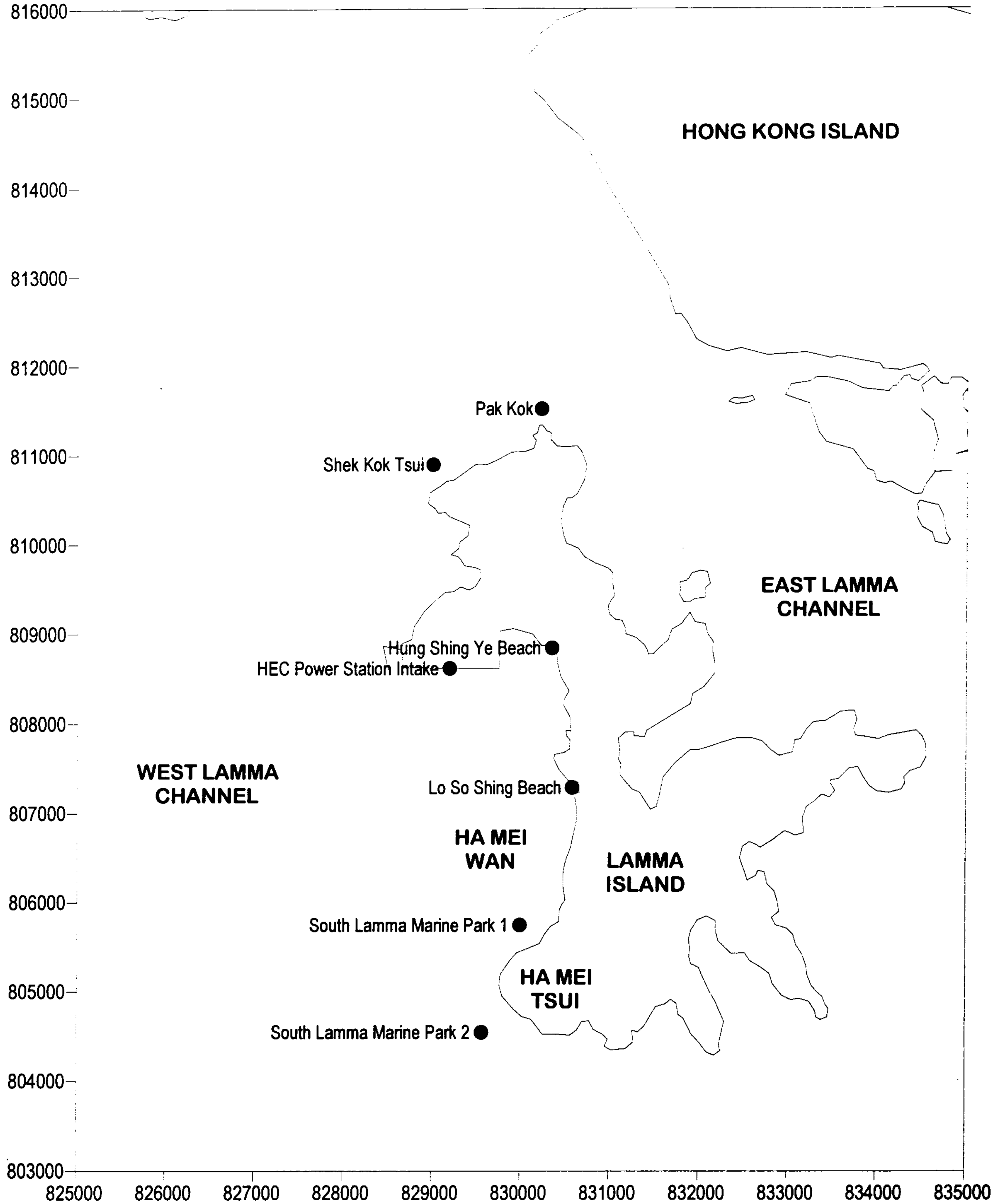

Figure 2.2a

LOCATIONS OF SENSITIVE RECEIVERS

FILE : lamsen3a.srf
DATE : 10/05/99

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determined that effects begin to occur at concentrations above 0.02 mg l^{-1}, while concern has been expressed at concentrations as low as 0.01 mg l^{-1}. As there are no WQOs for residual chlorine the lower level of 0.01 mg l^{-1} was chosen as the assessment criterion. Based on the previous modelling results it will be possible to determine the area around the discharge point which will be affected by concentrations in excess of this criterion.

2.3 *PREDICTION AND EVALUATION OF IMPACTS*

Two thermal discharge modelling scenarios were carried out representing the operation of the existing Lamma Power Station in 2003 (Scenario 1) and the operation of the power station in 2003 with the conversion of the two gas fired units to combined cycle operation (Scenario 2). Both scenarios have been simulated for 15 day spring-neap tidal cycles in the wet season. The results from the thermal plume modelling have been analysed to determine the plan areas of contours of temperature elevation. The results have also been presented graphically as contours of maximum temperature in the top four layers of the model and as graphs of temperature at sensitive receivers. The contour plots and graphs for Scenario 1 are contained in *Annex A* and those for Scenario 2 are contained in *Annex B*. The results have been presented as total temperature, which is ambient plus the temperature elevation from the thermal discharge plumes. The temperature elevation above ambient may be calculated by subtracting 28°C from the model results.

The results of the analysis of the plan areas of temperature elevation zones are shown in *Table 2.3a*.

Table 2.3a ***Plan Area Sizes of Temperature Elevation Zones (km^2)***

Scenario	Tide	Temperature Elevation			
		1°C	2°C	3°C	4°C
1	Neap	16.2	6.0	2.3	1.2
	Spring	28.8	8.9	3.8	1.5
2	Neap	17.2	6.2	2.5	1.2
	Spring	29.5	9.0	3.9	1.5

The above table shows that the temperature elevation zones for temperatures of 1-4°C above ambient are larger for the spring tides than for the neap tides, reflecting the higher tidal currents on the spring tides. Temperature elevation zones for temperatures greater than 4°C are not shown on the table but would be expected to be larger for the neap tide than for the spring tide. A larger area of higher temperature waters is expected in the immediate vicinity of the discharge point on the neap tide due to reduced dispersion resulting from the lower neap tide current speeds.

A comparison of the sizes of the temperature elevation zones for Scenarios 1 and 2 shows that the two scenarios are generally similar with Scenario 2 showing a small increase in size compared to Scenario 1. For the 2°C contour the largest increase from Scenario 1 to Scenario 2 is on the neap tide and the increase is shown to be 0.2 km^2 or 3% which is considered negligible.

The contours of maximum temperature are presented in *Figures A1* and *A2* for Scenario 1 and in *Figures B1* and *B2* for Scenario 2, which show the neap and spring tides respectively. The contours show that the dominant direction of dispersion is to the south of the power station. This is caused by the net drift in the ebb direction in the wet season, which is a result of the outward flows from the Pearl Estuary in the upper portion of the water column. The contours for Scenarios 1 and 2 are very similar and the greatest extent of the 2°C temperature elevation contour (as shown by the 30°C contour on the figures, which is light green) for both scenarios is predicted for the spring tide. The contour for both scenarios is shown to extend to the south western headland of Lamma Island for both Scenarios 1 and 2 for layer 3 in the model, which represents the top 20-30% of the water column.

The graphs of temperature at the sensitive receivers are shown in *Figures A3* to *A9* for Scenario 1 and in *Figures B3* to *B9* for Scenario 2. The only station which shows temperatures of over 2°C above ambient (30°C on the graphs) is South Lamma Marine Park 1. At this station the temperature is predicted to exceed this threshold value once during the 15 day spring-neap tidal cycle, during the spring period and is only shown to occur in the third model layer. The period of the exceedence is very short (less than 0.5 hour) and represents only 0.14% of the total time of the simulation. The exceedence is predicted for both Scenarios 1 and 2.

The results from the thermal plume modelling have predicted that the conversion of the two oil fired gas turbines at the existing power station (Scenario 2) will have minimal effect on the plan areas of temperature elevation zones compared to the existing operational strategy of the power station (Scenario 1), ie there is predicted to be a 3% increase in the size of the 2°C zone. The modelling predicted that the area which exceeds the 2°C temperature elevation limit touches the coast for a very small part of the northern shore of the Ha Mei Tsui headland. Graphs of temperature elevation show that this exceedence of the 2°C temperature elevation limit in this area will occur for less than 30 minutes over the simulated 15 day spring-neap tidal cycle, which accounts for less than 1% (ie 0.14%) of the time. As this change in the thermal environment is negligible and is shown for both Scenarios 1 and 2 (ie would occur with or without conversion), it is considered acceptable. Further discussion of the ecological impacts of this exceedence will be made in *Section* 3.

It should be noted that once the Lamma Extension Power Station becomes operational the cumulative impacts of the thermal discharges from the existing power station and Lamma Extension will reduce significantly due to the more efficient combined cycle operating strategy of the Lamma Extension and the existing power station. It was predicted in the EIA for the Lamma Extension that following the commissioning of the Lamma Extension power station the 2°C temperature increase contour will not impact any of the identified sensitive receivers. This means that not only will the predicted exceedences of the allowable temperature elevation be transitory during the operation of the existing power station following conversion of the gas units but that they will only occur until the Lamma Extension commences operation. This is expected to occur in 2004, which is one year after the proposed conversion of the oil fired gas turbines to combined cycle operation takes place.

The previous EIA for the Lamma Extension assumed an average flow rate for the existing power station of 323,280 m^3 $hour^{-1}$ and a discharge concentration of 0.3 mg l^{-1} for the residual chlorine[(4)]. Following the conversion of the gas turbines to

(4) ERM(1999). *Op cit.*

combined cycle operation the average flow rate, as defined in *Table 2.1b*, will be 334,250 m^3 $hour^{-1}$, which represents an increase of 3.4%. For the assessment here it is assumed that the power station will continue to discharge residual chlorine at a concentration of 0.3 mg l^{-1}. The previous EIA predicted that the discharge of residual chlorine from the existing power station would result in an area where the criterion of 0.01 mg l^{-1} was exceeded extending approximately 600 m offshore of the outfall and around the cost to the north of the power station. Such a discharge was deemed environmentally acceptable as this area was small and did not contain any sensitive receivers. An increase of 3% in the size of this area, which is very small, would not change this conclusion as the area of exceedence would still not contain any sensitive receivers. It should be noted that HEC, as part of the recommendations in the EIA for the Lamma Extension, is currently undertaking research into lowering the residual chlorine concentrations in the discharge and investigating whether suitable, less toxic, biocides could be used.

Based on the above assessment the conversion of the two oil fired gas turbines to combined cycle operation at the existing Lamma power station is deemed to be environmentally acceptable in terms of water quality impacts based on the following:

- The size of the thermal plumes from the combined cycle operation are very similar to thermal plumes which would be generated if the existing operating strategy were to be maintained in 2003;
- Although a small area of coast on the northern shore of the Ha Mei Tsui headland is predicted to be impacted by thermal plumes exceeding the WQO, the predicted exceedences are of very short duration and will occur only until the Lamma Extension becomes operational; and
- The cooling water flows are only expected to increase by 3% compared to the existing power stations which would only result in a very small increase in the size of the area exceeding the residual chlorine criterion, and this area of exceedence is currently considered to be environmentally acceptable as it is small and does not contain any sensitive receivers.

2.4 *MITIGATION OF ENVIRONMENTAL IMPACTS*

The impacts to water quality from the conversion of two oil fired gas units at the existing Lamma Power Station to combined cycle operation are considered to be acceptable. This means that no mitigation measures will be necessary.

3.1 INTRODUCTION

This section of the report presents the findings of the marine ecological impact assessment. Baseline information on the potentially affected existing marine ecological resources which is taken from recent studies and relevant literature, is presented and evaluated for the assessment.

3.2 BASELINE CONDITIONS

The most comprehensive information on the marine ecological conditions of the waters to the west of Lamma Island is available through the recent Environmental Impact Assessment (EIA) on the Lamma Extension[5]. The findings and characterisations described in this recent EIA will be used as the basis for this current assessment. As part of the recent EIA, the following surveys were conducted (*Figure 3.2a*):

- *Intertidal* - Intertidal survey of the west coast of Lamma (sites T1 - T6)
- *Subtidal*
  - Hard bottom - Remotely Operated Vehicle (ROV) survey of the proposed reclamation site.
    - ROV surveys of the west coast of Lamma (T1 - T6)
    - Dive surveys of the west coast of Lamma (T1 - T6)
  - Soft bottom - Benthic survey of the proposed reclamation site (RB)

The following sections present summarized characterisations of the marine ecology of west Lamma Island, based on the results of these surveys presented in the EIA for Lamma Extension and a review of the available literature.

Intertidal - Hard Surface Assemblages

The results of the recent intertidal rocky shore surveys conducted as part of the EIA for the Lamma Extension reported that a total 29 species of fauna and 8 species of macroalgae were recorded at the 6 sites on the west coast of the island. Except for Yung Shue Wan (site T1 on *Figure 3.2a*) and Ha Mei Tsui south (T6), where faunal species numbers were below 18, the number of faunal species at the surveyed sites was $\geq$ 19 and was highest at Lo So Shing (T4) where a total of 27 species was obtained. The number of macroalgal species generally ranged from 4 to 6, with the highest species number being recorded at Lo So Shing (T4).

Fauna that were reported on the shores at the surveyed sites were primarily molluscs and crustaceans. The most abundant were herbivorous molluscs, including on the low and mid shore, the chiton (*Acanthopleura japonica*) and the limpets (*Cellana grata, C. toreuma, Patelloida pygmaea, P. saccharina, Siphonaria atra*

(5) ERM (1999) Environmental Impact Assessment for an 1800MW Gas Fired Power Station at Lamma Extension. Final Report. For The Hongkong Electric Co., Ltd.

and *S. sirius*), the snails (*Monodonta labio* and *Planaxis sulcatus*) and the nerites (*Nerita albicilla, N. chamaeleon, N. costata* and *N. lineata*), and on the high shore, the periwinkles (*Nodilittorina radiata, N. trochoides* and *N. vidua*). Predatory gastropods, the common dogwhelks (*Thais clavigera* and *Morula musiva*), were also recorded as being in the mid and low shore region.

In terms of abundances and diversities of organisms reported as being present on the shores, sites at Lo So Shing (T4) and Ha Mei Tsui north (T5) were found to be the more diverse (in terms of number of species), whereas, sites at Yung Shue Wan (T1), Hung Shing Yeh (T2) and Tit Sha Long (T3)supported the highest densities of organisms, which was due to the high number of limpets. Macroalgae were, in general, sparsely distributed which was generally accounted for due to the surveys being undertaken in the summer months. Of the algae present, encrusting algae (*Neogoniolithon misakiense, Corallina* sp and *Hildenbrandia occidentalis*) and the filamentous green algae (*Cladophora divergens*) were of highest percentage cover.

Overall, the intertidal assemblages of the west coast of Lamma Island were classified as being of medium ecological value. This assessment was based on the fact that the habitat is undisturbed by human impact due to much of the terrain being too steep for human access. Although no species that are considered as rare were reported, the undisturbed nature of the assemblages warrants the classification of medium ecological value.

Intertidal - Soft Shore Assemblages

The west coast of Lamma Island contains two gazetted beaches at Lo So Shing and Hung Shing Yeh. There are also sandy shores located at Tai Wan San Tsuen (adjacent to the existing Hongkong Electric Co Ltd Lamma power station), to the north of Lo So Shing and on the south of the island at Sham Wan. In general, beaches that have been developed for recreational use, such as the gazetted swimming beaches at Hung Shing Yeh and Lo So Shing appear to have low abundances of organisms[(6)]. In contrast, sandy beaches exposed to waves from the surf often support communities with unique assemblages of surf clams, mole crabs and hermit crabs[(7)]. However, the only sandy wave exposed beach on Lamma Island can be found at Sham Wan.

Subtidal - Hard Surface Assemblages

The results of the subtidal ROV and dive surveys at the five sites (T1 to T6 in *Figure 3.2a*) carried out as part of the EIA for Lamma Extension reported that, with the exception of the southern- most site T6, the sites are of low ecological value in comparison with other areas in Hong Kong. Although many of the sites stretching the entire west coast of Lamma do support species of some ecological and conservation value (ie gorgonian sea whips, soft corals and hard corals), these organisms were reported to occur as isolated colonies. The EIA for the Lamma Extension compared the coral cover recorded at each survey site (*Figure 3.2a*) with two sites in Hong Kong, Pak Kok on the northern tip of Lamma, and Ping Chau in the eastern waters of Hong Kong. These sites were selected as their coral communities have previously been assigned ecological value based on a

(6) Morton B, Williams GA & Lee SY (1996) The benthic marine ecology of Hong Kong: A dwindling heritage. Pages 233-267, In: Coastal Infrastructure Development in Hong Kong: A Review. Civil Engineering Department.

(7) Wong ECK (1990) The fauna of exposed sand beaches in Hong Kong. Asian Marine Biology 7: 147-159.

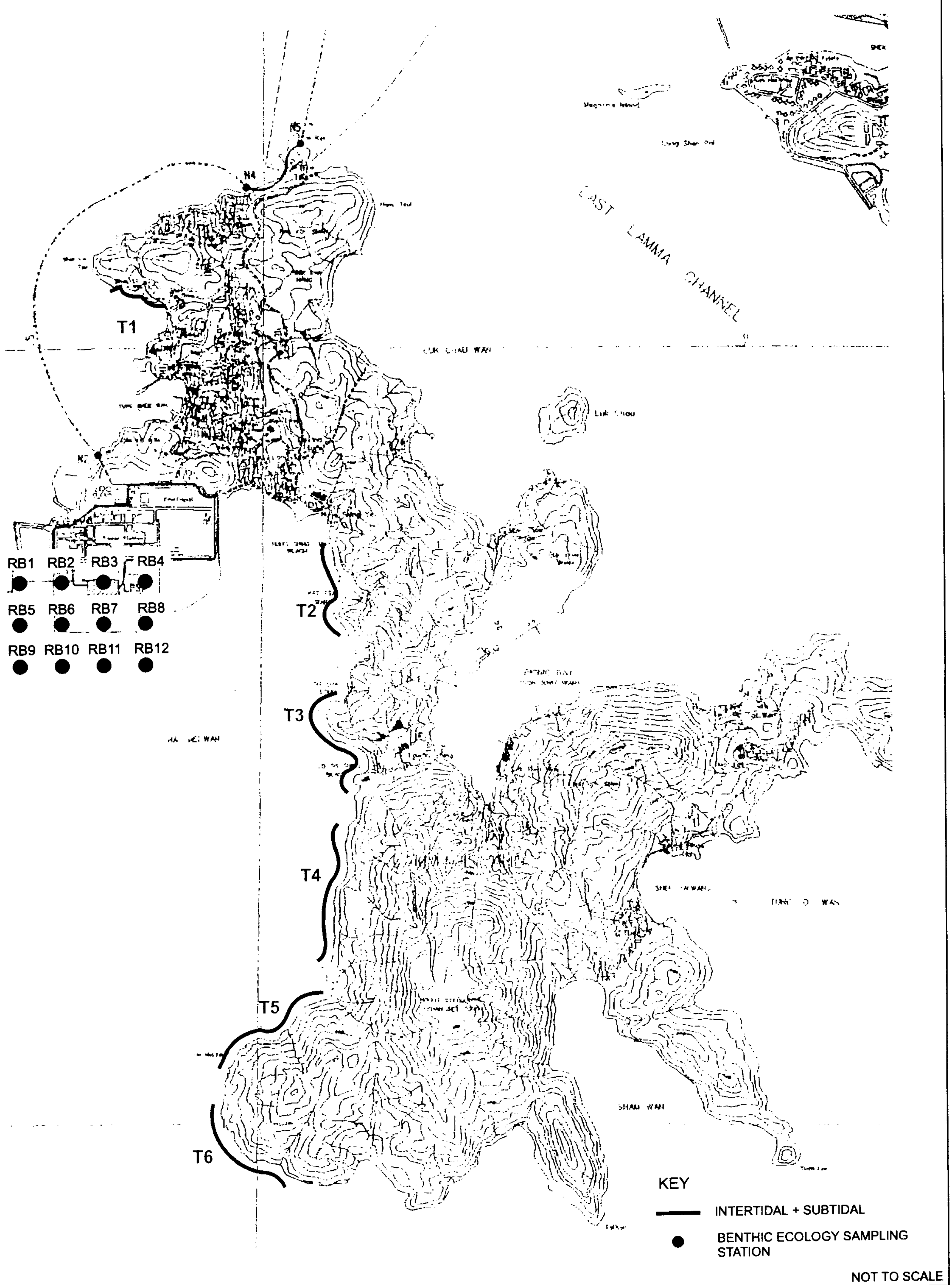

FIGURE 3.2a

LOCATION OF RECENT SURVEY SITES ON WEST LAMMA

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Hong Kong wide context[8]. Pak Kok was reported as having recorded soft corals and gorgonians with a cover of 13.09 %[9], whereas, the highest percent cover of corals (both hard and soft) for the sites on the west coast of Lamma were recorded in the EIA at 1.67 %. The comparison with an area of high conservation value, namely the coral colonies at Ping Chau, was used to emphasise the low ecological value of the sites on Lamma. The surveys at Ping Chau recorded coral covers (both hard and soft) of 55.9 %[10] and 61.9 %[11] in different areas, again considerably higher than those found at the sites on the west coast of Lamma during the EIA.

Subtidal - Soft Bottom Assemblages

As with the majority of Hong Kong, the most comprehensive work on the marine ecology of the waters surrounding the power station and Lamma Island itself has been on the benthos. The earliest reference to the benthos of the area can be found through the work undertaken by Shin & Thompson[12]. This study concluded that the southern waters of Hong Kong, an area of which samples were collected from the west coast of Lamma, are polychaete dominated (a mean of 80.4 % of the total number of individuals per grab), species diversity was the second highest in Hong Kong (mean 37.6 m^{-2}), mean number of individuals was lower than the average for Hong Kong (96.0 m^{-2} compared with 101.4 m^{-2}) and the mean biomass (20.2 g m^{-2}) was also low compared to the mean biomass for Hong Kong (35.2 g m^{-2}).

The survey for the Lamma Extension EIA provides the most recent data on the benthic communities in the west coast of Lamma (*Figure 3.2a*). Overall, the seabed was found to support assemblages that were mainly composed of polychaetes, typical of the majority of sediments in Hong Kong. However, the mean number of individuals (32.1 m^{-2}), mean biomass (0.60 g m^{-2}) and mean species diversity (12.0 m^{-2}) were considerably lower in Ha Mei Wan than Shin and Thompson's findings for both the southern waters and at other sites in Hong Kong. Based on this comparison, the benthic communities to the west of Lamma Island were considered to be of low ecological value.

Marine Mammals

The Indo-Pacific Hump-backed Dolphin (*Sousa chinensis*) and the Finless Porpoise (*Neophocaena phocaenoides*) are the only species of marine mammal regularly sighted in Hong Kong waters. The population of *Sousa chinensis* is reported to be centred around the Pearl River Estuary and Hong Kong waters are thought to represent the eastern portion of its range[13]. The Lamma Island area does not appear to represent an important habitat for *Sousa chinensis* in Hong Kong[14] and would seem to be at the eastern edge of the population's range as only four sightings have been made during extensive surveys in the Lamma Island area since early 1996. Based on the low level of sightings in this area, the Indo-Pacific Hump-backed Dolphin is not considered as an issue of concern[15].

(8) Binnie Consultants Limited (1995) Marine Ecology of Hong Kong - Report on Underwater Dive Surveys (October 1991 - November 1994) - Volume I. For the Geotechnical Engineering Office, Civil Engineering Department.
(9) Binnie Consultants Limited (1995) *Op cit.*
(10) Binnie Consultants Limited (1995) *Op cit.*
(11) Binnie Consultants Limited (1996) Ping Chau Quantitative Survey Final Report. For the Geotechnical Engineering Office, Civil Engineering Department.
(12) Shin PKS & Thompson GB (1982) Spatial Distribution of the Infaunal Benthos of Hong Kong. Marine Ecology Progress Series. Vol 10: 37-47
(13) Jefferson TA (1998) Population Biology of the Indo-Pacific Hump-backed Dolphin (*Sousa chinensis* Osbeck, 1975) in Hong Kong Waters. Final Report to AFD.
(14) Jefferson TA (1998) *Op cit.*
(15) ERM (1999) *Op cit.*

The Finless Porpoise, *Neophocaena phocaenoides*, is the most common and most important species of cetacean in the Lamma Island area and these waters appear to be among the most important habitats in Hong Kong for this marine mammal. Recent studies have found that the presence of the porpoise in the waters around Lamma Island appears to vary on both a spatial and temporal basis[16]. The main areas used by the porpoises around Lamma Island are the nearshore waters off the southwestern coast (Ha Mei Tsui peninsula). The sightings to date of the porpoise in the waters around Lamma Island indicate that the only months of the year when this cetacean is absent are July and August. During these months the porpoise is thought to move east to the waters around Po Toi, Waglan and Sung Kong Islands. Based on the number of sightings of this species, it appears that the waters off Ha Mei Tsui are an important habitat for the Finless Porpoise and, therefore, are considered of high ecological value in terms of marine mammals. In contrast, the waters in Ha Mei Wan, or west Lamma bay, do not appear to be such a key habitat to the Finless Porpoise and, therefore, are only considered as of medium to low ecological value in terms of marine mammals.

A summary of the ecological value assigned to each of the marine ecological habitats of the waters and shoreline of west Lamma in comparison to other sites in Hong Kong is presented in *Table 3.2a*.

(16) ERM (1999) *Op cit.*

Table 3.2a *Summary of Ecological Value of the Marine Ecological Habitats on the West Coast of Lamma in Comparison to other Sites in Hong Kong*

Marine Ecological Habitat	Location	Ecological Value
Intertidal		
Hard Surface Assemblages	T1 - Yung Shue Wan	Low
	T2 - Hung Ching Yeh	Medium
	T3 - Tit Sha Long	Medium
	T4 - Lo So Shing	Medium
	T5 - Ha Mei Tsui North	Medium
	T6 - Ha Mei Tsui South	Medium
Soft Surface Assemblages	Lo So Shing	Low
	Hung Shing Yeh	Low
	Tai Wan San Tsuen	Low
	Sham Wan	High
Subtidal		
Hard Bottom Assemblages	T1 - Yung Shue Wan	Low
	T2 - Hung Ching Yeh	Low
	T3 - Tit Sha Long	Low
	T4 - Lo So Shing	Low
	T5 - Ha Mei Tsui North	Medium
	T6 - Ha Mei Tsui South	High
Soft Bottom Assemblages	Ha Mei Wan	Low
Marine Mammals	Ha Mei Wan	Medium - Low
	Ha Mei Tsui Peninsula	High

Note: The ecological value of each habitat has been based on the findings of the recent EIA for Lamma Extension[17]

Based on the above it appears that, in terms of marine ecology, the most important sensitive receivers are the subtidal hard bottom communities on the south of the Ha Mei Tsui peninsula, as well as the importance of these waters directly off this peninsula to the Finless Porpoise.

3.3 *IDENTIFICATION OF IMPACTS*

The existing power station uses seawater in the cooling system, resulting in the discharge of large volumes of heated water. These heated waters are rapidly dispersed by surface mixing and tidal currents resulting in a body of offshore water with elevated temperatures, with the majority of the increased temperatures confined to the near surface waters. The proposed conversion of the gas units will result in changes to the heat rejection rates (flow rate and

(17) ERM (1999) *Op cit.*

temperature of cooling water discharge) compared with the existing power station, which will subsequently change the thermal plumes in the receiving waters. In addition, there will be small changes in the discharge of residual chlorine resulting from the changes to the flow rates of the cooling water.

Potential impacts to the surrounding water quality have been discussed in *Section 2*. In terms of impacts to marine ecology, two possible areas of concern have been identified. These are as follows:

- temperature elevations in the surrounding waters; and,
- the discharge of biocides.

As no construction work has been proposed as part of the study, each of these impacts are operational. These impacts are discussed below.

3.3.1 *Temperature Elevations in the Surrounding Waters*

Changes in cooling water discharges resulting from the proposed conversion of the gas units have been predicted using mathematical modelling (described in *Section 2*). The effects of cooling water being discharged into the surrounding sea water at a higher temperature than ambient levels can have a marked impact on the surrounding marine ecology. These impacts to marine organisms, generally occur either directly, resulting in a physiological or behavioural response, or indirectly, eliciting a chemical response. However, thermal impacts to organisms are variable based on a number of factors such as exposure time, degree of exposure and extent of acclimation[18].

In general, heated effluents often form a surface plume rather than vertically mixing with the receiving waters. Although this can compound some of the adverse effects associated with temperature increases by concentrating the heated water near the sea surface, it minimises effects on the benthic communities. Furthermore, thermal impacts can also be considered to be minimised for mobile organisms such as fish (discussed in *Section 4*) as they have the ability to avoid the elevated temperatures by remaining in deeper waters[19].

High elevations in the temperature of the water, generally occurring in waters directly surrounding the outlet, have either one of two effects on the plankton in the water column. One possible effect is an initial algal bloom, which increases primary productivity leading to super-saturation of dissolved oxygen. However, as a result of this population bloom depletion of the available carbon dioxide in the water column occurs. This leads to mass mortality, resulting in an oxygen depletion in the water column due to eventual decomposition of the algae on the seabed. The other possible effect follows a similar process. If the temperature increases are above the temperature tolerance thresholds of the plankton, rapid mortality will occur without the occurrence of an initial bloom. Again, increased bacterial decomposition will then occur, leading to oxygen depletion in the water column. In terms of effects to the plankton in the waters remote to the outfall, as temperature elevations generally decrease with increasing distance from the outfalls, these smaller temperature increases can lead to algal blooms, again resulting in oxygen depletion, as discussed above.

(18) Abel P D (1996) Water Pollution Biology. Second Edition. Published by Taylor and Francis.
(19) Abel P D (1996) *Op cit.*

One of the main concerns with algal blooms is the occurrence of potentially damaging blooms Although most algal blooms have no proven adverse effects on the ecosystem, there are, however, a number of algae species that are toxic and cause damage to marine life. These have been termed Harmful Algal Blooms (HABs)[20]. HABs can cause a variety of adverse impacts on marine ecosystems such as physical damage, oxygen depletion, and doth direct and indirect poisoning of marine life. However, information presented in the EIA for Lamma Extension has indicated that Harmful Algal Blooms are unlikely to occur solely as a result of discharges from the power station[21] and, therefore, will not be addressed further.

3.3.2 *Biocides*

There are considerable operational and ecological problems caused by organisms lodging within, and passing through, power station water systems. Operationally these problems can be costly[22]. Mussels, oysters and other marine organisms growing within cooling water circuits have resulted in losses in thermal efficiency and even total shutdowns. To counteract settling and actively growing fouling organisms, cooling water circuits are usually dosed with biocides (commonly chlorine) in large amounts. This causes mortalities of both the fouling and non-fouling organisms in the circuit. The discharge of the resulting chlorinated effluents together with dead organisms may in turn have effects on the marine ecosystem beyond the outfalls. Toxic effects of chlorine are increased synergistically[23] by the increases in temperature associated with cooling waters, however, this process is counterbalanced by the fact that both temperature increases in the water and concentrations of residual chlorine diminish rapidly with time and distance from the discharge point, due to dilution and chemical decay[24]. As a result, the effects of residual chlorine are generally reduced with increasing distanced from the outfall.

3.4 *ASSESSMENT OF IMPACTS*

The results of the thermal plume modelling for the proposed conversion of gas units predicts that there will be a thermal plume with a maximum dispersion length of approximately 5 km to the south of the power station and 4 km to the north (*Annex B*). The maximum increases has been predicted to be a maximum of 6°C above ambient conditions in the immediate vicinity of the discharge point. Areas where the increase in temperature are above 2°C, which exceeds the Water Quality Objectives, are located either directly surrounding the power station, or are confined to the open waters to the north and south of the power station (*Section* 2). The majority of these areas, such as the habitats located at Yung Shue Wan to the north of the power station, have previously been characterised in the EIA for Lamma Extension as of low ecological value and generally depauperate in comparison with other similar sites in Hong Kong[25], therefore, the impacts to these communities as a result of the predicted temperature elevations are not considered to be of concern.

(20) ERM (1999) *Op cit.*
(21) ERM (1999) *Op cit.*
(22) Langford TE (1983) Electricity generation and the ecology of natural waters. Liverpool University Press.
(23) Cairns J *et al* (1978) Effects of temperature on aquatic organisms sensitivity to selected chemicals. Virginia Water Resources Research Centre Bulletin 106 Virginia, USA.
(24) Mattice JS & Zittel HE (1976) Site specific evaluation of power plant chlorination. Journal of Water Pollution Control. 48 (10): 2284 - 2308.
(25) ERM (1999) *Op cit.*

One substrate, previously characterised as of medium ecological value, is predicted to come into contact with waters exceeding 2°C above ambient. This is the intertidal hard surface community of Ha Mei Tsui, to the south of the power station. Although these plumes have only been predicted to impact this area during spring tides, and for less than 30 minutes over the simulated 15 day spring-neap tide cycle (*Section 2*), these impacts exceed Water Quality Objectives and are assessed below.

As part of the marine ecology assessment in the Lamma Extension EIA, statistical analysis of variance (ANOVA) and Multi Dimensional Scaling (MDS) analysis was undertaken comparing intertidal hard surface assemblages on shores that experience elevated temperatures as a result of the existing discharges. The findings of this analysis was that no significant difference was found between the intertidal hard surface assemblages on a site affected by heated water discharges in the region of a 1 - 2°C above ambient, and those which were not subject to such increases in temperature. As a result, it was concluded that no adverse impacts on affected shores would result from such a temperature increase. Based on a comparison of species in these assemblages, heated discharges did not appear to affect the recruitment of intertidal organisms as no significant differences between species diversity was observed[26]. Finally, the majority of the affected areas have been predicted to only be affected by plumes with a temperature elevation of 1°C, which, based on the findings in the EIA as discussed above, have been deemed acceptable to intertidal communities.

The majority of the intertidal soft shore communities on the west coast of Lamma, as identified in *Section* 3.2 do not appear to come into contact with the predicted thermal plumes (*Annex B*). Only the gazetted beach at Lo So Shing has been identified as in contact with the predicted plumes. However, based on the fact that this sandy shore will only be affected by plumes with a temperature elevation of 1°C, which is below the Water Quality Objectives, combined with the characterisation of this intertidal soft shore community as being of low ecological value[27], this low impact has been deemed environmentally acceptable.

The subtidal hard surface habitat at Ha Mei Tsui was characterised in the Lamma Extension EIA[28] as of low ecological value. This was based on the fact that no hard coral colonies were identified in the upper regions of the substratum. Instead, only soft coral and gorgonian colonies, primarily made up colonies of *Dendronephthya* spp and the sea fan *Euplexaura robusta*, were found to be present in - 7 to 10 mCD survey transect. However, due to the surface discharge of the cooling water and the buoyancy of heated water, the thermal discharge modelling has predicted that the heated water would remain in the upper 40% of the water column (*Section* 2). As a result, impacts to these coral communities at these depths are not predicted as they would not come into contact with the temperature elevated water.

In terms of impacts to benthic communities this thermal stratification would also apply. Consequently, as the subtidal soft bottom communities would not be in contact with the heated water in the plume, impacts are, therefore, not predicted to occur.

Temperature elevations are not thought to impact marine mammal populations as aggregations of the Indo-Pacific Hump-backed Dolphin, *Sousa chinensis*, are

(26) ERM (1999) *Op cit.*
(27) ERM (1999) *Op cit.*
(28) ERM (1999) *Op cit.*

frequently observed around the discharge point for cooling waters from the Castle Peak Power Station[29]. In terms of the more commonly sighted marine mammal in the area, the Finless Porpoise *Neophocaena phocaenoides*, it is also not expected that these temperature elevations will be of a concern. This assessment has been based on the fact that the temperature elevations exceeding 2°C above ambient have only been predicted as being seasonal, primarily occurring during the stratified conditions of the wet season. In contrast, the EIA for the Lamma Extension predicted that thermal plumes in the dry season would be predominantly transported in a northerly direction. Observations of Finless Porpoises in Hong Kong waters have identified that these marine mammals' use of these waters around Lamma is also seasonal, and this species has not been observed to use these waters during the months of July and August, which comprise the majority of the wet season. Instead findings have shown that during the wet season the Finless Porpoise's habitat is generally restricted to the eastern waters Hong Kong, particularly those around the Po Toi island group[30]. Based on these findings, the predicted thermal plumes are not expected to be of concern to the marine mammals that frequent the surrounding waters.

In terms of impacts from biocides, the previous EIA for the Lamma Extension predicted a continuous discharge of total residual free chlorine at an initial concentration of 0.3 mgL^{-1} to the sea[31]. This concentration is the same as the existing power station and is below EPD's[32] existing licence condition for discharge of 0.5 mgL^{-1}. Modelling conducted for the EIA showed that the largest area covered by a concentration of 0.01 mgL^{-1} extended approximately 700m offshore indicating a very localised impact which did not impinge on any of the water quality or marine ecology sensitive receivers identified in the EIA for the Lamma Extension. As the present modelling has indicated that there will be only a 3% increase in the size of this area (*Section* 2), this increase would not change this conclusion as the area of exceedence would still not affect any sensitive receivers.

In summary, impacts to the marine ecology of the waters surrounding the Lamma power station as a result of the proposed conversion of the gas units is considered acceptable based on the following conclusions.

- The intertidal shore impacted by the portion of the thermal plume which exceeds the WQO at Ha Mei Tsui is impacted for only short periods during spring tides and previous studies have shown that such an impact would not have any adverse effects on the marine ecology of those communities;

- The coral colonies present on the subtidal hard surface habitat at Ha Mei Tsui are likely to be below the higher temperature surface plumes; and,

- The use of waters with predicted seasonal temperature elevations of 2°C by the Finless Porpoise is seasonal and these marine mammals are not expected to be present during the periods when the WQO is exceeded.

(29) ERL (Asia) Limited (1991) EIA of the Proposed 6000MW Thermal Power Station at Black Point. Draft Initial Assessment Report. Volume 3 : Operational Phase. For the China Light and Power Company Limited.

(30) Parsons E C M (1997) Hong Kong's Cetaceans: The biology, socioecology and behaviour of *Sousa chinensis* and *Neophocaena phocaenoides*. PhD thesis, University of Hong Kong.

(31) ERM (1999) *Op cit.*

(32) ERM (1999) *Op cit.*

3.5 *MITIGATION MEASURES*

The ecological impacts due to the conversion of two oil fired gas units at the existing Lamma Power Station to combined cycle operation are considered to be acceptable because zones of exceedance do not appear to unacceptably affect areas considered of marine ecological importance. Based on the thermal plume modelling data no mitigation measures aimed at reducing impacts to marine ecology are required.

4 ASSESSMENT OF FISHERIES IMPACTS

4.1 INTRODUCTION

This section of the report presents the findings of the assessment of impacts to fisheries resources and fishing operations. Baseline information on the potentially affected existing fisheries resources and fishing operations, which is taken from recent studies and relevant literature, is presented and evaluated for the assessment.

4.2 BASELINE CONDITIONS

In Hong Kong, the commercial marine fishing industry is divided into capture and culture fisheries. As a result, the following baseline information has been presented under the headings of *Capture fisheries* and *Culture Fisheries*. The baseline information has been derived from the most up-to-date information on the Hong Kong fishery[(33)]. Information from other relevant studies was also reviewed in order to determine if the areas on the western side of Lamma Island are important nursery and spawning grounds for commercial fisheries[(34)]. Mariculture information was obtained from the AFD annual report 1996-1997[(35)].

4.2.1 *Capture Fisheries*

Fishing Operations

In 1989-1991 AFD devised a system whereby the waters of Hong Kong were divided up into individual Fishing Zones[(36)]. Data were gathered at that time on the catches of the Hong Kong fleet derived from these Fishing Zones. Since this first Hong Kong wide survey, AFD have updated the information which now indicates that the number of Fishing Zones equates to 189, down from the original 210 listed in 1991[(37)], of which 179 are actively fished by vessels in the Hong Kong fleet. Five AFD Fishing Zones make up the waters surrounding the Lamma power station, covering southern Lamma, northeast Lamma and include the waters to the west of the island (*Figure 4.2a*). The area of these Fishing Zones and the numbers of vessels that operate in these waters are presented in *Table 4.2a*.

(33) Agriculture and Fisheries Department (1998) Port Survey 1996 - 1997.
(34) ERM (1998) Fisheries Resources and Fishing Operations in Hong Kong Waters, Final Report. For Agriculture and Fisheries Department.
(35) Agriculture and Fisheries Department (1998) Annual Report 1996 - 1997.
(36) Agriculture and Fisheries Department (1991) Port Survey 1989 - 1991.
(37) Agriculture and Fisheries Department (1991) *Op cit.*

Table 4.2a *Area (ha) and Number of Vessels Operating During 1996 - 1997 in Each AFD Fishing Zone within the waters surrounding the Power Station*

Code	Fishery Area	Area (Ha)	Vessels < 15 m	Vessels > 15 m	All Vessels
96	Pak Kok	873	66	5	71
97	Po Law Tsui	403	160	20	180
98	Ha Mei	1,636	237	58	295
99	Tai Kok	2,134	251	65	316
109	West Lamma Channel	4,538	130	60	190
Total		**9,584**	*	*	*
Total of All Fishing Zones in Hong Kong		**181,791**	**2,352**	**266**	**2,618**
Percentage of Hong Kong Total		**5.27%**	*	*	*

Note: * No values can be calculated for these parameters from the information provided as it cannot be determined whether the vessels reported as operating within one zone are the same vessels that are reported for another zone.

Although the majority of fishing vessels operating in the Fishing Zones on the western coast of Lamma Island are less than 15m in length, in comparison to other Fishing Zones in Hong Kong, these waters also support a high number of vessels many of which are greater than 15m in length. The majority of these vessels have been identified as operating trawling gear[38].

Fisheries Resources

The number of vessels operating within the waters of these Fishing Zones is reflected in the production and catch values of the individual zones (*Table 4.2b*).

[38] ERM (1998) *Op cit.*

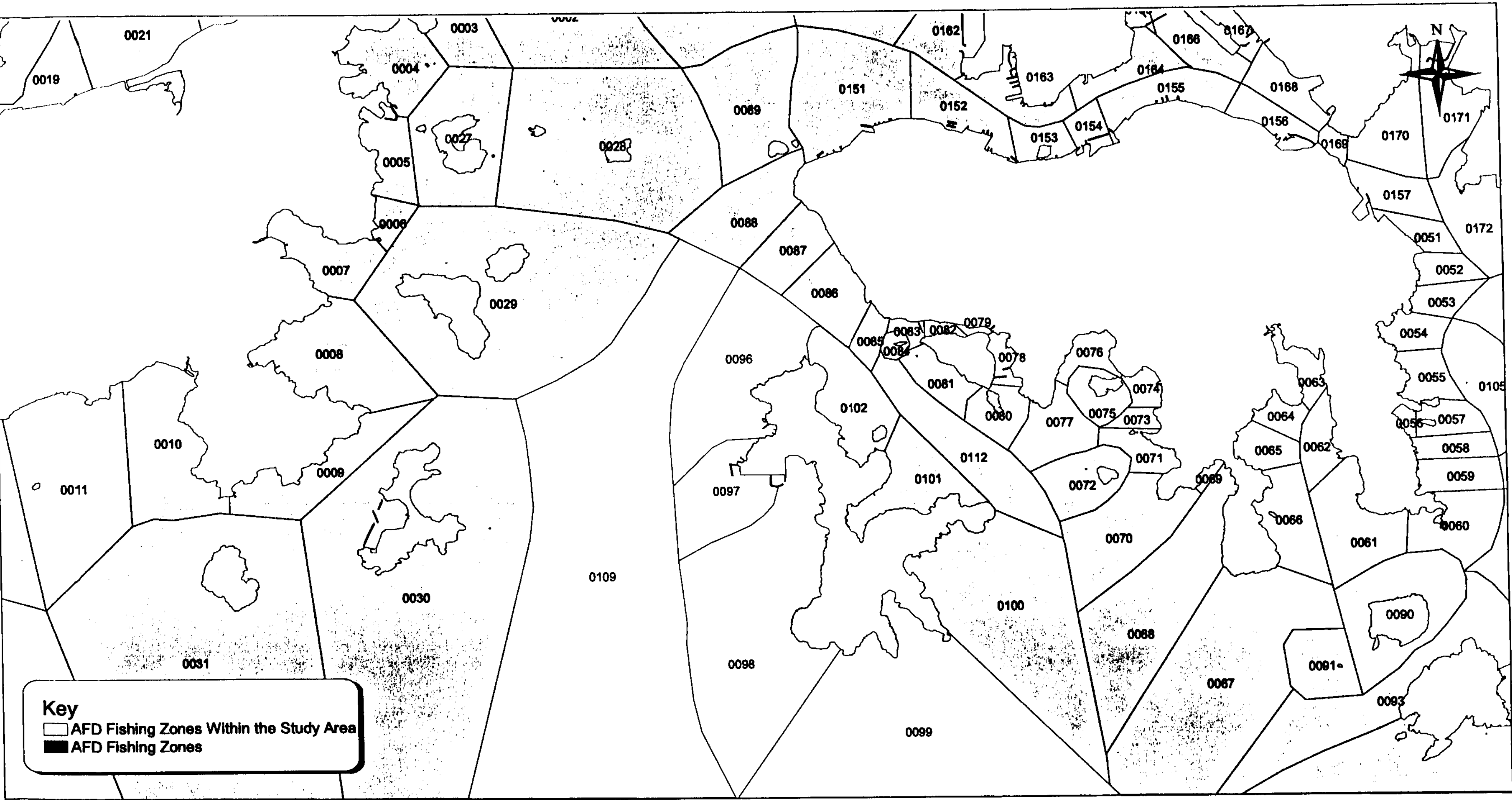

Fig 4.2a

AFD FISHING ZONES IN THE VICINITY OF THE LAMMA POWER STATION

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Table 4.2b *Total Value ($), Adult Catch (kg) and Fry Catch (tails) Displayed on a Total Production, Production (Ha^{-1}) and Rank (Ha^{-1}) Basis for the Fishing Zones in the waters surrounding the Power Station (all fishing vessels)*

AFD Code/ Zone	Total Production			Production (Ha^{-1})			Rank Production (Ha^{-1})		
	Adult Fish (kg)	Fry (tails)	Value ($)	Adult Fish (kg)	Fry (tails)	Value ($)	Adult Fish	Fry	Value
0096 Pak Kok	64,687	55,544	1,211,980	74	64	1,388	108/189	43/89	128/189
0097 Po Law Tsui	85,553	62,904	3,073,372	212	156	7,629	43/189	39/89	27/189
0098 Ha Mei	246,278	79,464	6,078,196	149	48	3,676	66/189	45/89	70/189
0099 Tai Kok	407,638	86,824	6,884,342	191	41	3,226	50/189	49/89	84/189
0109 West Lamma Channel	504,235	-	8,090,005	111	-	1,783	87/189	-	113/189
Total (HK$)			**25,337,895**						
Hong Kong Total (HK$)[39]			**343,969,863**						
Percentage of Hong Kong Total			**7.4%**						

In general the production values from the waters surrounding the power station are similar and rank highly in comparison to other areas in Hong Kong. The exception to this is the Fishing Zone on the northern tip of Lamma Island at Pak Kok. This Fishing Zone is ranked only 108 out of the 189 areas for fisheries production and only 128 out of the 189 areas for catch value. It is noted that the Fishing Zone at Po Law Tsui (0097) has the highest ranking in terms of production value (27 out of 189) within the waters surrounding the power station. This high production value is due to the large catches and small area of the Fishing Zone. However, this zone directly surrounds the existing power station and, as a result, will be likely to be the most directly affected by any works associated with the cooling water discharges from the power station. *Table 4.2c* lists the five most abundant species caught within the Fishing Zones, as well as their commercial value.

(39) Agriculture and Fisheries Department (1998) *op cit.*

Table 4.2c *Top Five Adult Fish (by weight) Caught in Each Fishing Zone within the waters surrounding the Power Station* [40]

Code	Fishing Area	Top Five Fish in Order (by Weight)		Commercial Value
		Species	Common Name	
0096	Pak Kok	Mixed Species		Low
		Siganus oramin	Rabbitfish	Low
		Eleutheronema tetradactylus	Threadfin	Low
		Pseudosciaena crocea	Yellow Croaker	High
		Sebastiscus marmoratus	Rockfish	Low
0097	Po Law Tsui	Mixed Species		Low
		Caranx spp	Scad/Crevalle	Medium
		Sardinella jussieui	Sardine	Low
		Sebastiscus marmoratus	Rockfish	Low
		Pseudosciaena crocea	Yellow Croaker	High
0098	Ha Mei	Mixed Species		Low
		Caranx spp	Scad/Crevalle	Medium
		Argyrosomus spp	Croaker	Low
		Sardinella jussieui	Sardine	Low
		Oratosquilla spp	Mantis Shrimp	Low
0099	Tai Kok	Mixed Species		Low
		Caranx spp	Scad/Crevalle	Medium
		Argyrosomus spp	Croaker	Low
		Sardinella jussieui	Sardine	Low
		Oratosquilla spp	Mantis Shrimp	Low
0109	West Lamma Channel	*Sardinella jussieui*	Sardine	Low
		Mixed Species		Low
		Caranx spp	Scad/Crevalle	Medium
		Argyrosomus spp	Croaker	Low
		Caranx kalla	Shrimp Scad	Medium

Note: Mixed Species consists of juveniles of *Caranx kalla, Siganus oramin, Sardinella* spp, *Leiognathus brevirostris* and *Clupanodon punctatus*.

The Fishing Zones surrounding west Lamma Island yield mainly low value pelagic species as their most abundant catch in terms of weight. The most common species group within these waters, reported as the most common in terms of catch weight at four of the five Fishing Zones, is the Mixed Species. This species group, as well as other common species reported in these waters, such as the sardine, *Sardinella jussieui*, and the croaker, *Argyrosomus* spp, are generally sold at a low cost (approximately $1.6 per kg) to mariculturists as fish feed.

Fishermen operating within the each of these Fishing Zones, with the exception of the West Lamma Channel (0108), also report catches of fish fry. This recording is not unexpected due to the Mixed Species group, comprising of juvenile fish, commonly recorded as the most abundant species by weight caught within these waters, as discussed above. The fry catches from these Fishing Zones, however, are not large in comparison to other areas in Hong Kong, and are only ranked as average for Hong Kong (range = 39 to 49 out of the 89 areas in Hong Kong that report fry catches) (*Table 4.2b*).

(40) Agriculture and Fisheries Department (1998) *op cit.*

In summary, records of fishing operations in the waters surrounding the power station indicate that the area is of medium to high importance to the Hong Kong fishery. On a catch weight ha^{-1} basis these Fishing Zones rank from 43rd to 108th of the 189 fishing areas in Hong Kong. The majority of catches reported by fishermen operating in the waters are small fast growing pelagic species of low commercial value.

Spawning and Nursery Areas

The recent study on fisheries resources in Hong Kong waters has shown that the southern waters of Hong Kong are a spawning ground and nursery area for important and high value commercial species[41]. The waters directly surrounding the power station have been identified as lying within these known spawning and nursery areas. Commercial species reported as using this area as a spawning ground are the croaker, *Johnius belengeri,* the coastal mud shrimp, *Solenocera crassicornis* and the jinga shrimp *Metapenaeus affinis*. Similarly, species reported as using these waters as a nursery ground for the shrimps, *Metapenaeopsis barbata* and *Metapenaeopsis palmensis,* the mantis shrimp, *Oratosquilla* spp, the goby, *Oxyurichthys tentacularis,* and both croaker (Sciaenidae) and grouper (Serranidae) fry[42].

4.2.2 *Culture Fisheries*

No AFD gazetted Fish Culture Zones (FCZs) are within the waters surrounding the Lamma power station. As a result, FCZs are not be discussed further in this report.

4.3 IDENTIFICATION OF IMPACTS

As discussed in *Sections* 2 and 3, the existing power station uses seawater in the cooling system, resulting in the discharge of large volumes of heated water. Thermal plume modelling on the new dispersion rates of the cooling waters associated with the proposed conversion of the gas units has shown that there will only be small changes in the thermal plumes in the receiving waters from existing conditions (*Section* 2). In addition, there will be changes in the discharge of biocides, residual chlorine. Potential impacts to the surrounding water quality and marine ecology have been previously discussed (*Sections* 2 and 3). However, in terms of potential impacts to fisheries resources, three possible areas of concern have been identified. These are as follows:

- temperature elevations in the surrounding water;
- entrainment and impingement at the cooling water intake; and,
- the discharge of biocides.

Each of these impacts are operational as no construction work has been proposed as part of the study. As a result of there being no construction impacts and no habitat loss, no impacts to fishing operations are expected. However, potential impacts to the fisheries resources are discussed below.

(41) ERM (1998) *op cit.*
(42) ERM (1998) *op cit.*

4.3.1 *Temperature Elevations in the Surrounding Water*

Impacts to fisheries resources associated with elevated temperatures in their surrounding environment are dependent on a number of factors. The maximum temperature elevation a fish can withstand varies from species to species[43]. Fish have the ability to acclimate to rising temperatures, however, studies have shown that small, sudden changes to water temperature generally present more adverse effects to fish than more gradual changes. As a result, the temporal gradient of temperature change is important when assessing potential thermal impacts to fisheries resources.

High increases in the temperature of the water may also result in oxygen depletion in the water column due a number of factors associated with algal blooms, as discussed in *Section 3.* Oxygen depletion in the water column is particularly detrimental to the eggs and larvae of fish, due to their increased metabolic rates, and subsequent high requirements for oxygen. Furthermore, dense aggregates of algae can suffocate fish by clogging or irritating their gills preventing them from normal respiration and potentially causing mass mortality[44]. Other forms of damage to fish include the recently discovered feeding of fish tissue by certain algae resulting in the death of the fish within a few hours, or the presence of toxins in some algae that effect the nervous systems of fish also resulting in mortalities[45].

4.3.2 *Entrainment & Impingement*

In the USA, intake mortalities through entrainment of juvenile fish and impingement of adult fish are thought to have caused serious impacts to wild fish populations[46]. For example, the San Onofre Nuclear Generating Station (SONGS) in California, which uses approximately 7.3 million litres per minute[47], was predicted to kill 50 - 84 tonnes of juvenile and adult fish per year through entrainment into the cooling water system and impingement onto intake screens[48].

4.3.3 *Biocides*

Environmental impacts to marine ecology through the use of biocides, in the form of residual chlorine, are discussed in *Section* 3.3. However, impacts to fisheries resources also occur through the use of such biocides. Research has been conducted internationally on the effects of residual chlorine discharges on fisheries resources, however, no research has been conducted on local fish species.

International work on the toxic effects of chlorine on fish eggs and larvae, which can be used as a benchmark for Hong Kong species, has indicated that abnormal

(43) Abel P D (1996) *Op cit*

(44) ERM (1999) *Op cit.*

(45) ERM (1999) *Op cit.*

(46) Van Winkle W (1977) Proceedings of the Conference on Assessing the Effects of Power Plant Induced Mortality on Fish Populations. Pergamon Press.

(47) Ambrose RF *et al* (1996) Predicted and Observed Impacts: can we foretell ecological change? In - Detecting Ecological Impacts: Concepts and Applications in Coastal Habitats. Edited by RJ Schmitt and CW Osenberg Pages 345 - 369. Academic Press Inc.

(48) NRC (Nuclear Regulatory Commission) (1981) Final Environmental Statement related to the operation of San Onofre Nuclear Generating Station Units 2 and 3. Southern California Edison Company, the San Diego Gas and Electric Company, The City of Riverside, and The City of Anaheim. US Nuclear Regulatory Commission Office of Nuclear Reactor Regulation.

development has occurred at concentrations of 0.31 to 0.38 mg l^{-1}[49]. The effects of chlorine on adult fish indicate that lethal effects have been reported for some species at concentrations as low as 0.02 mg l^{-1}. Lethal effects on fish occur due to chlorine causing the gill epithelium to slough off followed by excessive mucous production. This causes blockage of the respiratory process (oxygen and carbon dioxide transport across the gill epithelium) and subsequent death[50].

4.4 *ASSESSMENT OF IMPACTS*

The Lamma power station uses seawater in the cooling system resulting in the discharge of large volumes of heated water. The heated waters are rapidly dispersed by surface mixing and tidal currents resulting in a body of offshore water with surface temperatures elevated above background. *Section 2* discusses this issue in more detail and plots illustrating the dispersion of the predicted thermal plumes resulting from the conversion of the gas units are presented in *Annex B*.

The results of the modelling show that the overall area of the thermal plumes discharged from the power station will increase as a result of the proposed conversion of the gas units (*Section 2*). However, these increases are very small, calculated to amount to a total of 0.2 km^2, or 3% for the 2°C elevation contour. As the fisheries productivity and resources from the Fishing Zones presently affected by the existing plumes are ranked highly in comparison to other Fishing Zones in Hong Kong, it does not appear that the elevated temperatures are currently causing an adverse effect to fish in these areas. Therefore, in view of the relatively small changes in the quantity of cooling water predicted to be discharged into the water column, and the resulting temperature increases, the impacts to fisheries resources are acceptable. Furthermore, in terms of the current utilization of the area as a spawning and nursery habitat, as evidenced by fry capture in these waters, there also appears to be no current detrimental impacts from the present cooling water discharges to juvenile fish. As a result, the increase predicted in thermal plumes as a result of the cooling water discharges are also deemed environmentally acceptable to the spawning and nursery grounds.

Potential impacts through entrainment and impingement are based on the quantity of water taken in for cooling purposes in the power station. Following the proposed conversion of the gas units, this volume has been predicted to increase from the existing average rate of 323,280 m^3 hr^{-1} to the new average rate of 334,250 m^3 hr^{-1}, representing an increase of 3.4% (*Section 2*). As this increase from existing conditions is considered negligible, impacts through entrainment and impingement of fisheries resources are predicted to be environmentally acceptable.

Although the toxic effects of chlorine are increased synergistically[51] by the increases in temperature associated with cooling waters, the concentrations of residual chlorine diminish rapidly with time and distance from the discharge

(49) Morgan RP & Prince RD (1977) Chlorine Toxicity to eggs and larvae of five Chesapeake Bay fishes. Transactions of the American Fisheries Society. 106 (4): 380 - 385.

(50) Bass ML *et al* (1977) Histopathological effects of intermittent chlorine exposure on bluegill (*Lepomis macrochirus*) and rainbow trout (*Salmo gairdneri*). Water Research 11: 731-735.

(51) Cairns J *et al* (1978) Effects of temperature on aquatic organisms' sensitivity to selected chemicals. Virginia Water Resources Research Center Bulletin 106 Virginia, USA.

point[52]. The modelling exercises conducted for the water quality assessment (discussed in *Section 2*) indicate that residual chlorine levels of 0.02 mg l^{-1} are likely to occur only in close proximity to the outfall, mirroring the existing power station conditions. Lethal or sublethal (growth or reproduction) effects are not predicted to occur to fisheries resources as research has indicated that adult fish will avoid areas where concentrations of free residual chlorine in the water exceeds 0.035 mg l^{-1}[53]. As both the predicted residual chlorine concentrations are below fish avoidance levels, and discharges are only negligibly greater than that at present, which appear to have a low impact on fisheries due to the current high production rates, the predicted residual chlorine discharges are considered acceptable.

In summary, the conversion of the two oil fired gas turbines to combined cycle operation at the existing Lamma power station would be environmentally acceptable in terms of impacts to fisheries resources based on the following:

- No impacts to fishing operations are predicted as there will be no permanent loss of fishing grounds;
- The area of the thermal plume has been predicted to increase by only 3% for the 2°C elevation contour. Based on the current high productivity of the Fishing Zones within the current plume, it is inferred that existing thermal discharges are not having an adverse effect and thus an increase of 3% is deemed acceptable;
- Increases in flow rates, and subsequent risk of entrainment and entrapment of fisheries resources, particularly juvenile fish, are only negligibly increased from existing levels; and,
- Residual free chlorine concentrations are at concentrations below those which fish have been shown to avoid due to the potential of toxic effects to adults, fry and eggs.

4.5 *MITIGATION OF ENVIRONMENTAL IMPACTS*

Based on the above assessment, impacts to both fisheries resources and fishing operations are considered acceptable. As a result, no mitigation measures are required.

(52) Mattice JS & Zittel HE (1976) Site specific evaluation of power plant chlorination. Journal of Water Pollution Control. 48 (10): 2284 - 2308.

(53) Grieve JA *et al* (1978) A program to introduce site-specific chlorination regimes at Ontario hydro generating stations. Pages 77-84 in Jolley RL *et al* eds (1978) Water Chlorination: Environmental Impacts and Health Effects, Volume 2 . Michigan: Ann Arbor Science.

At the existing Hongkong Electric Company Ltd (HEC) Lamma Power Station there are eight coal fired units, three 250MW units and five 350MW units, and six 125MW oil fired gas turbines. HEC propose to convert the two of the oil fired gas turbines to combined cycle operation by the year 2003. This will be prior to the construction of the Lamma Extension, which is scheduled for completion in 2004, although the reclamation for the Lamma Extension will have been completed by 2003. The Lamma Extension will be an 1,800MW facility, consisting of six 300MW gas fired turbines and will be operated as a combined cycle plant with the existing power station. An Environmental Impact Assessment has already been carried out for the proposed Lamma Extension[54].

An assessment of the impacts on water quality, marine ecology and fisheries of the discharge of cooling water from the proposed conversion of oil fired gas turbines to combined cycle operation at the existing power station has been carried out. Discharges of cooling water were simulated by Delft Hydraulics using a thermal discharge model. This model had previously been set up for the Environmental Impact Assessment of the Lamma Extension[55]. Two thermal discharge modelling scenarios were simulated, representing the operation of the existing Lamma Power Station in 2003 (Scenario 1), and the operation of the power station in 2003 with conversion of the two oil fired gas turbines to combined cycle operation (Scenario 2). Both scenarios were simulated for 15 day spring-neap tidal cycles in the wet season. The assessment of the results of the thermal discharge modelling was undertaken by considering the Water Quality Objective (WQO) for the effects of heated water discharges on the marine environment. The WQO limit is specified as the allowable temperature elevation from human activities should be less than 2°C above ambient. In addition, the impacts of the discharge of residual chlorine have been assessed qualitatively and were based on modelling carried out for the Lamma Extension EIA.

The water quality assessment concluded that the conversion of the two oil fired gas turbines to combined cycle operation at the existing Lamma power station would be environmentally acceptable in terms of water quality impacts based on the following:

- The size of the thermal plumes from the combined cycle operation are very similar to thermal plumes which would be generated if the existing operating strategy were to be maintained in 2003;
- Although a small area of coast on the northern shore of the Ha Mei Tsui headland is predicted to be impacted by thermal plumes exceeding the WQO, the predicted exceedences are of very short duration and will occur only until the Lamma Extension becomes operational; and
- The cooling water flows are only expected to increase by 3% compared to the existing power stations which would only result in a very small increase in the size of the area exceeding the residual chlorine criterion, and this area of exceedence is currently considered to be environmentally acceptable as it is small and does not contain any sensitive receivers.

(54) ERM (1999). *Op cit.*
(55) ERM (1999). *Op cit.*

As the impacts to water quality from the conversion were predicted to be acceptable, no mitigation measures were specified.

Impacts to the marine ecology of the waters surrounding the Lamma power station as a result of the proposed conversion of the gas units is considered acceptable based on the following conclusions.

- The intertidal shore impacted by the portion of the thermal plume which exceeds the WQO at Ha Mei Tsui is impacted for only short periods during spring tides and previous studies have shown that such an impact would not have any adverse effects on the marine ecology of those communities;

- The coral colonies present on the subtidal hard surface habitat at Ha Mei Tsui are likely to be below the higher temperature surface plumes; and,

- The use of waters with predicted seasonal temperature elevations of 2°C by the Finless Porpoise is seasonal and these marine mammals are not expected to be present during the periods when the WQO is exceeded.

No mitigation measures were specified as the marine ecological impacts were predicted to be acceptable.

The fisheries assessment concluded that impacts the conversion of the two oil fired gas turbines to combined cycle operation at the existing Lamma power station would be environmentally acceptable based on the following:

- No impacts to fishing operations are predicted as there will be no permanent loss of fishing grounds;

- The area of the thermal plume has been predicted to increase by only 3% for the 2°C elevation contour. Based on the current high productivity of the Fishing Zones within the current plume, it is inferred that existing thermal discharges are not having an adverse effect and thus an increase of 3% is deemed acceptable;

- Increases in flow rates, and subsequent risk of entrainment and entrapment of fisheries resources, particularly juvenile fish, are only negligibly increased from existing levels; and,

- Residual free chlorine concentrations are at concentrations below those which fish have been shown to avoid due to the potential of toxic effects to adults, fry and eggs.

Based on the above assessment, impacts to both fisheries resources and fishing operations are considered acceptable. As a result, no mitigation measures are required.

Annex A

Thermal Discharge Modelling Results for Scenario 1 - Existing Lamma Power Station

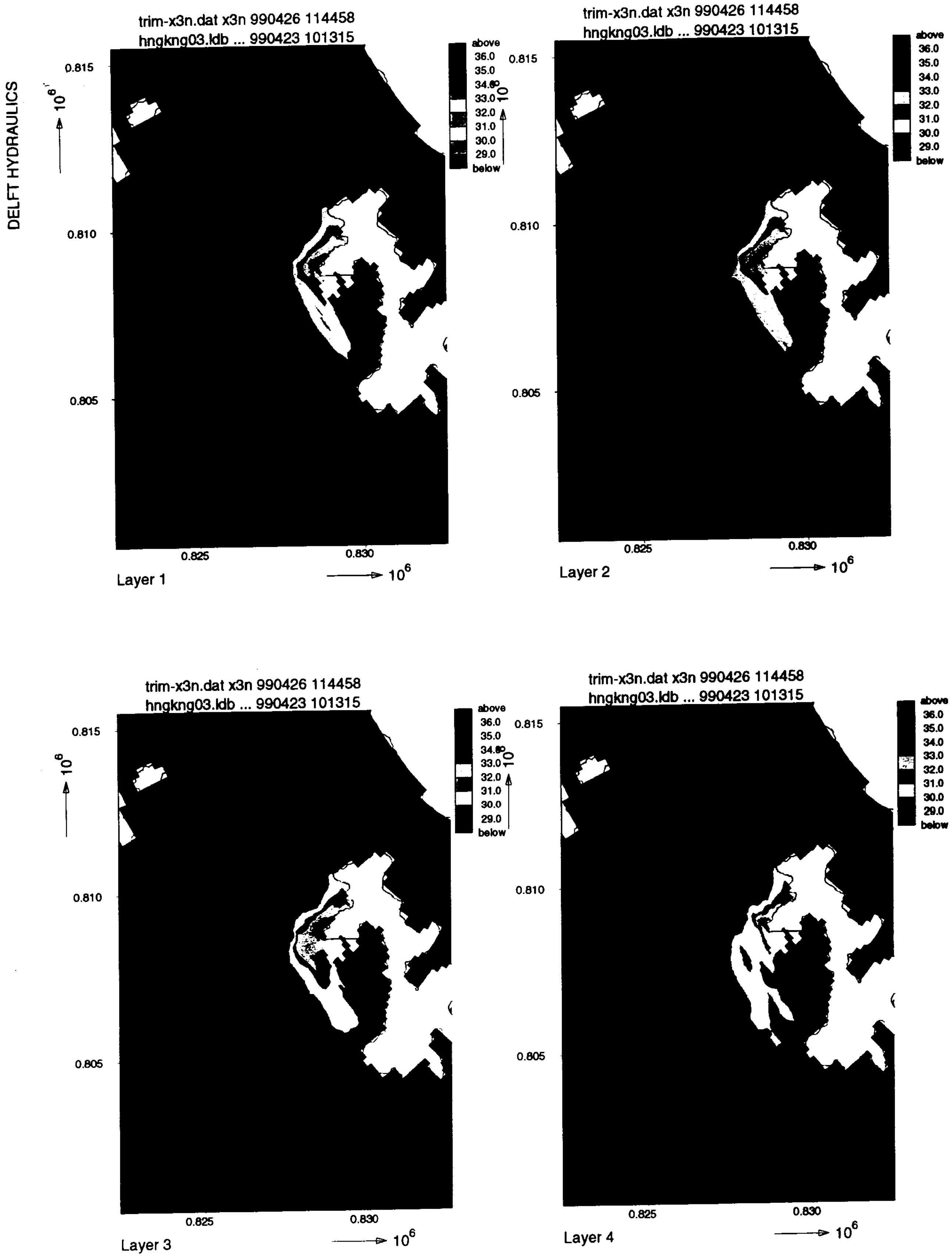

FIGURE A1

MAXIMUM TEMPERATURE FOR LAYERS 1 TO 4
SCENARIO 1 - WET SEASON NEAP TIDE

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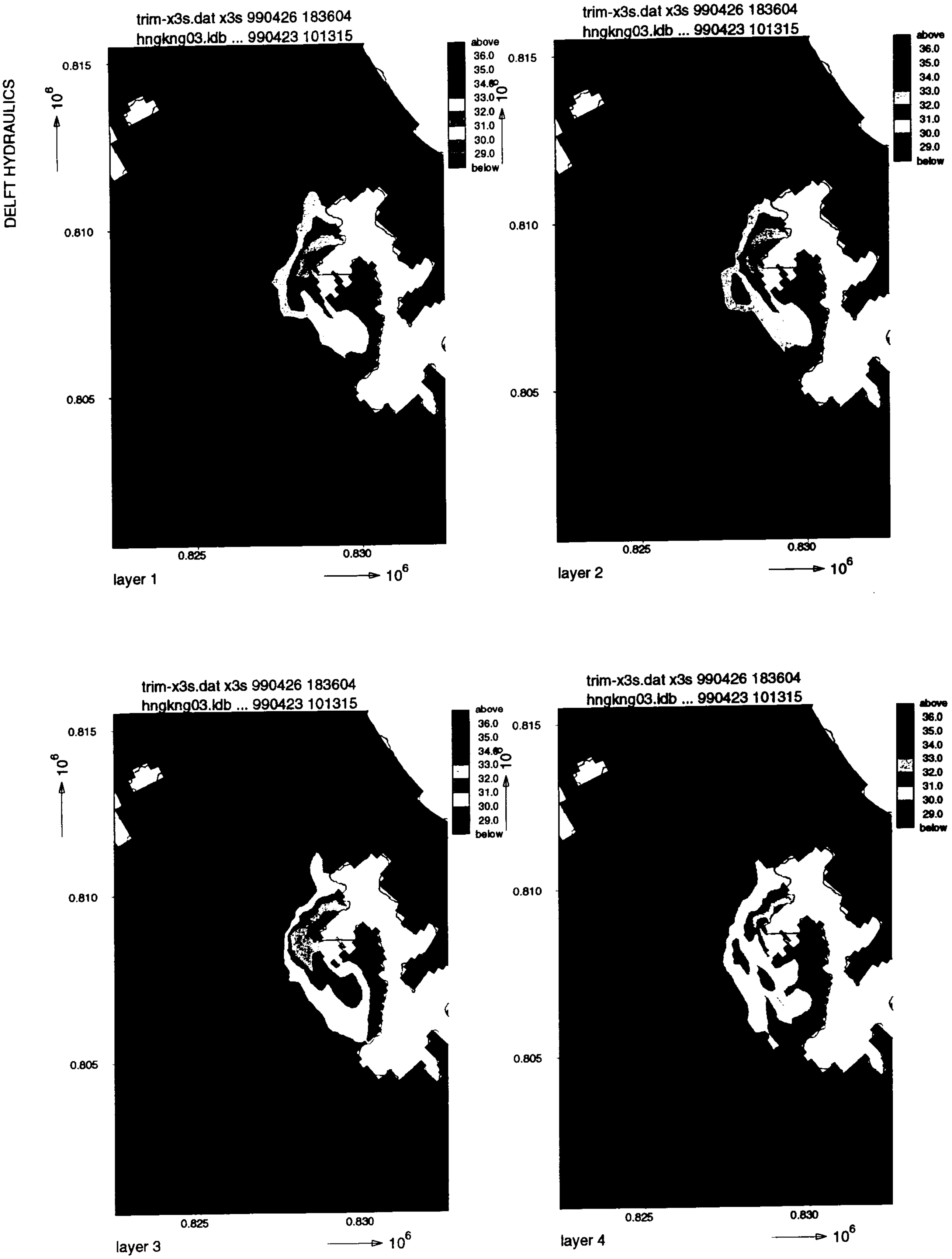

FIGURE A2

MAXIMUM TEMPERATURE FOR LAYERS 1 TO 4
SCENARIO 1 - WET SEASON SPRING TIDE

Environmental Resources Management

ERM

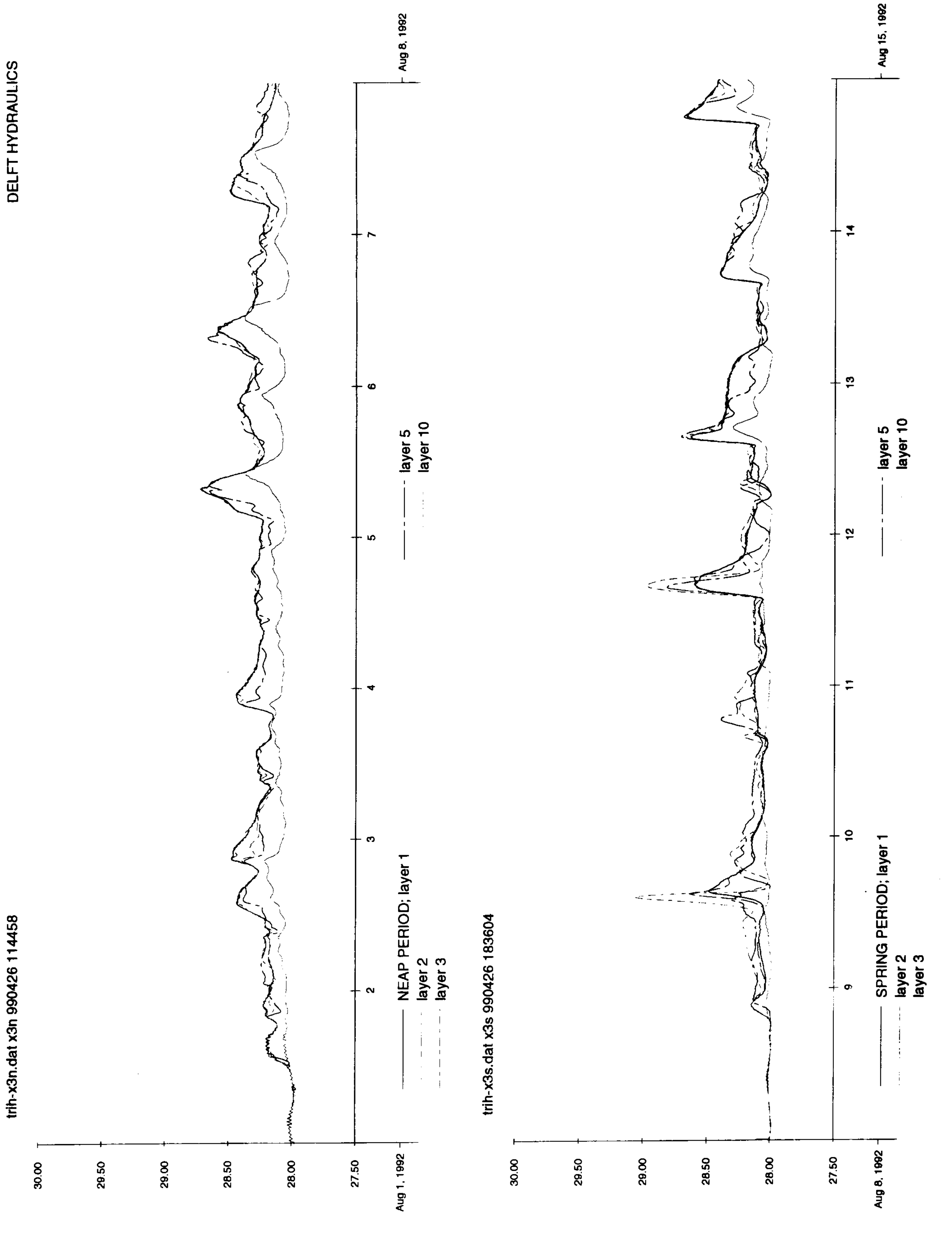

FIGURE A3

TIME SERIES OF TEMPERATURE AT LAMMA POWER STATION INTAKE SCENARIO 1 - WET SEASON SPRING AND NEAP TIDES

Environmental Resources Management

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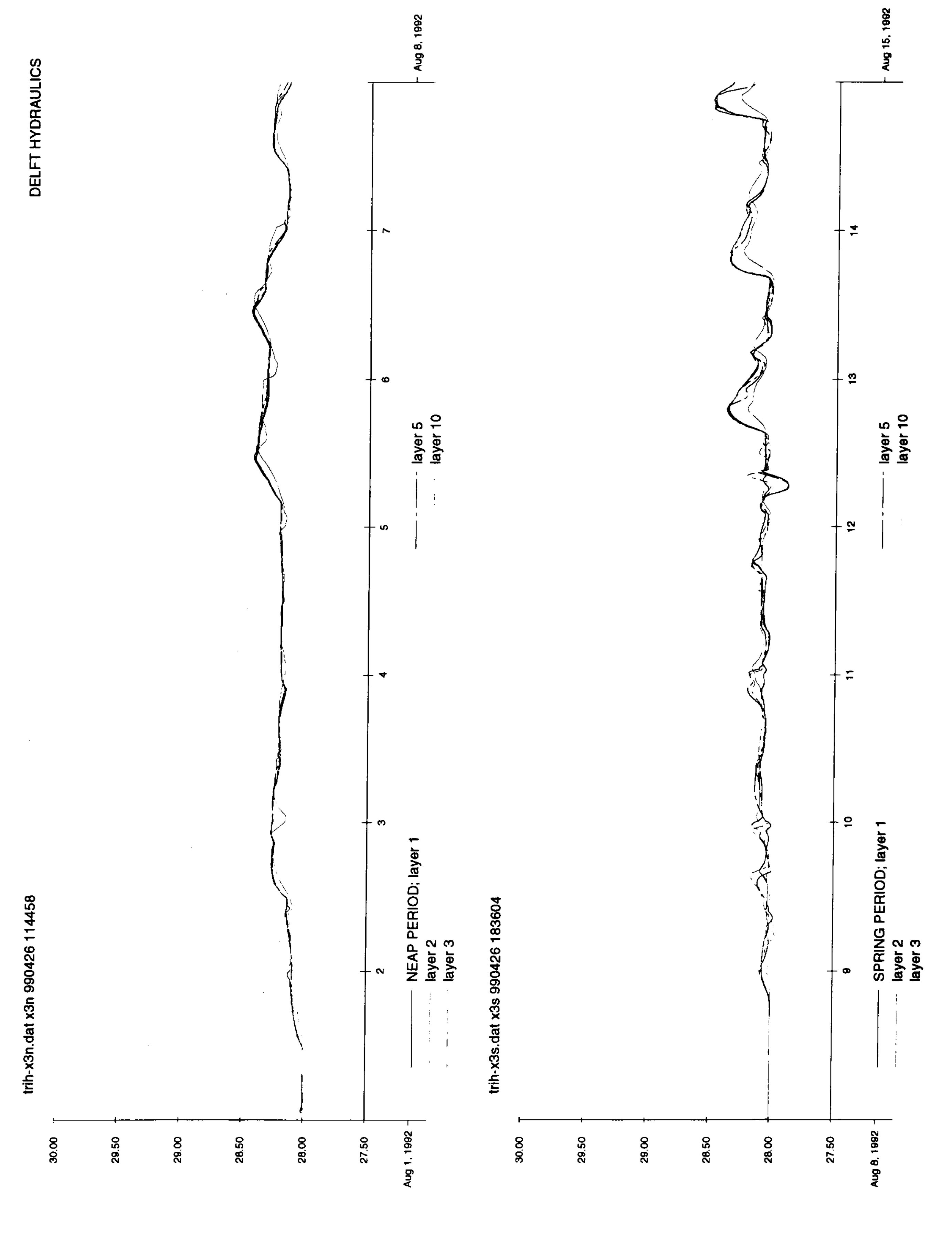

FIGURE A4

TIME SERIES OF TEMPERATURE AT HUNG SHING YE BEACH
SCENARIO 1 - WET SEASON SPRING AND NEAP TIDES

Environmental Resources Management

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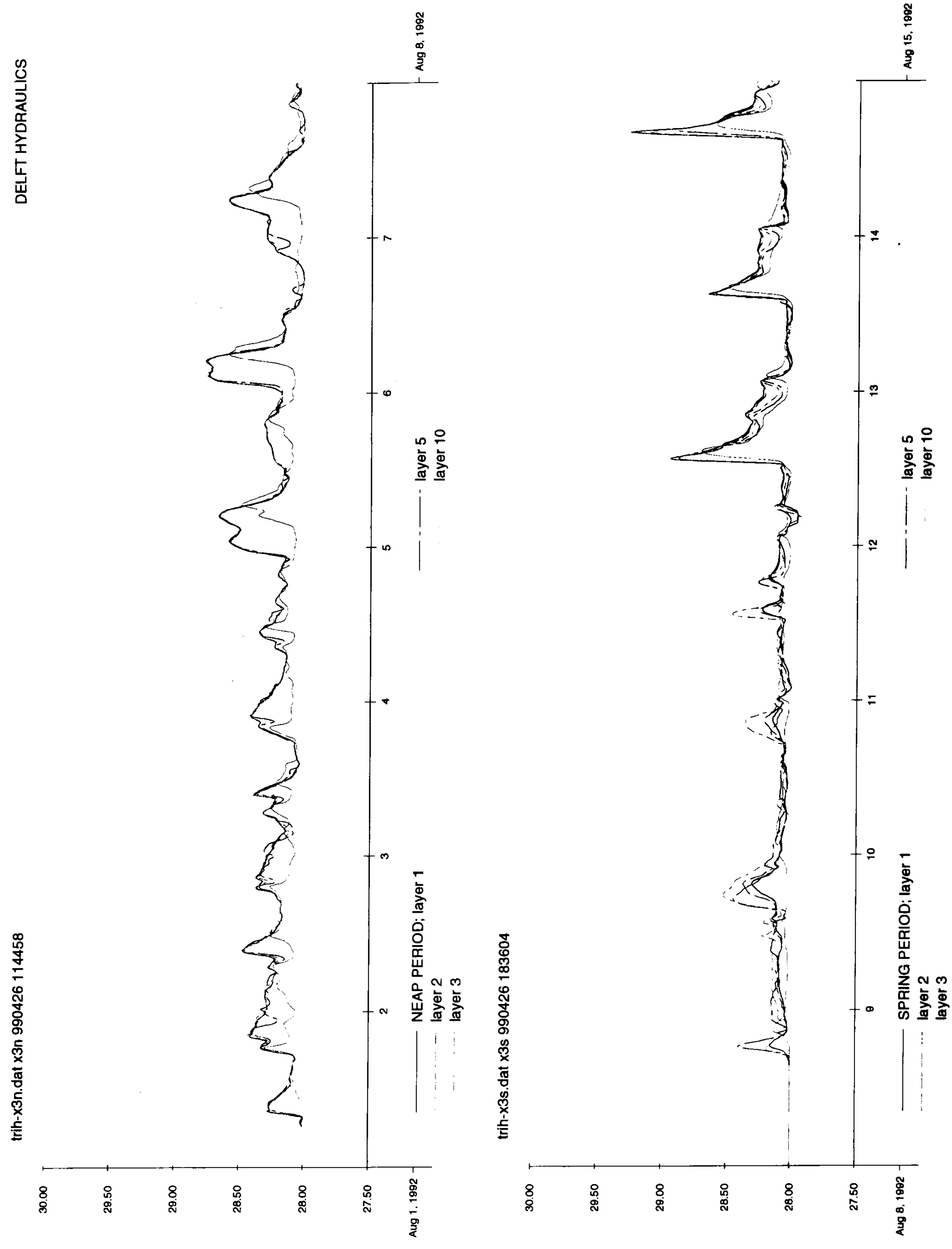


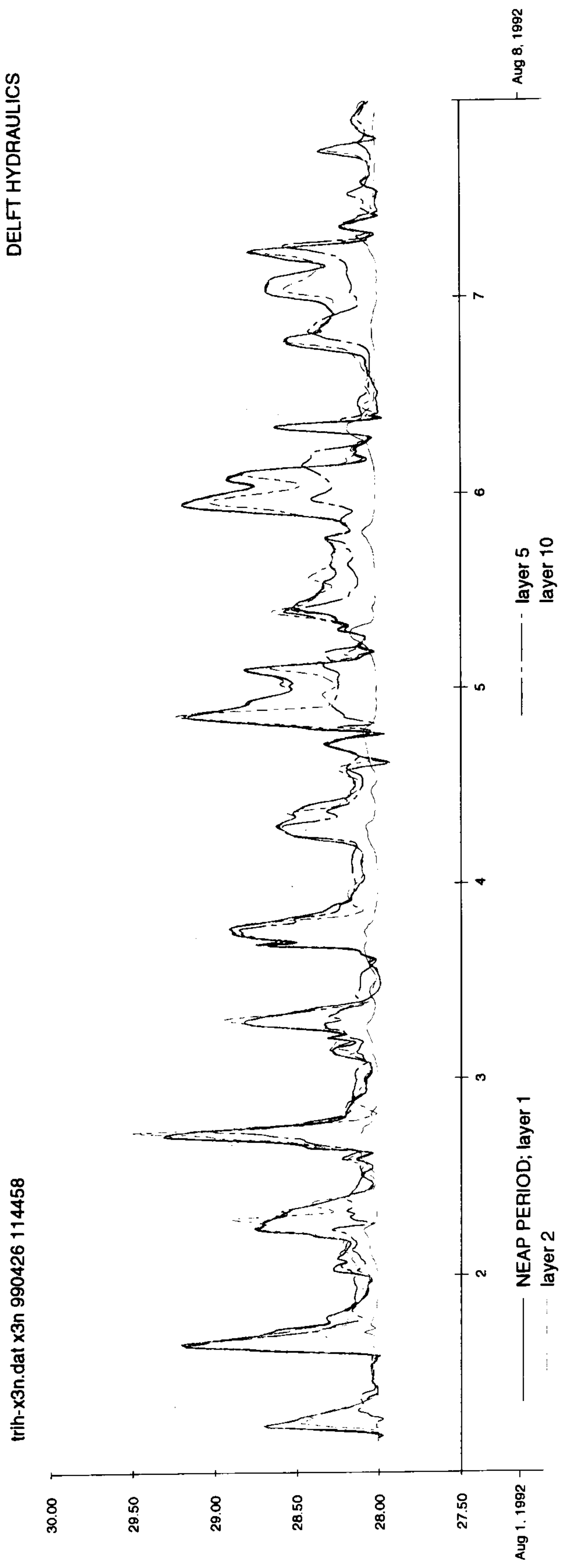
FIGURE A5

TIME SERIES OF TEMPERATURE AT LO SO SHING BEACH
SCENARIO 1 - WET SEASON SPRING AND NEAP TIDES

Environmental Resources Management

ERM

DELFT HYDRAULICS



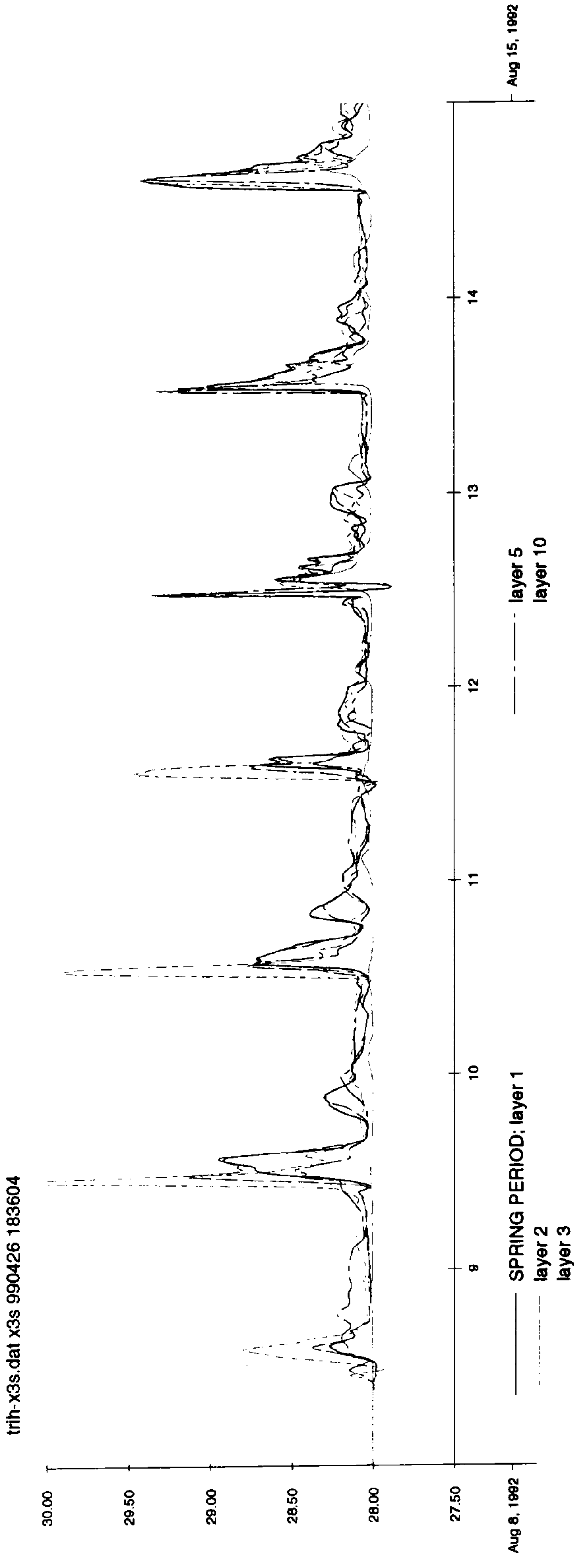


FIGURE A6	TIME SERIES OF TEMPERATURE AT SOUTH LAMMA MARINE PARK 1 SCENARIO 1 - WET SEASON SPRING AND NEAP TIDES	Environmental Resources Management ERM

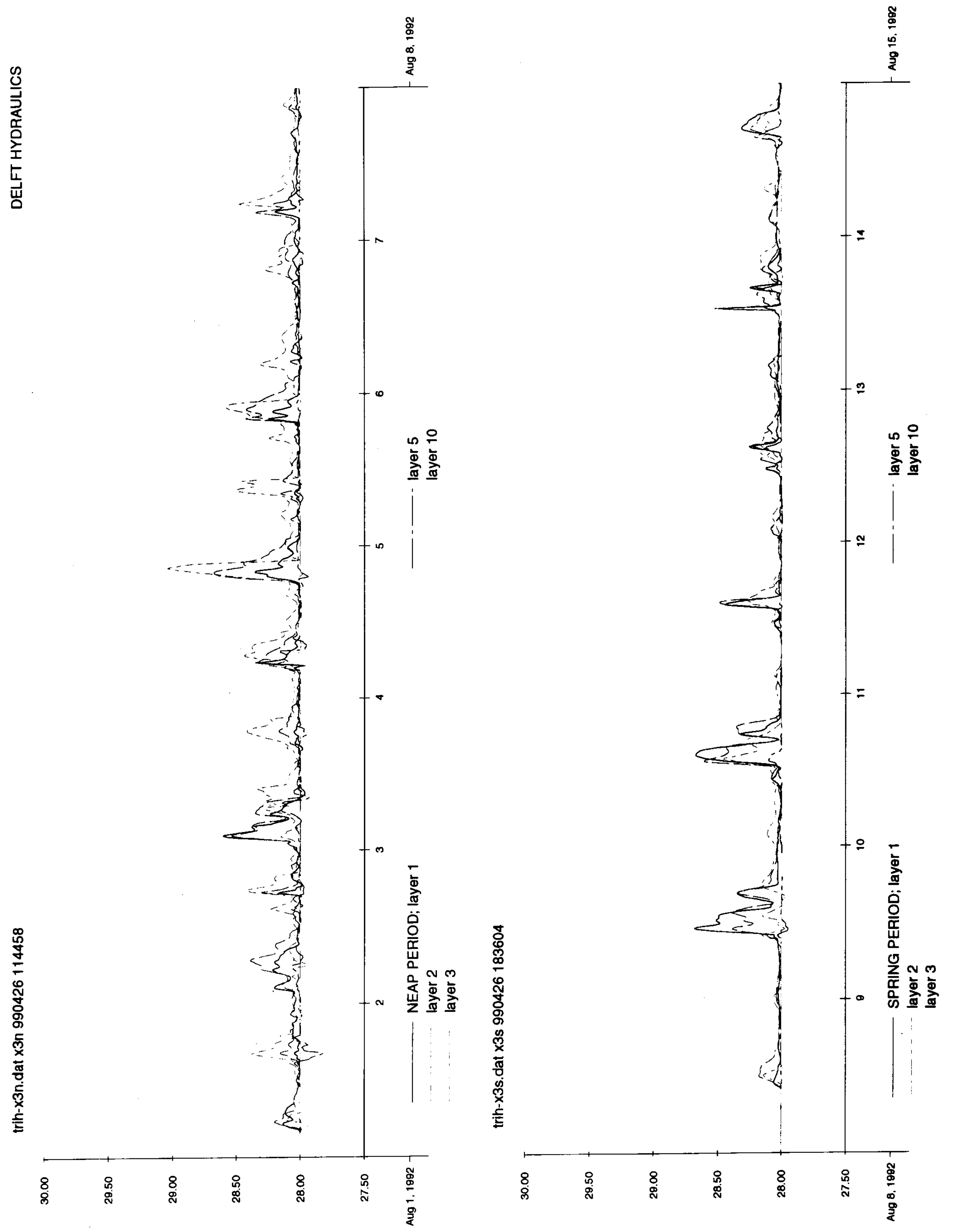


FIGURE A7 TIME SERIES OF TEMPERATURE AT SOUTH LAMMA MARINE PARK 2
SCENARIO 1 - WET SEASON SPRING AND NEAP TIDES

Environmental Resources Management

ERM

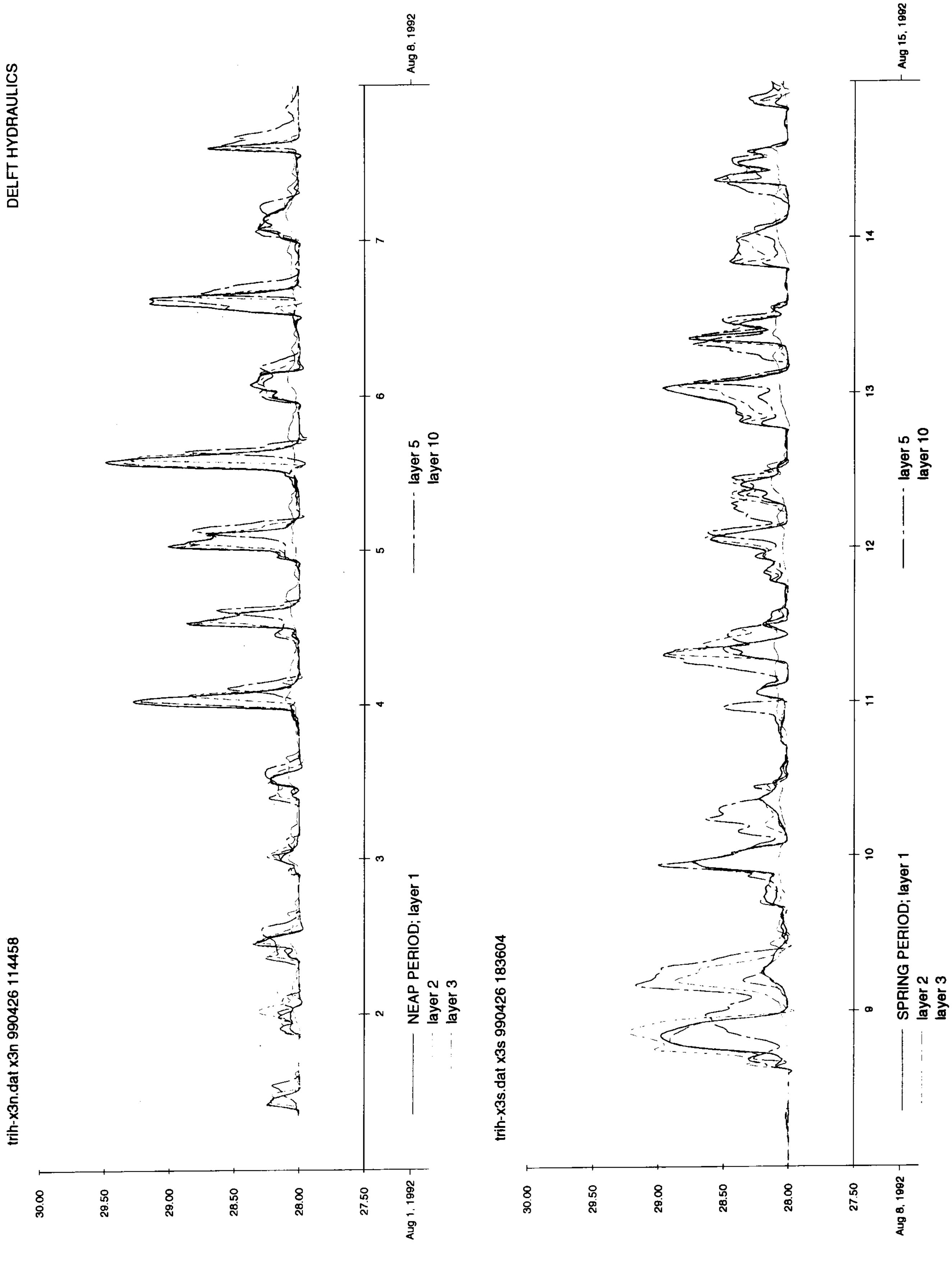


FIGURE A8

TIME SERIES OF TEMPERATURE AT AHEK KOK TSUI
SCENARIO 1 - WET SEASON SPRING AND NEAP TIDES

Environmental Resources Management

ERM

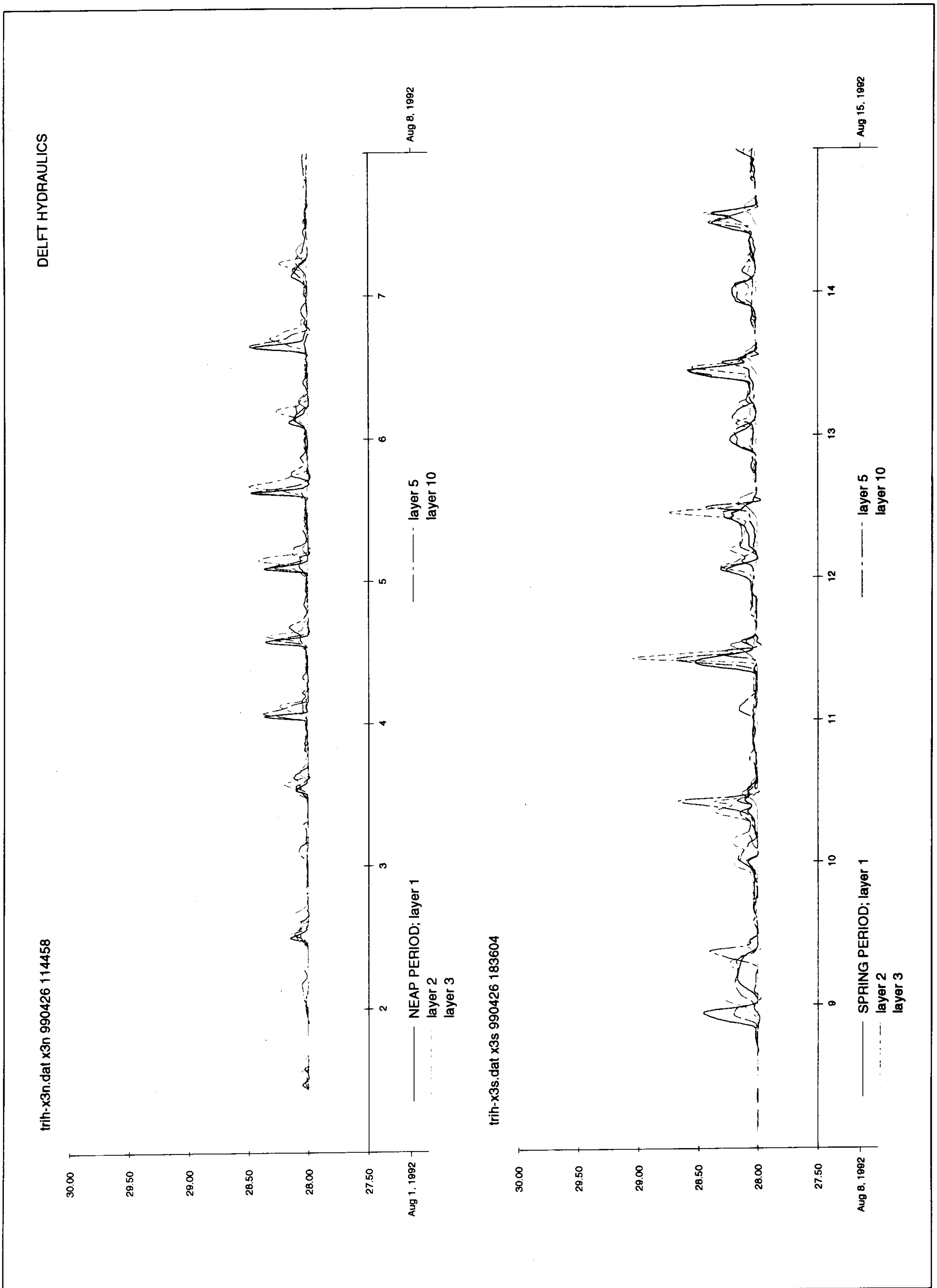


FIGURE A9

TIME SERIES OF TEMPERATURE AT PAK KOK
SCENARIO 1 - WET SEASON SPRING AND NEAP TIDES

Environmental Resources Management

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Annex B

Thermal Discharge Modelling Results for Scenario 2 - Lamma Power Station after Conversion of the Two Gas Fired Units to Combined Cycle Operation

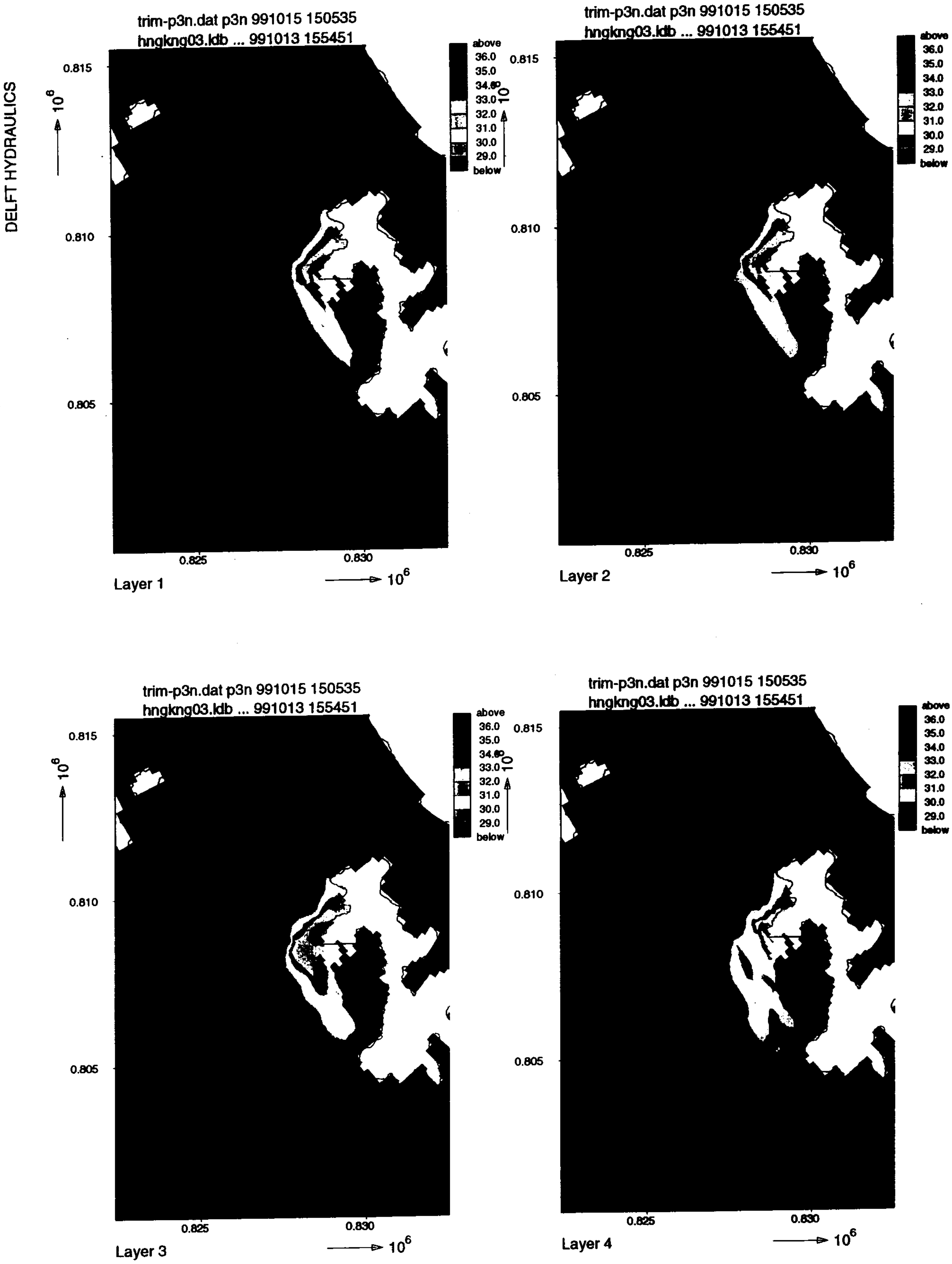


FIGURE B1	MAXIMUM TEMPERATURE FOR LAYERS 1 TO 4 SCENARIO 2 - WET SEASON NEAP TIDE	Environmental Resources Management ERM

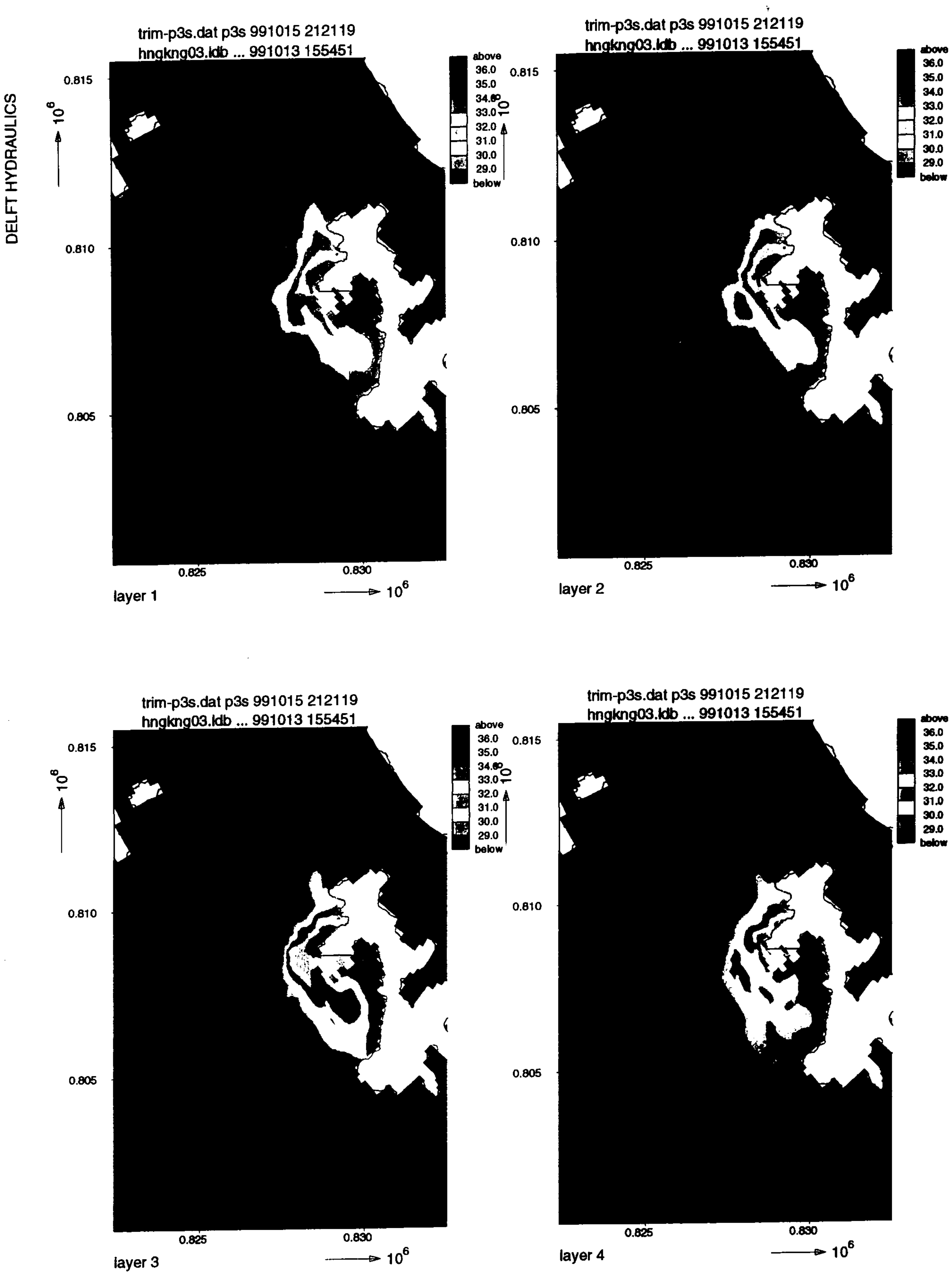


FIGURE B2

MAXIMUM TEMPERATURE FOR LAYERS 1 TO 4
SCENARIO 2 - WET SEASON SPRING TIDE

Environmental Resources Management

ERM

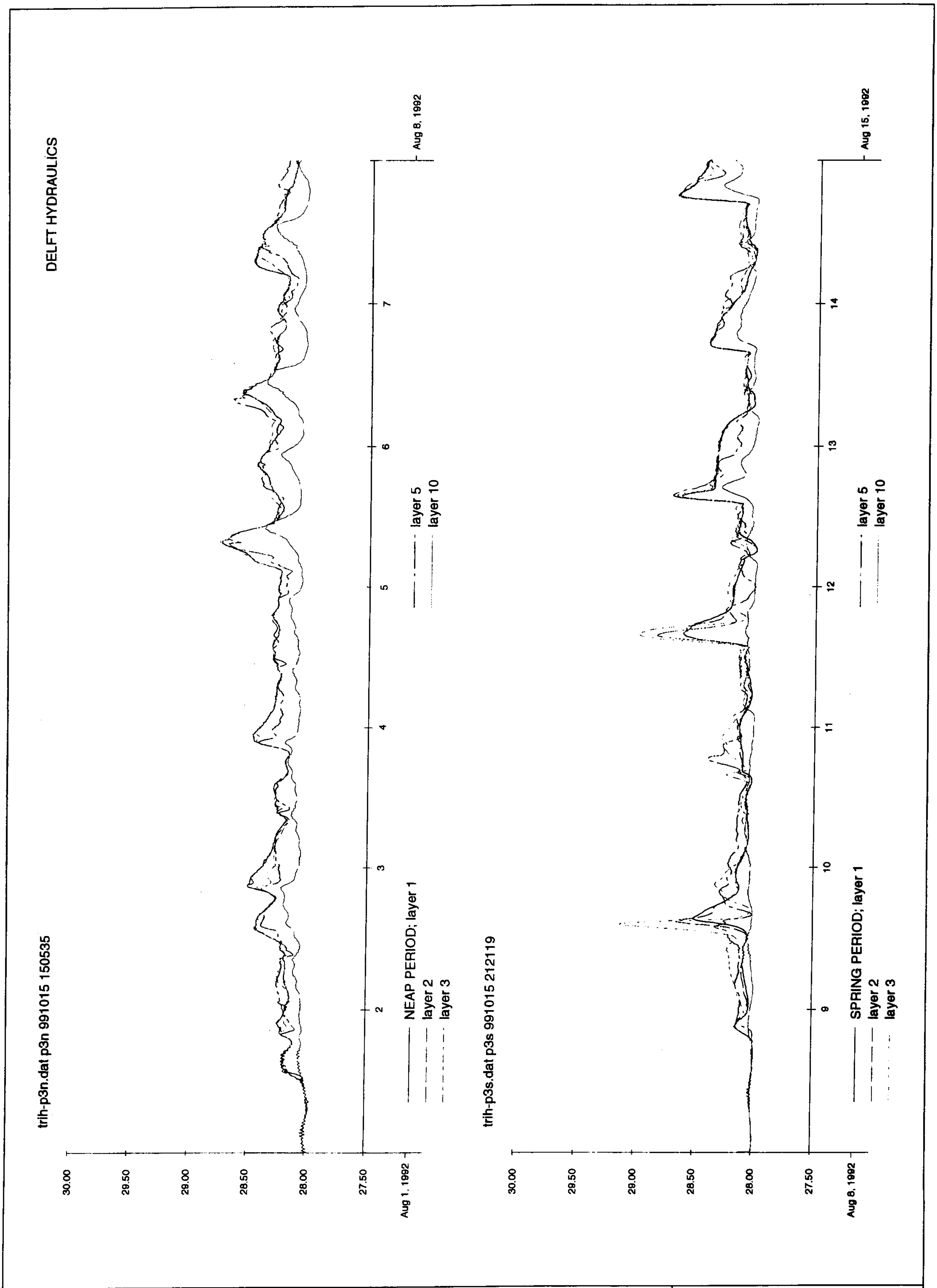
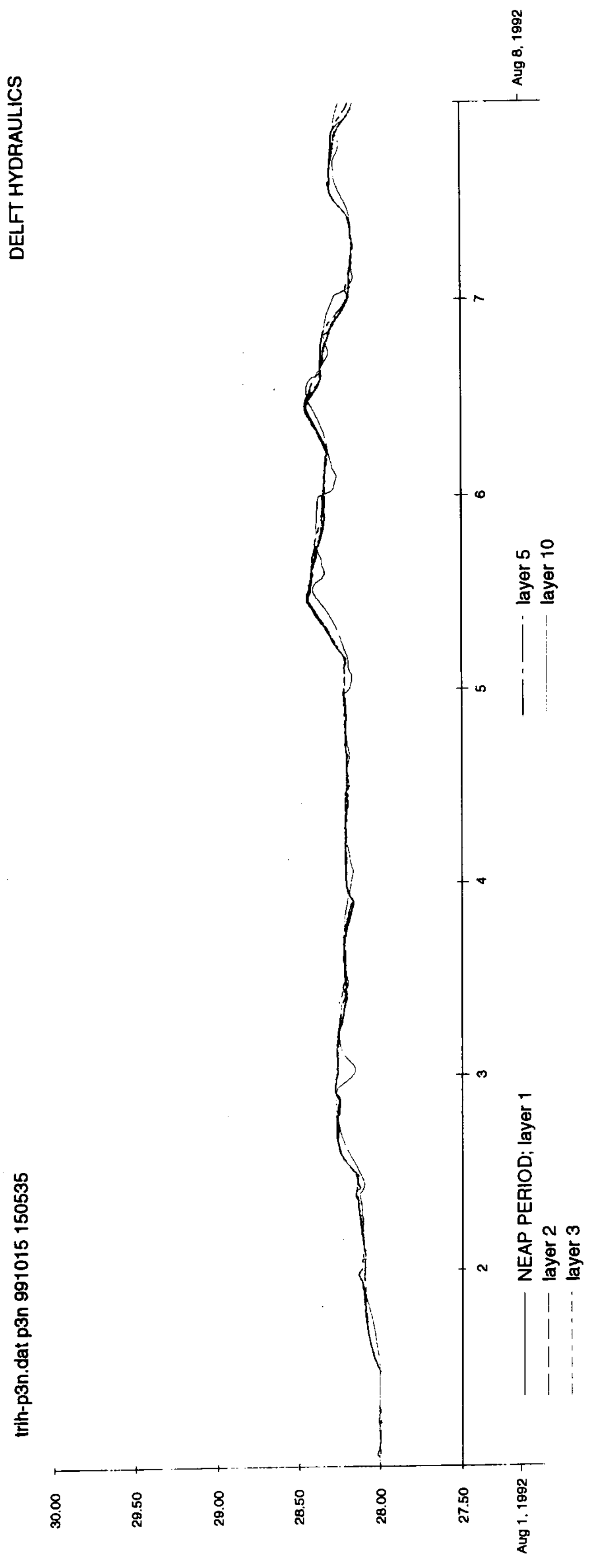


FIGURE B3 TIME SERIES OF TEMPERATURE AT LAMMA POWER STATION INTAKE SCENARIO 2 - WET SEASON SPRING AND NEAP TIDES

Environmental Resources Management

ERM

DELFT HYDRAULICS



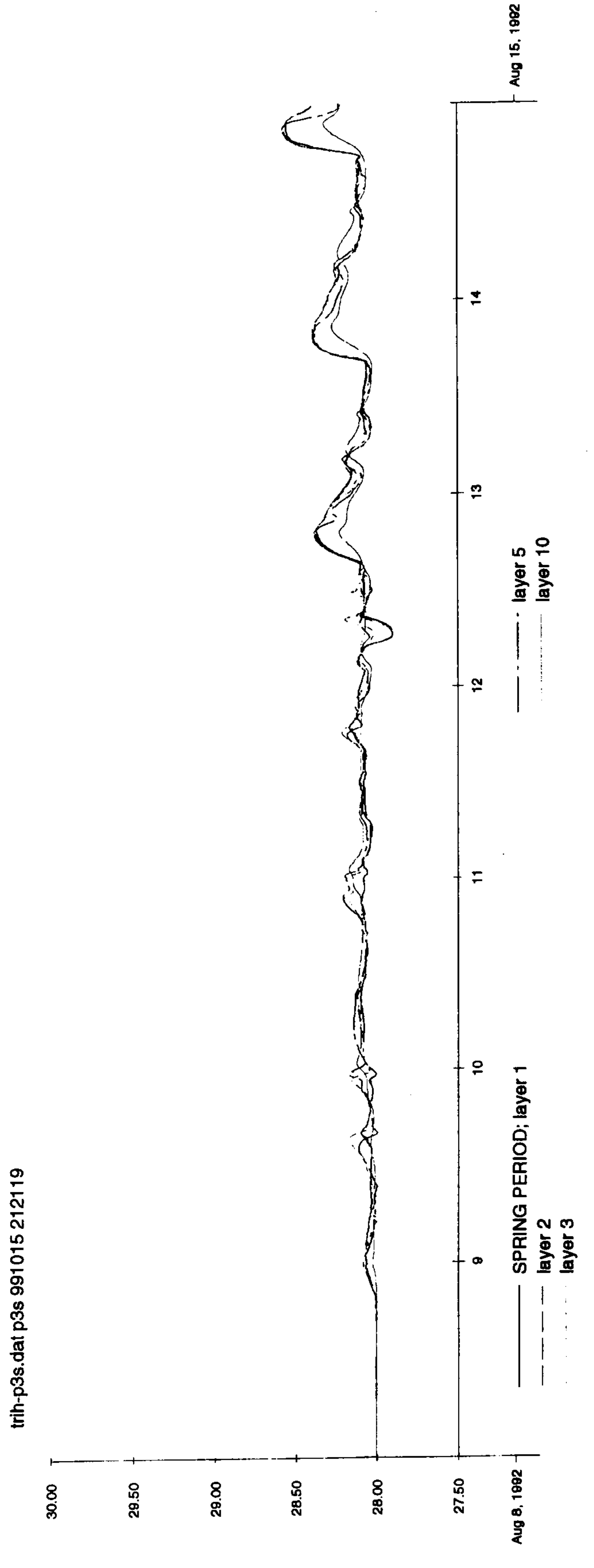


FIGURE B4 TIME SERIES OF TEMPERATURE AT HUNG SHING YE BEACH
SCENARIO 2 - WET SEASON SPRING AND NEAP TIDES

Environmental Resources Management

ERM

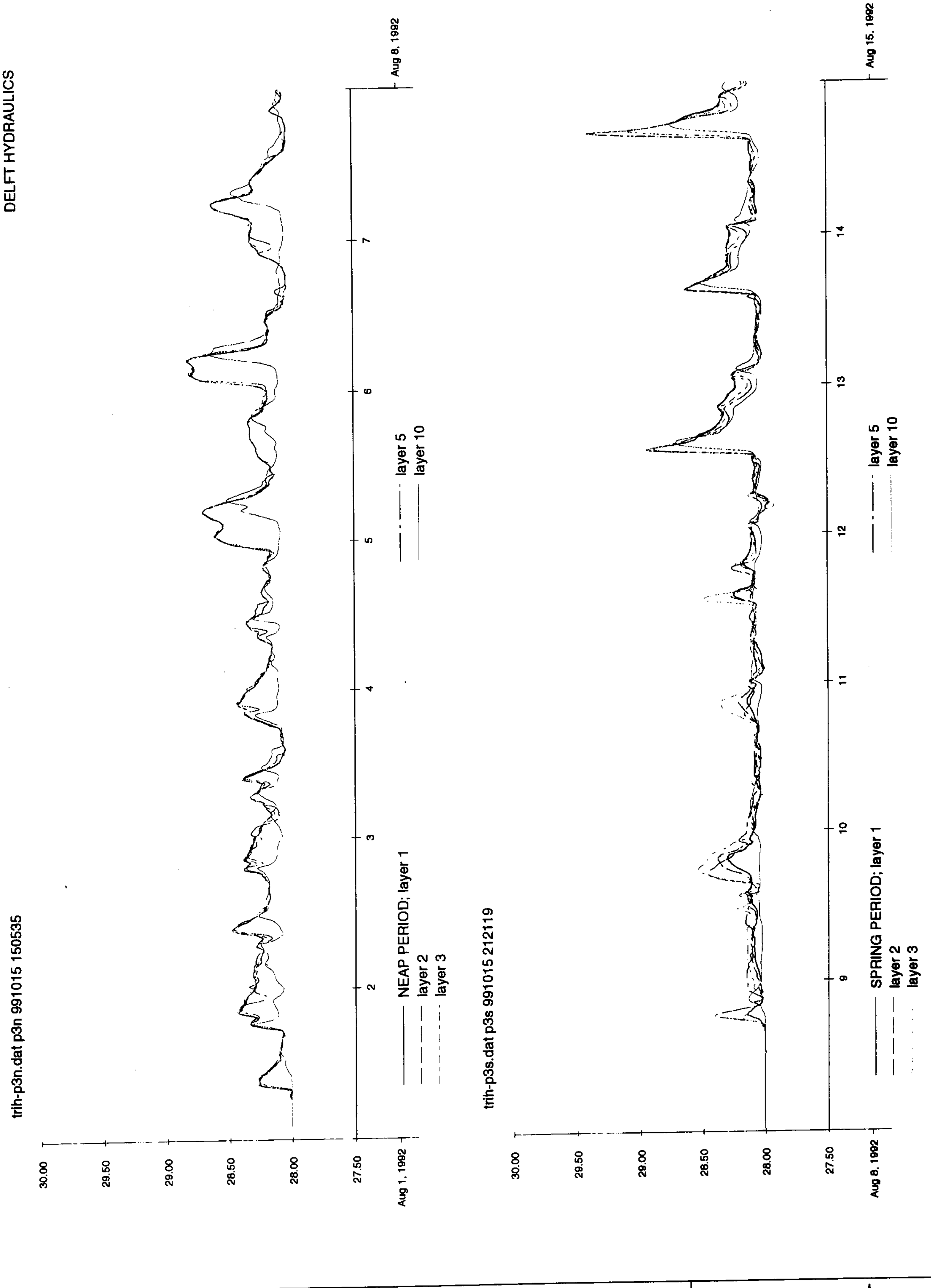


FIGURE B5 TIME SERIES OF TEMPERATURE AT LO SO SHING BEACH SCENARIO 2 - WET SEASON SPRING AND NEAP TIDES

Environmental Resources Management

ERM

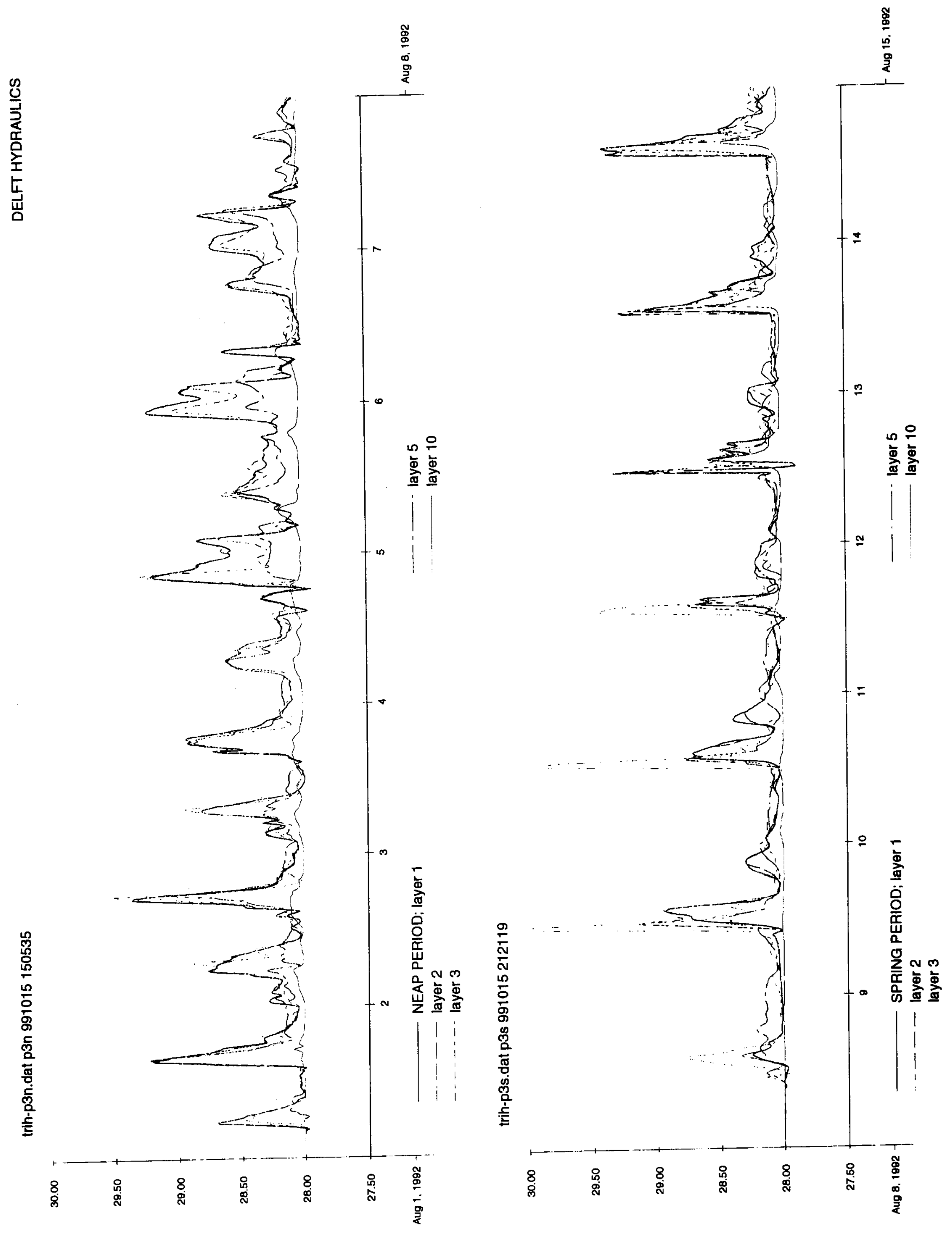


FIGURE B6 TIME SERIES OF TEMPERATURE AT SOUTH LAMMA MARINE PARK 1
SCENARIO 2 - WET SEASON SPRING AND NEAP TIDES

Environmental Resources Management

ERM

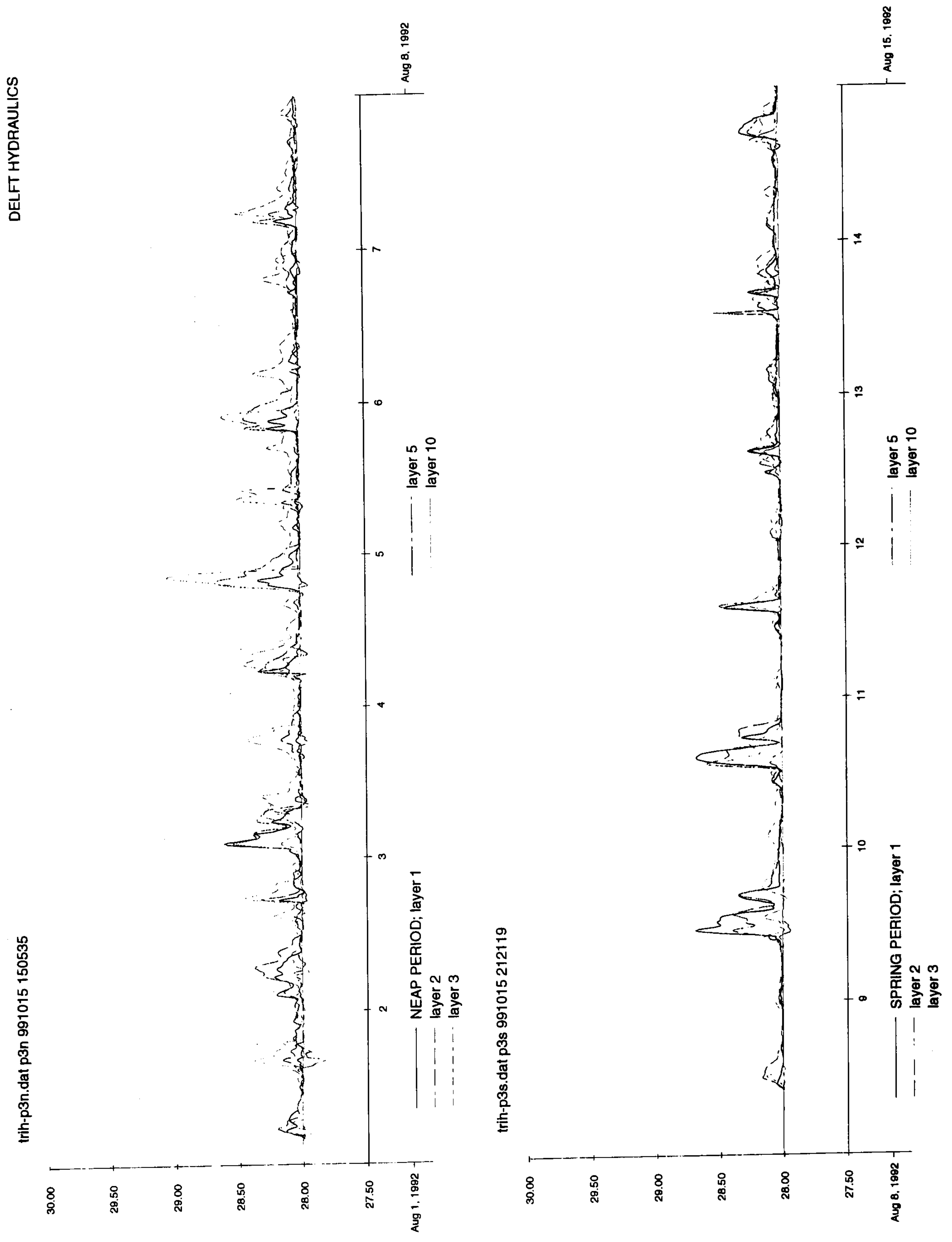


FIGURE B7 TIME SERIES OF TEMPERATURE AT SOUTH LAMMA MARINE PARK 2
SCENARIO 2 - WET SEASON SPRING AND NEAP TIDES

Environmental Resources Management

ERM

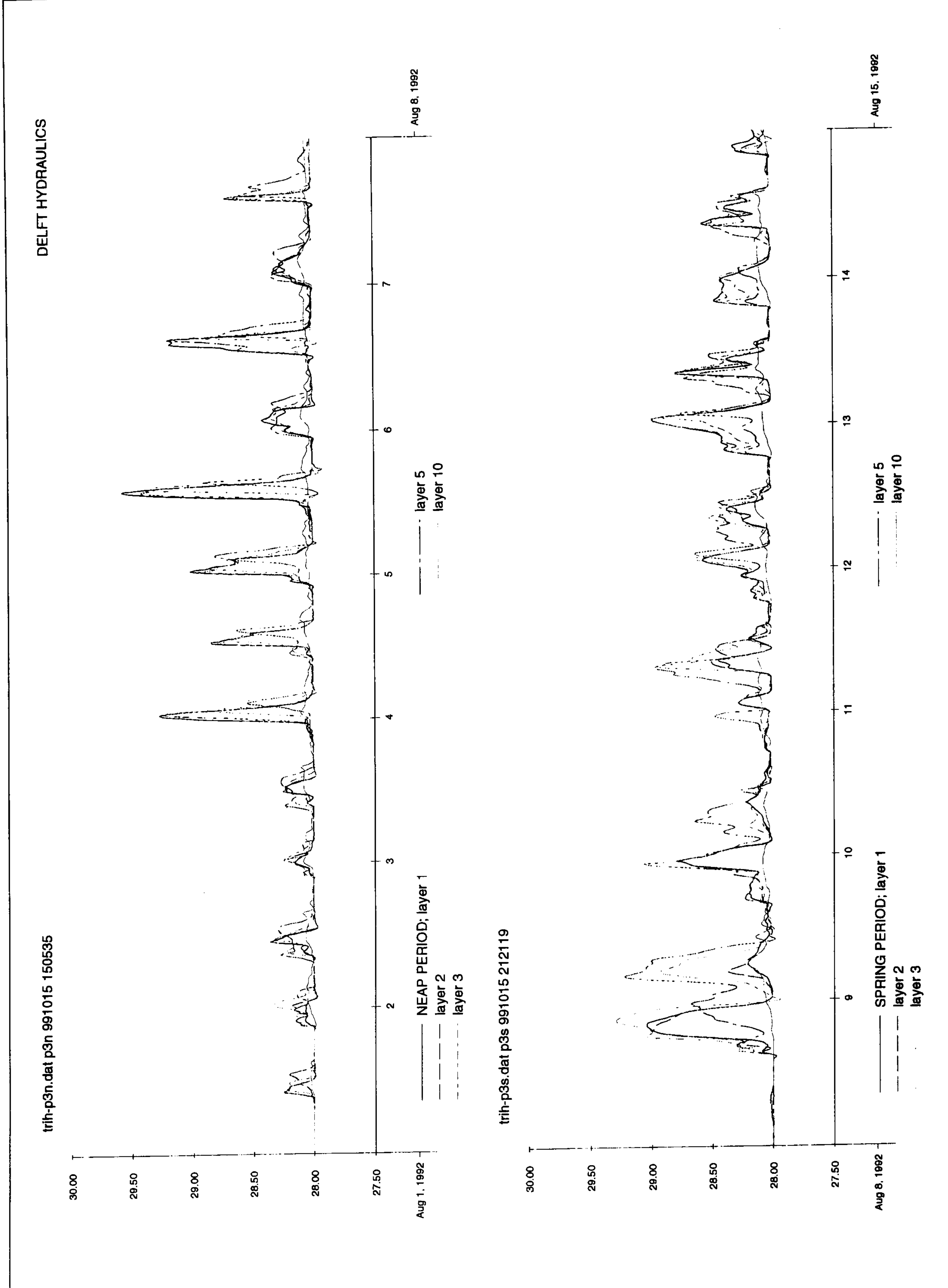


FIGURE B8

TIME SERIES OF TEMPERATURE AT SHEK KOK TSUI
SCENARIO 2 - WET SEASON SPRING AND NEAP TIDES

Environmental Resources Management

ERM

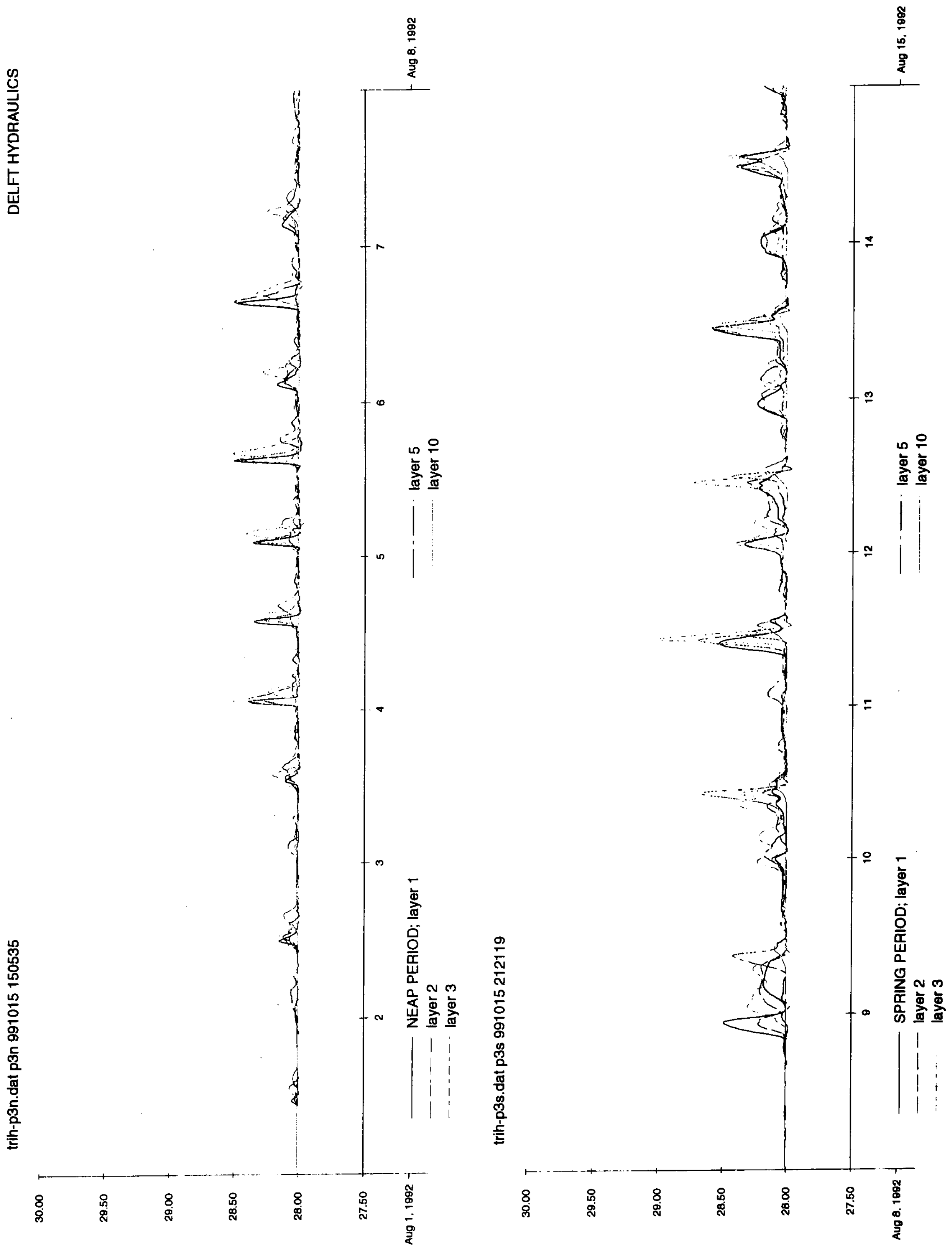


FIGURE B9

TIME SERIES OF TEMPERATURE AT PAK KOK
SCENARIO 2 - WET SEASON SPRING AND NEAP TIDES

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Annex D

View from West Lamma Channel of Proposed Conversion

FIGURE D1

VIEW FROM WEST LAMMA CHANNEL AT SEA LEVEL (WITHOUT CONVERSION)

FILE: C2035a
DATE: 28/02/00

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Management

ERM

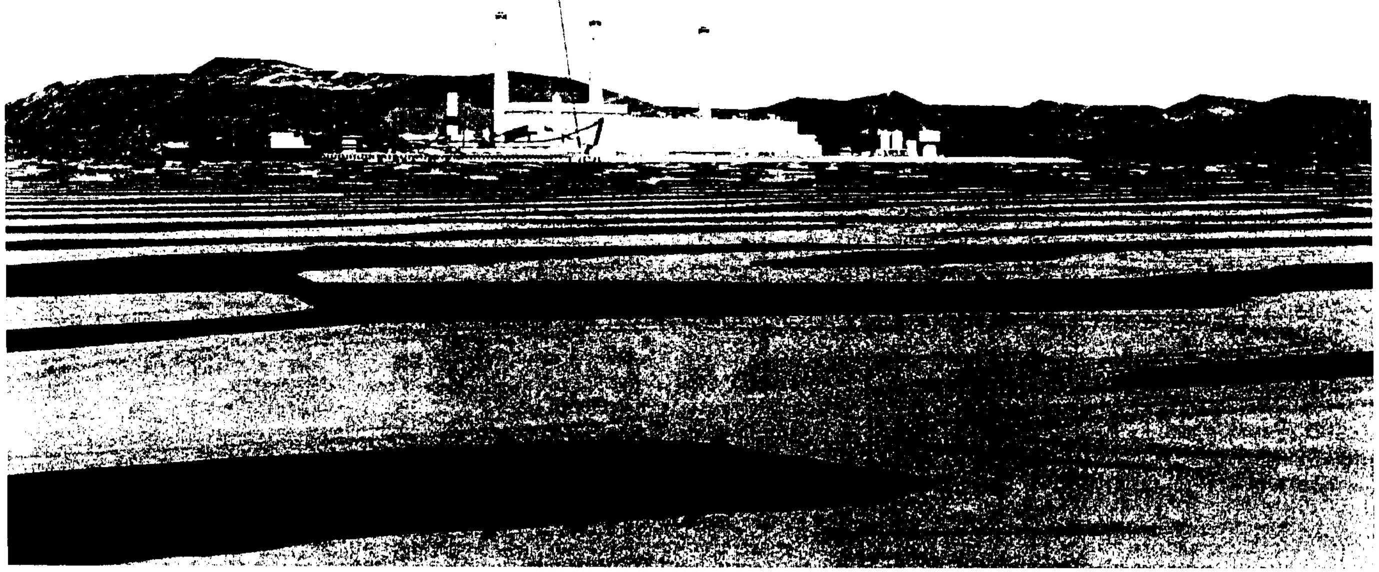

FIGURE D2

VIEW FROM WEST LAMMA CHANNEL AT SEA LEVEL (WITH CONVERSION)

FILE: C2035b
DATE: 28/02/00

Environmental
Resources
Management

ERM