

工程項目簡介

根據環境影響評估條例第5(10)條為獲豁免的指定工程項目的實質改變申請批准直接申請環境許可證

1. 引言

在南丫電廠擴建的第一台新燃氣發電機組於二零零四年投產前，香港電燈有限公司（以下簡稱“港燈”）計劃增加現有的發電容量以應付二零零二年的最高電力需求。此計劃是按照港燈根據最新的最高負荷增長預測而製訂的電力發展計劃。

為了篩選出最好的方案來增加發電量，以應付二零零二年的電力需求，港燈詳細考慮了各項有關技術、經濟、環境和時間因素，而建議將現有的兩台燃氣輪機加以改良。該兩台位於南丫發電廠的機組，現時是以單循環方式運作。根據建議，會將該兩台機組改裝為聯合循環的運作方式，將煙氣中的熱能加以回收，用以產生蒸汽，從而產生額外的電力，以應付南丫電廠擴建部份的燃氣機組於二零零四年投產前的電力需求。

按照港燈所建議的機組改裝計劃，需要將現有的燃氣輪機更新改裝。根據《環境影響評估條例》，這是一項對受豁免的指定工程（即現時的南丫發電廠）的實質改變。現有的南丫電廠曾經進行過環境影響評估研究（詳見第二十節之參考文件一），但該項環境影響評估研究（以下簡稱“環評研究”）只涉及至二零零零年為止的發電量對環境的影響。

與該工程較有實質關連的，是於一九九九年二月完成的南丫電廠擴建部份的環評研究（詳見第二十節之參考文件二）。這份環評研究報告，包括了為南丫電廠擴建部份所進行過的風洞模擬、水質評估、海洋生態和漁業影響的評估結果，均對這項工程有參考價值。這份環評研究報告認為，只要採納和實施該研究所建議的各項緩解措施，該發電廠在施工和運作時，均不會對環境造成不可接受或不可緩解的影響。然而，該等緩解措施主要是為工地平整和敷設海底輸氣管所需的挖泥工程而設，因此與這項機組改裝工程沒有直接關係。

這份工程簡介，旨在評估建議中的機組改裝工程在施工和運作期間對環境可能造成的影響，以便向有關當局申請批准為是項工程直接申請環境許可證。

2. 基本資料

2.1 工程項目名稱

改裝兩台現有燃氣輪機為聯合循環機組。

2.2 工程項目之目的及性質

港燈的南丫發電廠現時裝設有六台燃油氣輪發電機組（GT2至GT7），每台的發電量為125兆瓦，用以調峯及緊急備用之用。建議中的改裝工程將會裝設一個蒸汽循環輔助系統，主要包括裝設於GT5及GT7機組背後的兩個餘熱鍋爐和一個蒸汽輪機發電裝置，從而組成一個聯合循環機組。新建的蒸汽循環系統，將利用燃氣輪機排出廢氣所含的餘熱，額外產生115兆瓦的電力。

2.3 工程項目倡議人名稱

香港電燈有限公司（簡稱“港燈”）

2.4 工程項目的地點

圖2.4a顯示了建議的改裝工程的位置。是項工程將利用位於南丫電廠西南角的現有氣輪機之間的空地，裝設一個蒸汽循環輔助系統，以便將GT5及GT7機組所排放的廢氣中的餘熱回收，從而形成一個總發電量為365兆瓦的聯合循環機組。

2.5 聯絡人姓名及電話號碼

馬劉展萍女仕（公共事務經理） 電話：2843 3268

呂羅中先生（副公共事務經理） 電話：2843 3287

2.6 擬議的增補、改良及修改工程

是項機組改裝工程的其中一環，會將現時燃油的GT5及GT7機組，改裝成可以利用天然氣的機組。待南丫電廠擴建部份獲得天然氣的供應後，便會從擴建部份敷設輸氣管支線，為建議中的燃機改裝機組供應天然氣。由於南丫電廠擴建部份將會與現時的發電廠相連，因此上述輸氣管將會以架空或坑槽的方式在陸地上敷設。

現時的單循環燃氣輪機，是將尚含餘熱的廢氣直接排入大氣中，而不加利用。建議中的改裝工程，是要加裝一個蒸汽循環系統，以便利用餘熱鍋爐來回收GT5及GT7機組的煙氣廢熱，並利用這些熱能來產生蒸汽，然後推動一個蒸汽輪機進行再次發電。由燃氣輪機所排放的廢氣，在通過餘熱鍋爐後，會經由八十米高的現有燃氣輪機煙囪排放到大氣中。蒸汽循環系統所需的冷卻用水，會由新裝設的冷卻水泵供應，並經現有一號冷卻水出口，排放入海。圖2.6a展示了建議中的改裝工程將會裝設的新設備的佈局。這些設備包括：

- 兩個餘熱鍋爐；
- 一座汽機大樓，用以安放蒸汽輪機和輔助設施；
- 發電機及單元變壓器；以及
- 二個新增的冷卻水泵。

由蒸汽循環系統所產生的額外電力，令系統的熱能效益從現時單循環燃氣機組的約百分之三十大幅提升至百分之四十六。圖2.6b是改裝後的機組示意圖。

2.7 擬議的工程計劃

根據設計和施工所需要的時間，這項改裝工程的預訂竣工日期如下：

樓宇工程動工	二零零零年九月
發電機組開始安裝	二零零一年八月
發電機組開始運作	二零零二年七月
改以天然氣為燃料	二零零四年底

3. 對環境可能造成的影響

3.1 環境事宜的範圍

表3.1a羅列了將燃氣輪機改裝為聯合循環機組的計劃，在施工和運作期間對環境可能造成的影響。

表 3.1a 可能造成環境影響的項目

可能的影響	施工階段	運作階段
氣體排放	✓	✓
塵埃	✓	×
氣味	×	×
噪音	✓	✓
夜間操作	×	×
交通流量	×	×
污水排放或受污染的徑流	✓	✓
廢物或副產品的產生	✓	×
製造、貯存、使用、處理、運送、或棄置危險品或廢物	✓	✓
可能產生環境污染或傷亡的意外	×	✓
棄置廢物，包括可能受污染的物料	✓	×
干擾水流或海底沉積物	×	×
不悅目的外觀	×	×
文物古蹟	×	×
生態影響		
– 陸上	×	×
– 海洋	×	✓
附註： ✓ = 可能 × = 預計不會		

4. 廢氣排放

4.1 施工階段的廢氣排放

雖然建築機器所排放的廢氣可能會影響空氣質素，但由於工程規模很小，因此在施工期間所使用的建築機器將會很少；而且對空氣敏感的接收地點距離工地最近也超過八百米，中間更有南丫電廠的工業設施擋隔，因此預計施工期間不會對空氣質素造成不良影響。

4.2 運作階段的廢氣排放特點

是項改裝工程的目的，是要將現時GT5及GT7機組所排放煙氣中的餘熱有效地加以回收，否則這些熱能會被排進大氣之中。餘熱鍋爐的設計，只為回收燃氣輪機所排放的氣體中的熱能，並用以產生蒸汽。整個過程毋須任何燃料。因此，無論在改裝工程之前或之後，燃氣輪機所排放的廢氣都是唯一產生污染物的設施。由於燃氣輪機在改裝工程完成後，將會改用天然氣而非燃油作為燃料，因此改裝工程將會令污染物的排放量大幅減少。詳見表4.2a。

表4. 2a GT5及GT7改裝之前和之後的廢氣排放特點（於排放源）

	改裝前 (燃油) (現時的指定工序牌照)	改裝後 (燃氣)
二氧化硫(微克/立方米)	290	10
氮氧化物(微克/立方米) (以二氧化氮表示)	185	90
塵粒(微克/立方米)	12	5
最低排放溫度(攝氏)	390	80
最低排放速度(米/秒)	32	15
附註： 本表所列的各種空氣污染物濃度，均屬氣溫在攝氏零度，氣壓在101.325千帕斯卡及氧氣濃度為百分之十五的乾燥大氣狀況下的數字。		

4.3 最高時均地面濃度

在南丫電廠擴建的環評研究中，已利用了風洞模擬分析、預測了在改裝工程後，南丫電廠產生的污染物（即不包括其擴建部份）在敏感接收地點的累積地面濃度。風洞模擬的結果羅列於附件A，以供參考。

表4. 3b列載了在改裝工程前後的情形下，根據表4. 3a中的負荷預測，在最高發電量情況下各敏感接收地點二氧化硫及氮氧化物的每小時平均濃度。結果顯示，各敏感接收地點的二氧化硫及氮氧化物地面濃度將不會超出“空氣質素指標”的有關規定。

表4. 3a 在最高發電量時，改裝工程前後的最差情況下的負荷預測（單位：兆瓦）

	L8	L7	L6	L5	L4	L2	L1	L3	GT5/7	GTs	合計
改裝前	350	350	350	350	350	250	250	250	0	435	2935
改裝後	350	350	350	350	350	250	250	250	365	185	3050

表4. 3b 累積時均二氧化硫及氮氧化物地面濃度（微克/立方米）的預測

污染物	改裝前 (發電量2935兆瓦)	改裝後 (燃油發電) (發電量3050兆瓦)	改裝後 (燃氣發電) (發電量3050兆瓦)	空氣質 素指標
二氧化硫	69-788	58-796	51-697	800
氮氧化物	52-262	52-293	51-264	300

GT5及GT7機組在改裝工程完成後，初期仍會以燃油發電，直至南丫電廠獲天然氣供應為止。就算在以最高發電量3,050兆瓦運作的最差情況下，按百分之零點二的含硫量燃油為燃料計算累積的地面濃度，如表4. 3b所顯示全都低於空氣質素指標。若以燃氣發電，預計地面濃度將會顯著下降。

4.4 溫室氣體排放

改裝工程除了會減少二氧化硫和氮氧化物的排放量外，二氧化碳的排放亦可減少。這是因為機組熱效能的提高（從百分之三十增至百分之四十六）和GT5及GT7機組將會從燃油發電改為燃氣發電，並改裝為聯合循環機組所致。表4.4a顯示了經過改裝的機組和單循環燃油氣輪機組生產每千瓦小時電力所分別排放的二氧化碳。

表4.4a 每千瓦小時之二氧化碳排放量比較

	燃機改裝機組 (燃氣發電)	燃機改裝機組 (燃油發電)	燃油氣輪機組
二氧化碳排放量 (公斤/千瓦小時)	0.39	0.55	0.81

5. 塵埃

由於擬建的餘熱鍋爐將位於已平整的土地上，因此只需要極少量地盤平整工程；加上實施適當的緩解措施，預計在施工時不會造成塵埃滋擾。

當GT5及GT7機組改用天然氣作為燃料時，預計所排放的塵粒將會減少約百分之六十（見表4.2a），因此將燃氣輪機改裝為聯合循環發電機組，有助於改善環境質素。

6. 氣味

預計建議中的工程在施工和運作階段都不會造成氣味滋擾。

7. 噪音

7.1 易受噪音滋擾的地點

在南丫島北端的民居（多屬一至三層的住宅樓宇），大都集中在榕樹灣，以及附近的鄉村，包括榕樹塢、沙埔、高塢、橫塢和大灣新村。這些民居大都受發電廠北面的山丘（螭螭礪）的遮擋而不同程度上免受發電廠的噪音滋擾。

由於該區地形複雜，再加上當地居民過去曾經表達對噪音的關注，所以顧問列選了四個具代表性對噪音敏感的地點（表7.1a示）作出研究。

表 7.1a 對噪音敏感地點的位置

地點編號	位置	與地盤距離(米)
NSR1	龍仔村／洪聖爺	1150
NSR2	高壟	850
NSR3	榕樹灣港對上之北坡	1300
NSR4	大灣新村內之學校	1200

7.2 施工階段

為了預測建築機器可能造成的噪音滋擾，顧問已進行了一項建築噪音評估（見附件B）。表7.2a展示了噪音敏感接收地點由建築噪音引致的噪音聲級。

表 7.2a 對噪音敏感地點的一般建築噪音(日間，早上七時至晚上七時)的預測

施工期間 (月／年)	NSR 1 法例標準 75分貝(A)	NSR 2 法例標準 75分貝(A)	NSR 3 法例標準 75分貝(A)	NSR 4 法例標準 65分貝(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

預計所有在施工階段的噪音聲級均在有關的政府標準範圍內，因此在為期二十二個月的施工階段內，將不會有額外的噪音滋擾。

7.3 運作階段

經過改裝後的發電機組在運作階段可能產生的噪音聲級列於表7.3a，而有關的計算詳情則在附件B內加以闡述。雖然在室外量度到的背景噪音是51.7分貝(A)，但加上3分貝(A)的外牆反射修正之後，背景噪音應為55分貝(A)，相等於《環境影響評估程序的技術備忘錄》所列載的“可接受噪音聲級”。

表 7.3a 經過改裝的聯合循環機組在運作期間噪音聲級的預測

地點編號	位置	噪音聲級 (分貝(A))
NSR 1	龍仔村／洪聖爺	41
NSR 2	高壟	44
NSR 3	榕樹灣港對上之北坡	39
NSR 4	大灣新村內之學校	40

雖然經過改裝的發電機組本身所產生的噪音遠低於55分貝(A)，不過，經過改裝的燃氣輪機和現有發電廠所共同產生的累積噪音，則是按照上述研究結果而計算。正如南丫電廠擴建部份的環評研究報告所指出，現有發電廠可能產生的最大噪音，可以根據有關的監察資料而作出保守估計。表7.3b所示，是運作階段的預計累積噪音聲級。

表 7.3b 運作階段之累積噪音聲級

地點編號	位置	現有發電廠 (分貝(A))	燃機改裝機組 (分貝(A))	整體噪音聲級 (分貝(A))
NSR 1	龍仔村／洪聖爺	55	41	55
NSR 2	高壟	55	44	55
NSR 3	榕樹灣港對上之北坡	55	39	55
NSR 4	大灣新村內之學校	55	40	55

整體的評估結果顯示，經過改裝的機組將不會令各個噪音敏感地點的現有噪音環境惡化。在NSR 2地點感測到由燃機改裝機組所產生的噪音預計會比背景噪音約低11分貝(A)，而比60分貝(A)的日間標準低16分貝(A)。此外，在正常情況下，改裝機組只會在夏季日間的做調峯運作，因此所產生的些微額外噪音只會局限於夏季日間。

如上所述，在對噪音敏感地點所感測到的南丫電廠累積噪音是55分貝(A)，比60分貝(A)的日間標準低5分貝(A)。因此預計該發電廠在運作階段所產生的噪音不會超出有關的標準，而燃機改裝機組的運作亦不會令各噪音敏感地點所感測到的整體噪音聲級有明顯變化。

8. 夜間運作

預計建議中的機組改裝工程，無論在施工還是運作階段，在正常情況下都毋須在夜間運作。

9. 交通流量

由於建議的改裝位址位於南丫島，因此不會產生任何陸上交通。此外，建議中的改裝工程將會利用燃氣輪機所產生的餘熱，而毋須其他燃料，因此亦毋須運送額外燃料至發電廠。

預計這項工程對現有交通情況將不會造成任何影響。

10. 污水排放或受污染徑流

10.1 施工階段

因建議中的工地位於已平整的土地上，預計這些工程將產生極少的徑流，並不會對水質造成不良影響。

10.2 運作階段

顧問已就建議中將現有發電廠的兩台燃油氣輪機改裝為一台聯合循環機組的工程所排放的冷卻用水，對水質、海洋生態及漁業可能造成的影響進行了評估（見附件C）。對於冷卻用水的排放情形，亦利用了溫排水電腦模型來進行模擬分析。

水質評估的預測顯示，南丫電廠兩台燃油氣輪機改裝為一台聯合循環機組將引致整體溫水排放量輕微增加百分之三，這只會對現有溫水區的大小及殘餘氯氣的排放有微不足道的影響。報告認為這微量的改變亦將不會明顯增加泡沫的形成。假若泡沫的產生真的成為問題，亦可透過適當措施去把泡沫包圍於排放口附近加以控制。報告總結這項改裝工程對水質的影響在環境方面是可接受的，因此毋須指定任何緩解措施。

11. 廢物及副產品之產生

在建議中的改裝工程於施工期間，將會產生建築廢物。此外亦會產生工業廢物，例如包裝物料等。若能將這些廢物盡量妥善分類、循環再用和棄置，預計將不會造成不良的建築廢物影響。

12. 製造、貯存、使用、處理、運送或棄置危險物品或廢物

所有燃油均會按照南丫電廠的現行方法處理。由於餘熱鍋爐會利用現有燃氣輪機的煙氣餘熱，因此毋須使用額外燃油。

在興建和使用任何氣體裝置時，均會按照有關當局對南丫電廠擴建部份所指定的條件，並符合《氣體安全（氣體供應）規例》的有關規定。

13. 可能產生環境污染或傷亡的意外

改裝機組在興建和使用任何氣體裝置時，均會遵照《氣體安全（氣體供應）規例》的規定。在南丫電廠擴建部份的首台機組投產前，及深圳液化天然氣接收站開始為該發電廠供應天然氣之前，該燃機改裝機組會以燃油發電。當獲政府依例批准後，機組將重新改裝以用燃氣發電。

14. 棄土的處理

在為餘熱鍋爐平整地盤時，只會挖出極小量的泥土，因此預計在處置棄土時將不會對環境造成不良影響。

15. 對水流及海底沉積物的干擾

由於毋須填海，因此將不會對水流和海底沉積物造成影響。

16. 視覺及景觀影響

現時的GT5及GT7，以及建議中的燃機改裝機組均位於現有的發電廠內，因此將不會直接影響南丫島的現有地形和海岸特色。燃機改裝機組將會被低景觀質素的電廠設備所包圍。新建的餘熱鍋爐和汽機大樓均為低視覺特徵的小規模建築物（最高的電機結構約有三十五米，而最高的樓房類建築物則為二十米）。若從南丫島上人煙較多的地區望向發電廠，視線大都會被菠蘿咀遮擋。若能為新建的建築物選擇適當的配色，改裝工程所造成的任何視覺影響都可被現時發電廠的既有特色吸收。建議中的燃機改裝機組將和南丫電廠的現有裝置融合（見附件D）。

預計建議中的GT5及GT7機組改裝工程將不會對現有的環境造成視覺和景觀影響。

17. 文物古跡

由於建議的改裝工程位於發電廠範圍內的填海土地上，將不會影響文物古跡。

18. 生態影響

18.1 陸上生態

由於建議的改裝工程位於發電廠範圍內的填海土地上，將不會影響陸上生態。

18.2 海洋生態

根據溫排水模擬的結果，顧問做了一項對海洋生態及漁業資源的影響評估(見附件C)。電廠附近的海洋生態及漁業資源基線數據是取自於最近完成的南丫電廠擴建燃氣發電廠的環境影響評估報告。評估總結這項工程不會對海洋生態及漁業資源造成不良影響。

19. 緩解措施的詳情

基於上述各項評估，若能實施下列各項緩解措施，則建議中的改裝工程在施工和運作階段均不會對環境造成不良影響：

- 應用良好的工地管理措施去處理建築廢物、污水排放和一般建築噪音的緩解，例如：
 - 所有砂礫和物料必須加覆蓋或存放於一個有遮蔽的砂礫收集區內。按照《空氣污染管制條例》的規定實施控制塵埃的措施，例如在道路和多塵的位置洒水、以防水的布塊覆蓋貨車，並管制卸下填料的高度等。
 - 在整個施工階段於地盤內實施一般的噪音緩解措施，例如選用低噪音量的機動設備。將於星期日及公眾假期提供緩解建築噪音的措施，例如在噪音源頭裝設流動性的隔音屏障，或將使用機動設備的工序排編於較不敏感的時段內進行。
 - 建築廢物會在工地內妥善存放，並以有蓋的貨車或以密封的貨櫃來運送，務能將因風吹產生的垃圾和灰塵減至最低。所有廢物會按照《廢物處置條例》的規定棄置於領有牌照的地點。若有需要，會向有關當局申領棄置許可證。若有化學廢物需要處理，會按照有關的工作守則處理。

- 施工期間所排放的污水均會按照 ProPECC Note 的規定處理，並符合《水污染管制條例》的要求。
- 以燃油發電的燃機改裝機組將使用含硫量為百分之零點二的燃油為燃料。
- 以隔音物料將主要的運作期間的噪音源圍起。

20. 使用先前批准的環境影響評估報告

這份工程項目簡介曾參考下列環評報告：

參考文件一

名稱：香港電燈有限公司
南丫發電廠第7及8號機組
環境影響評估：最後初步評估報告

參考編號：EIA - 012/BC

獲批准時間：一九九二年五月

批准人：環境保護署署長

所涉及的環境事宜：

空氣質素	陸上生態
水質	景觀及視覺
噪音	社會經濟影響
廢物管理	海上運輸
海洋生態	環境監察與審核

參考文件二

名稱：香港電燈有限公司
南丫擴建之1,800兆瓦燃氣發電廠：
環境影響評估報告（1999年2月8日）

參考編號：AEIAR-010/1999

獲批准時間：一九九九年五月五日

批准人：環境保護署署長

所涉及的環境事宜：

空氣質素	生態
水質	漁業資源
噪音	景觀及視覺
廢物管理	生命安全
土地污染	

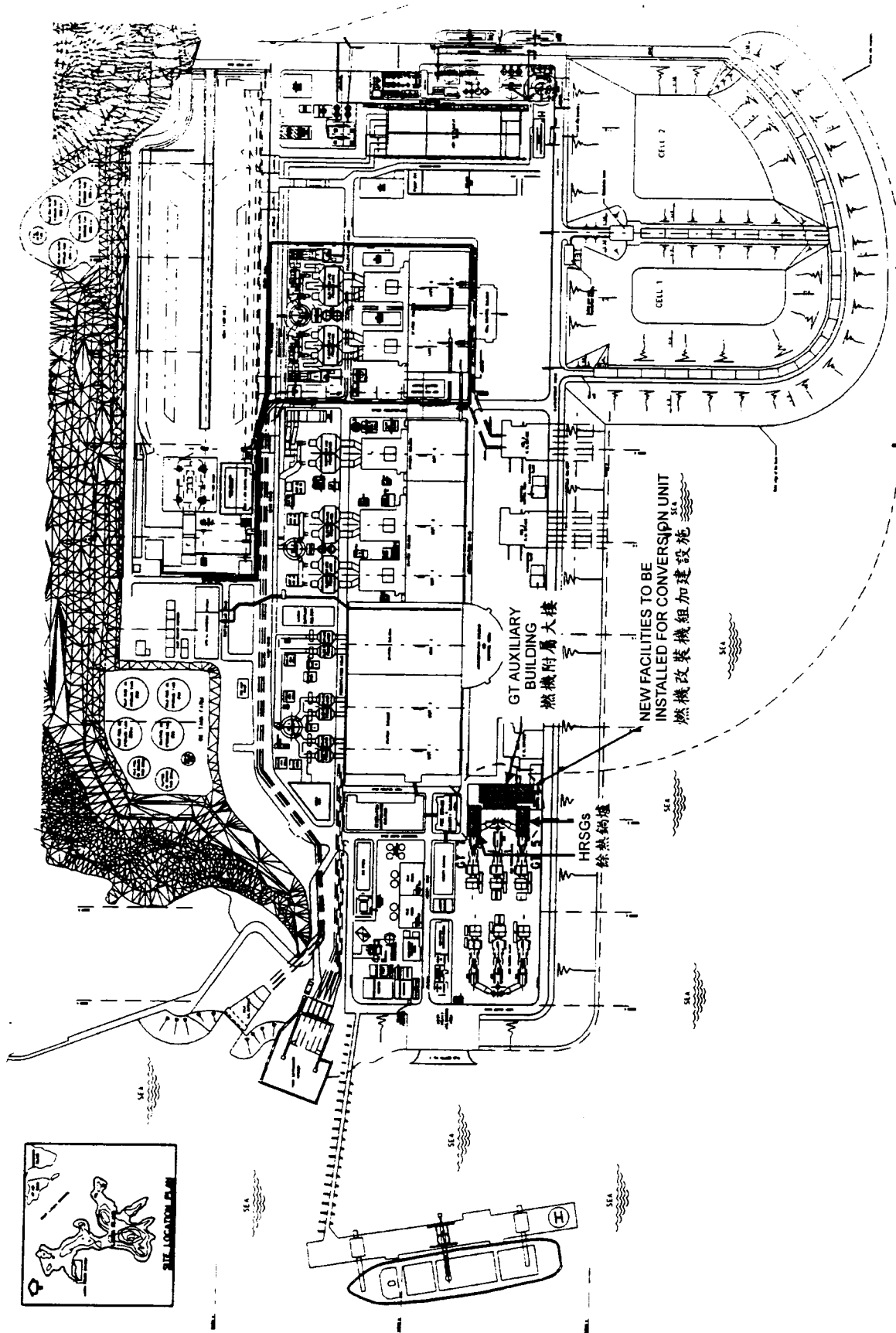


FIGURE 2.4a
圖 2.4a

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

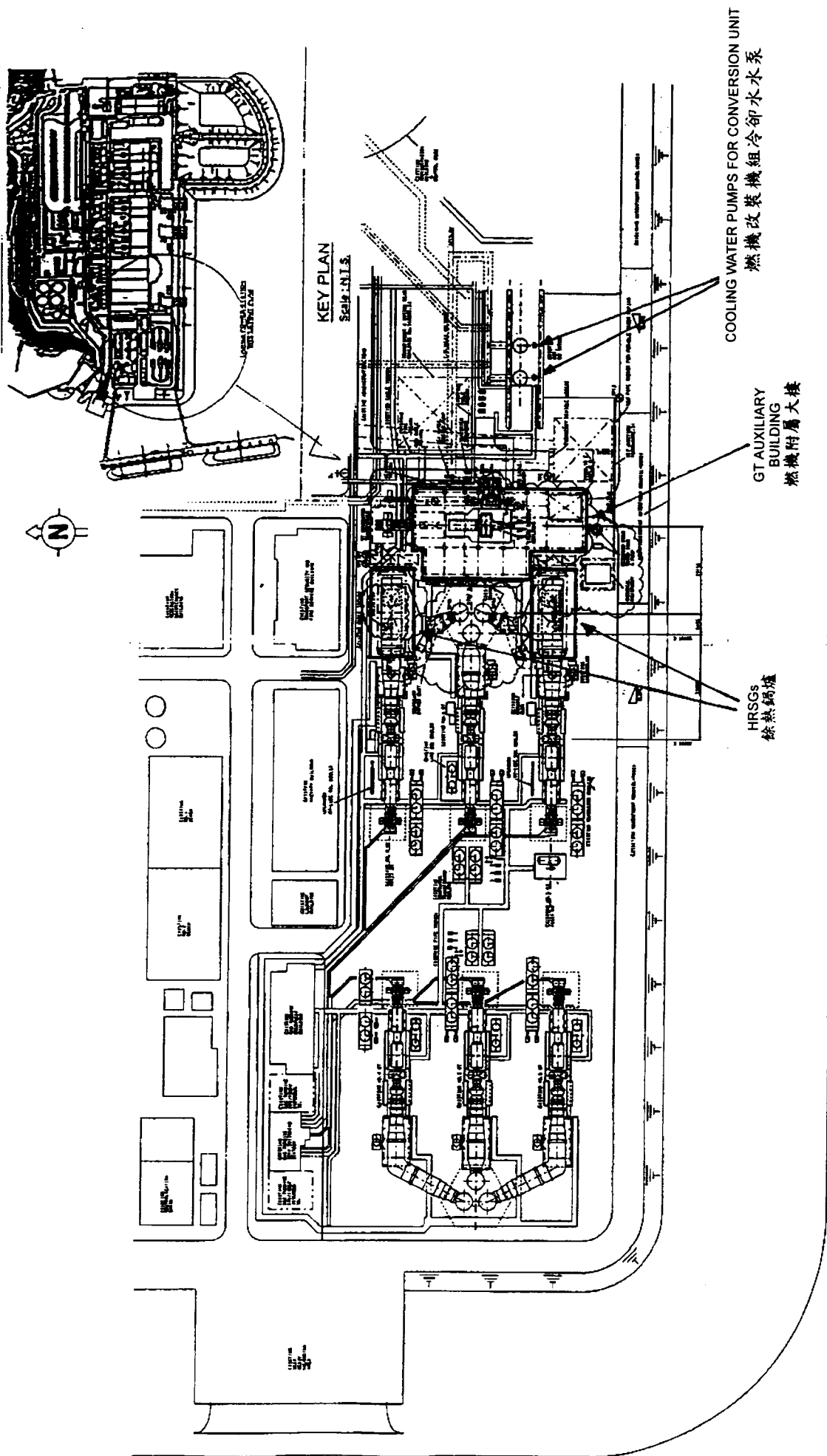


FIGURE 2.6a

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

FILE C20351
DATE 06/03/00

EXISTING EQUIPMENT
現有設備

ADDITIONAL EQUIPMENT
新裝設備

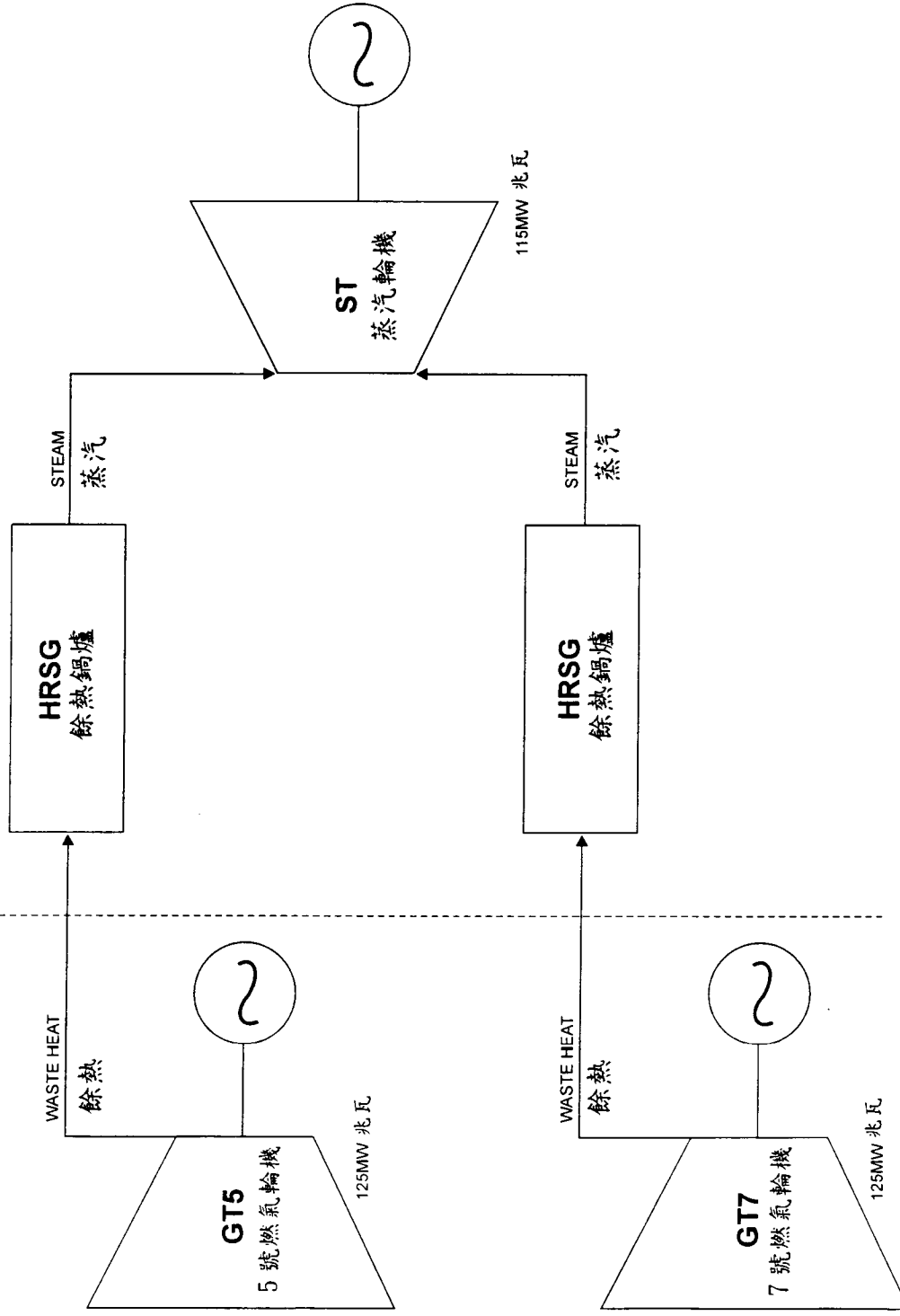


FIGURE 2.6b
圖 2.6b

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

Annex A

Results of Wind Tunnel Modelling

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 SO₂ 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 SO₂ 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 SO₂ and NO₂

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

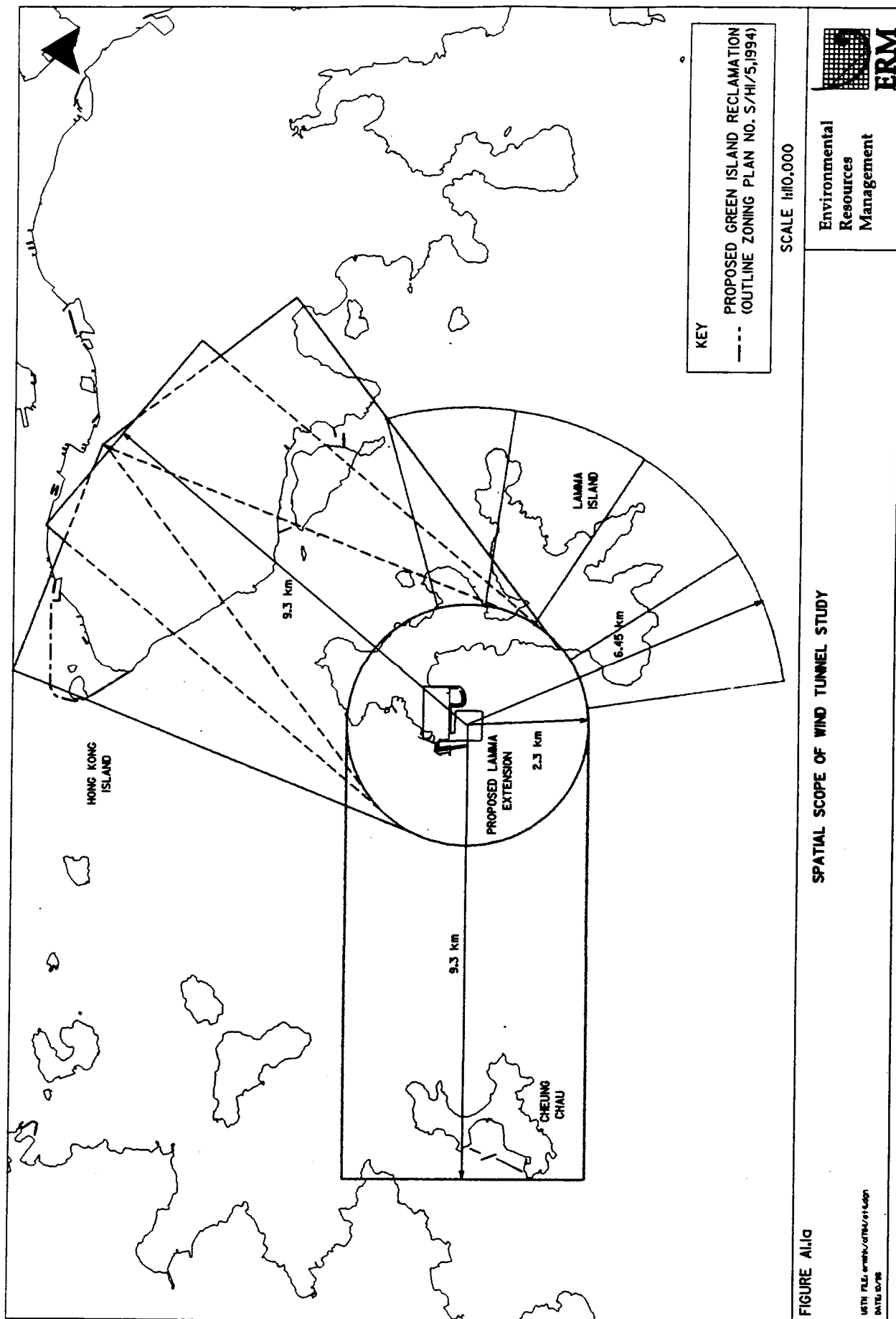
The results are summarised in following *Table A1.5a*:

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

Scenarios / Hourly Concentration of Pollutant	SO ₂ (µgm ⁻³)	NO ₂ (µgm ⁻³)
	AQO = 800	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 SO₂ and NO₂ at ASRs in the near-field of the power station.



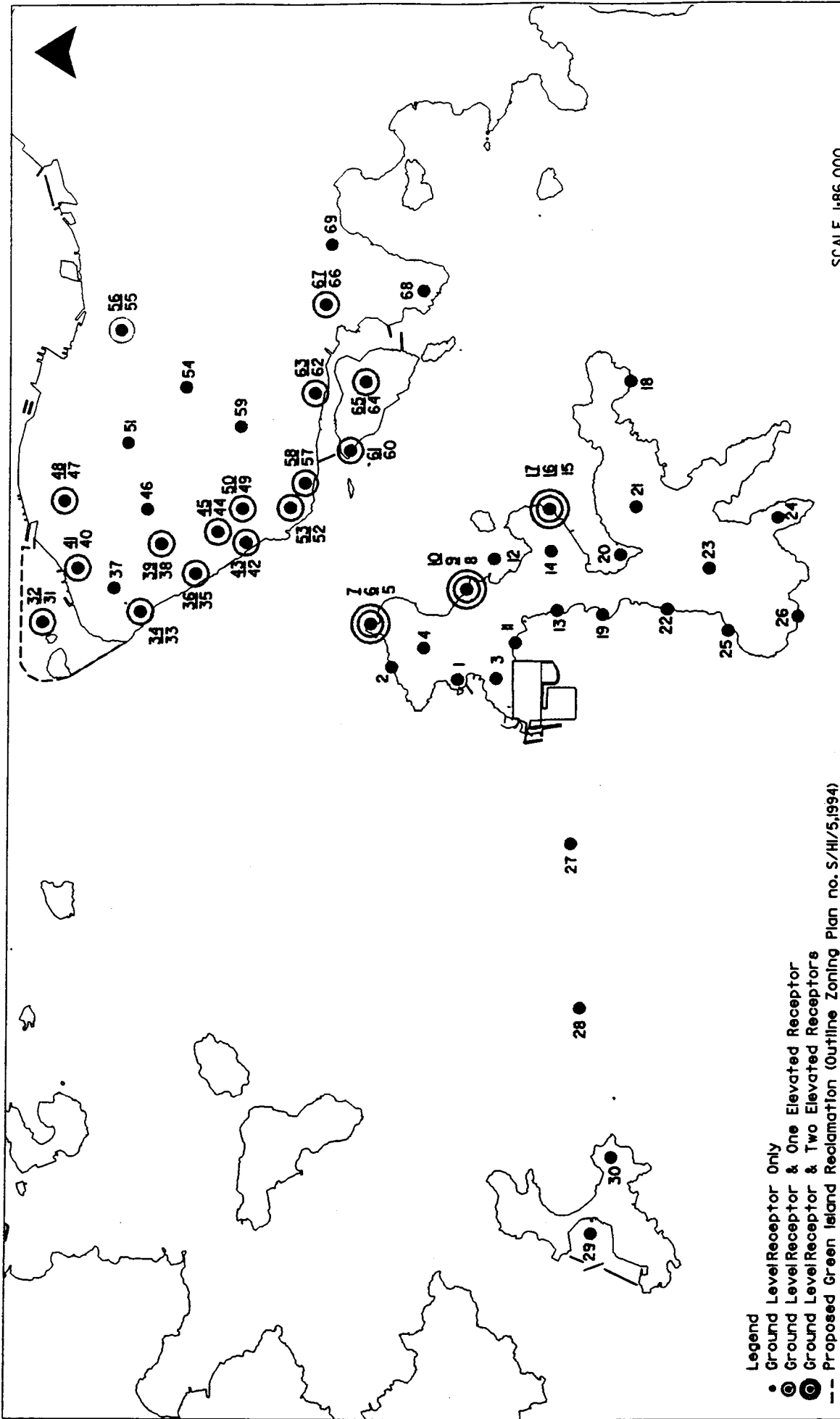


FIGURE A1.3a

WIND TUNNEL MEASUREMENT LOCATIONS

Environmental
Resources
Management



Table A1.5c Predicted SO2 QLC for Scenario 2

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Receptor	Wind Tunnel Data Scenario 1 OT2-2	Wind Tunnel Data Scenario 2 CC	Predicted Data Receptor			Distance Correction	GLC - ug/m ³ A+B+C+D1+D2	GLC With/Without	System Peak Load (MW)			Background	LGO's Content	Results NO ₂ G/LC ug/m ³
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1	21	10	0	0	0	0.52	28	64	1	13	15	0	49	64
2	16	9	0	0	0	0.81	23	68	2	10	13	0	49	69
3	8	8	0	0	0	0.36	14	54	3	5	9	0	40	54
4	30	16	0	0	0	0.71	14	60	4	19	24	1	49	80
5	23	13	0	0	0	0.83	14	62	5	14	20	1	49	83
6	21	12	1	1	1	0.80	37	84	6	14	18	1	49	84
7	21	13	16	10	1	0.86	37	108	7	13	18	2	49	108
8	24	14	0	0	0	0.72	36	75	8	15	20	5	49	75
9	24	14	0	0	0	0.76	36	79	9	15	20	5	49	79
10	38	18	0	0	0	0.72	40	100	10	23	23	25	49	100
11	11	8	0	0	0	0.42	31	58	11	7	13	1	49	58
12	14	8	0	0	0	0.65	23	65	12	9	12	2	49	65
13	3	1	0	0	0	0.80	5	51	13	2	4	0	49	51
14	7	3	0	0	0	0.71	9	55	14	2	4	0	49	55
15	6	3	0	0	0	1.00	16	85	15	5	5	6	49	85
16	6	3	0	0	0	0.83	16	85	16	5	5	6	49	85
17	10	4	0	0	0	0.91	25	72	17	6	7	12	49	72
18	1	2	0	0	0	1.44	21	79	18	4	4	1	49	54
19	7	3	0	0	0	0.80	16	82	19	4	4	1	49	54
20	11	6	0	0	0	0.80	20	82	20	4	4	1	49	54
21	6	3	0	0	0	1.00	22	84	21	0	0	0	49	71
22	0	0	0	0	0	0.99	22	84	22	0	0	0	49	67
23	0	0	0	0	0	0.92	24	84	23	0	0	0	49	67
24	0	0	0	0	0	1.23	150	150	24	0	0	0	49	150
25	3	1	0	0	0	0.83	83	83	25	2	2	2	49	83
26	4	2	0	0	0	0.90	25	102	26	3	3	3	49	102
27	33	16	27	2	2	0.80	49	102	27	21	23	5	49	79
28	33	16	27	2	2	1.41	49	141	28	13	14	4	49	141
29	21	14	28	38	41	1.25	29	284	29	19	19	3	49	284
30	15	9	30	19	28	1.68	30	154	30	3	5	5	49	154
31	4	3	6	13	4	1.92	135	135	31	2	4	4	49	135
32	2	2	1	4	4	1.93	80	136	32	1	3	25	80	136
33	9	7	33	3	3	1.89	80	88	33	6	10	7	49	88
34	10	8	34	5	5	1.56	49	100	34	6	10	7	49	88
35	6	5	35	16	17	1.52	51	100	35	12	12	11	49	100
36	9	6	36	20	21	1.77	61	109	36	8	12	16	49	109
37	10	6	37	7	7	1.52	34	142	37	8	12	16	49	142
38	13	6	38	10	10	1.64	38	119	38	8	12	16	49	119
39	2	1	39	10	12	1.81	85	85	39	1	1	1	49	85
40	1	0	40	7	7	1.86	49	158	40	1	1	1	49	85
41	3	4	41	18	18	1.64	49	119	41	2	2	2	49	119
42	11	7	42	17	18	1.55	49	110	42	2	2	2	49	110
43	6	5	43	12	13	1.55	49	102	43	3	3	3	49	102
44	5	5	44	6	6	1.75	49	146	44	4	4	4	49	146
45	7	4	45	14	15	1.93	49	142	45	6	6	6	49	142
46	8	5	46	10	11	1.92	49	134	46	3	5	20	80	134
47	8	5	47	8	8	1.92	49	134	47	3	5	20	80	134
48	5	3	48	4	4	1.54	49	105	48	6	8	33	49	105
49	10	6	49	4	4	1.54	49	105	49	12	12	9	49	105
50	11	5	50	10	10	1.54	49	105	50	11	11	8	49	105
51	6	3	51	16	17	1.46	49	97	51	11	11	8	49	97
52	12	7	52	6	6	1.41	49	113	52	13	13	24	49	113
53	13	7	53	10	11	1.41	49	113	53	13	13	24	49	113
54	13	7	54	36	36	1.81	49	228	54	4	9	23	80	228
55	4	2	55	12	12	2.00	60	150	55	2	4	23	80	150
56	4	2	56	10	10	1.36	49	111	56	4	4	29	80	111
57	10	6	57	11	11	1.36	49	111	57	4	4	29	80	111
58	9	6	58	13	14	1.36	49	111	58	4	4	29	80	111
59	9	6	59	14	15	1.36	49	111	59	4	4	29	80	111
60	17	7	60	10	11	1.36	49	111	60	4	4	29	80	111
61	11	7	61	19	20	1.37	63	136	61	7	10	31	49	136
62	13	8	62	12	13	1.60	49	127	62	7	10	31	49	127
63	13	8	63	13	14	1.33	49	114	63	8	12	23	49	114
64	19	9	64	16	16	1.33	49	114	64	8	12	23	49	114
65	19	9	65	20	20	1.33	49	114	65	8	12	23	49	114
66	11	5	66	21	23	1.78	65	145	66	7	14	37	49	145
67	10	5	67	17	18	1.80	65	145	67	7	14	37	49	145
68	14	8	68	6	6	1.86	65	145	68	9	13	42	49	145
69	11	6	69	26	26	1.85	65	145	69	7	7	62	49	145
70	11	6	70	26	26	1.85	65	145	70	7	7	62	49	145
71	11	6	71	26	26	1.85	65	145	71	7	7	62	49	145
72	11	6	72	26	26	1.85	65	145	72	7	7	62	49	145
73	11	6	73	26	26	1.85	65	145	73	7	7	62	49	145
74	11	6	74	26	26	1.85	65	145	74	7	7	62	49	145
75	11	6	75	26	26	1.85	65	145	75	7	7	62	49	145
76	11	6	76	26	26	1.85	65	145	76	7	7	62	49	145
77	11	6	77	26	26	1.85	65	145	77	7	7	62	49	145
78	11	6	78	26	26	1.85	65	145	78	7	7	62	49	145
79	11	6	79	26	26	1.85	65	145	79	7	7	62	49	145
80	11	6	80	26	26	1.85	65	145	80	7	7	62	49	145
81	11	6	81	26	26	1.85	65	145	81	7	7	62	49	145
82	11	6	82	26	26	1.85	65	145	82	7	7	62	49	145
83	11	6	83	26	26	1.85	65	145	83	7	7	62	49	145
84	11	6	84	26	26	1.85	65	145	84	7	7	62	49	145
85	11	6	85	26	26	1.85	65	145	85	7	7	62	49	145
86	11	6	86	26	26	1.85	65	145	86	7	7	62	49	145
87	11	6	87	26	26	1.85	65	145	87	7	7	62	49	145
88	11	6	88	26	26	1.85	65	145	88	7	7	62	49	145
89	11	6	89	26	26	1.85	65	145	89	7	7	62	49	145
90	11	6	90	26	26	1.85	65	145	90	7	7	62	49	145
91	11	6	91	26	26	1.85	65	145	91	7	7	62	49	145
92	11	6	92	26	26	1.85	65	145	92	7	7	62	49	145
93	11	6	93	26	26	1.85	65	145	93	7	7	62	49	145
94	11	6	94	26	26	1.85	65	145	94	7	7	62	49	145
95	11	6	95	26	26	1.85	65	145	95	7	7	62	49	145
96	11	6	96	26	26	1.85	65	145	96	7	7	62	49	145
97	11	6	97	26	26	1.85	65	145	97	7	7	62	49	145
98	11	6	98	26	26	1.85	65	145	98	7	7	62	49	145
99	11	6	99	26	26	1.85	65	145	99	7	7	62	49	145
100	11	6	100	26	26	1.85	65	145	100	7	7	62	49	145

Annex B

Noise Assessment

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 loading 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 (Leq, 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, Leq, 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, Leq, 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.

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 from 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
<i>Superstructure (structural concrete)</i>				
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
<i>Inlet & Outlet Culvert</i>				
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
<i>Transformer & Switchgear Bldg No. 1</i>				
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
<i>E&M Construction Work</i>				
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) approximately which 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

<u>Superstructure</u>								
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 SWL	NSR2	NSR3	NSR4
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 Including 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

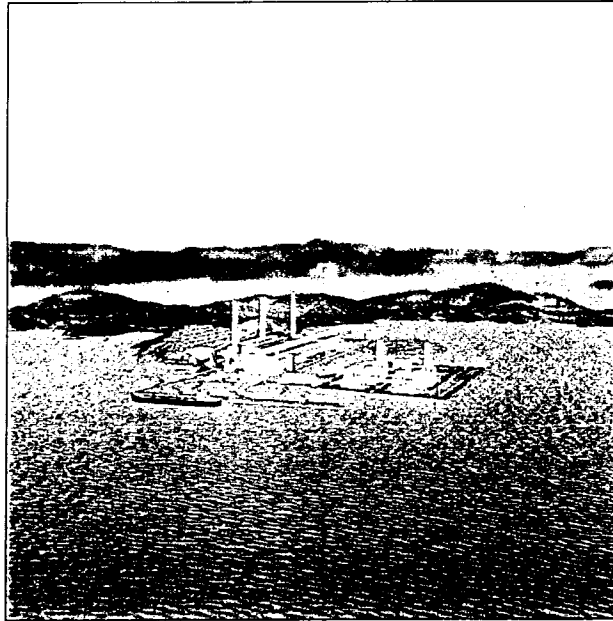
Max Operational Noise Level at NSR - Overall Noise Level (SPL)

		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**

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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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: <u>Shelley Clarke</u>
Signed: <u>Shelley Clarke</u>
Position: <u>Technical Director</u>
Date: <u>13 December 1999</u>

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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.

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.

2.1

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.*

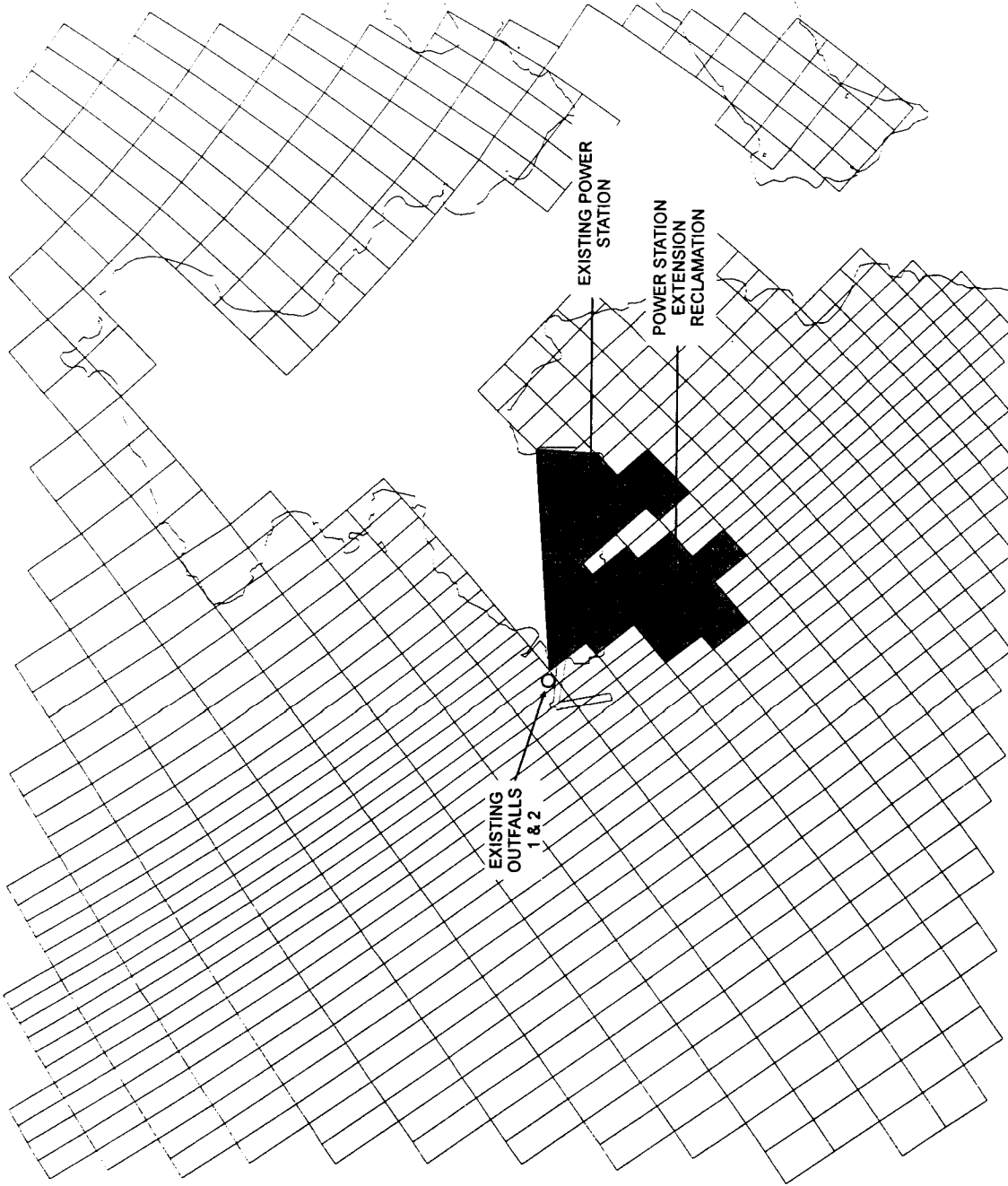
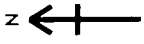


FIGURE 2.1a

LOCATION OF EXISTING OUTFALL AND THE RECLAMATION LAYOUT IN 2003

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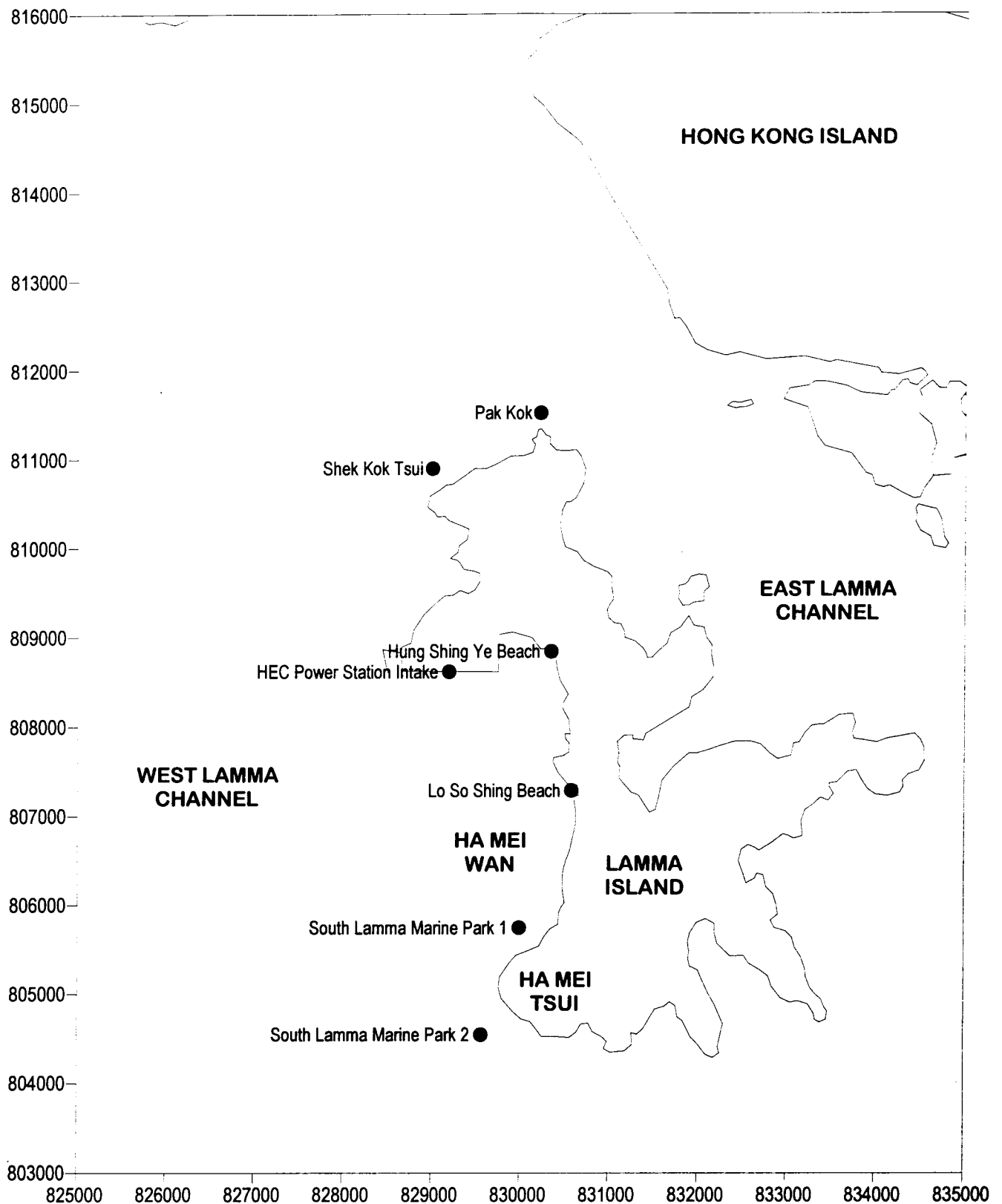


Figure 2.2a

LOCATIONS OF SENSITIVE RECEIVERS

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

Environmental
Resources
Management



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 (km²)*

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 km² 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 m³ 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 $334,250 \text{ m}^3 \text{ hour}^{-1}$, 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 coast 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 ≥ 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.

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
<i>Intertidal</i>		
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
<i>Subtidal</i>		
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 both 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 distance 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 increase 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*.

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.

4.1 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.*

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
		<i>Siganus oramin</i>	Rabbitfish	Low
		<i>Eleutheronema tetradactylus</i>	Threadfin	Low
		<i>Pseudosciaena crocea</i>	Yellow Croaker	High
		<i>Sebastiscus marmoratus</i>	Rockfish	Low
0097	Po Law Tsui	Mixed Species		Low
		<i>Caranx</i> spp	Scad/Crevalle	Medium
		<i>Sardinella jussieui</i>	Sardine	Low
		<i>Sebastiscus marmoratus</i>	Rockfish	Low
		<i>Pseudosciaena crocea</i>	Yellow Croaker	High
0098	Ha Mei	Mixed Species		Low
		<i>Caranx</i> spp	Scad/Crevalle	Medium
		<i>Argyrosomus</i> spp	Croaker	Low
		<i>Sardinella jussieui</i>	Sardine	Low
		<i>Oratosquilla</i> spp	Mantis Shrimp	Low
0099	Tai Kok	Mixed Species		Low
		<i>Caranx</i> spp	Scad/Crevalle	Medium
		<i>Argyrosomus</i> spp	Croaker	Low
		<i>Sardinella jussieui</i>	Sardine	Low
		<i>Oratosquilla</i> spp	Mantis Shrimp	Low
0109	West Lamma Channel	<i>Sardinella jussieui</i>	Sardine	Low
		Mixed Species		Low
		<i>Caranx</i> spp	Scad/Crevalle	Medium
		<i>Argyrosomus</i> spp	Croaker	Low
		<i>Caranx kalla</i>	Shrimp Scad	Medium
Note:	Mixed Species consists of juveniles of <i>Caranx kalla</i> , <i>Siganus oramin</i> , <i>Sardinella</i> spp, <i>Leiognathus brevirostris</i> and <i>Clupanodon punctatus</i> .			

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 jussieu*, 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.*

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⁾.

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⁾.

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 km², 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 m³ hr⁻¹ to the new average rate of 334,250 m³ 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

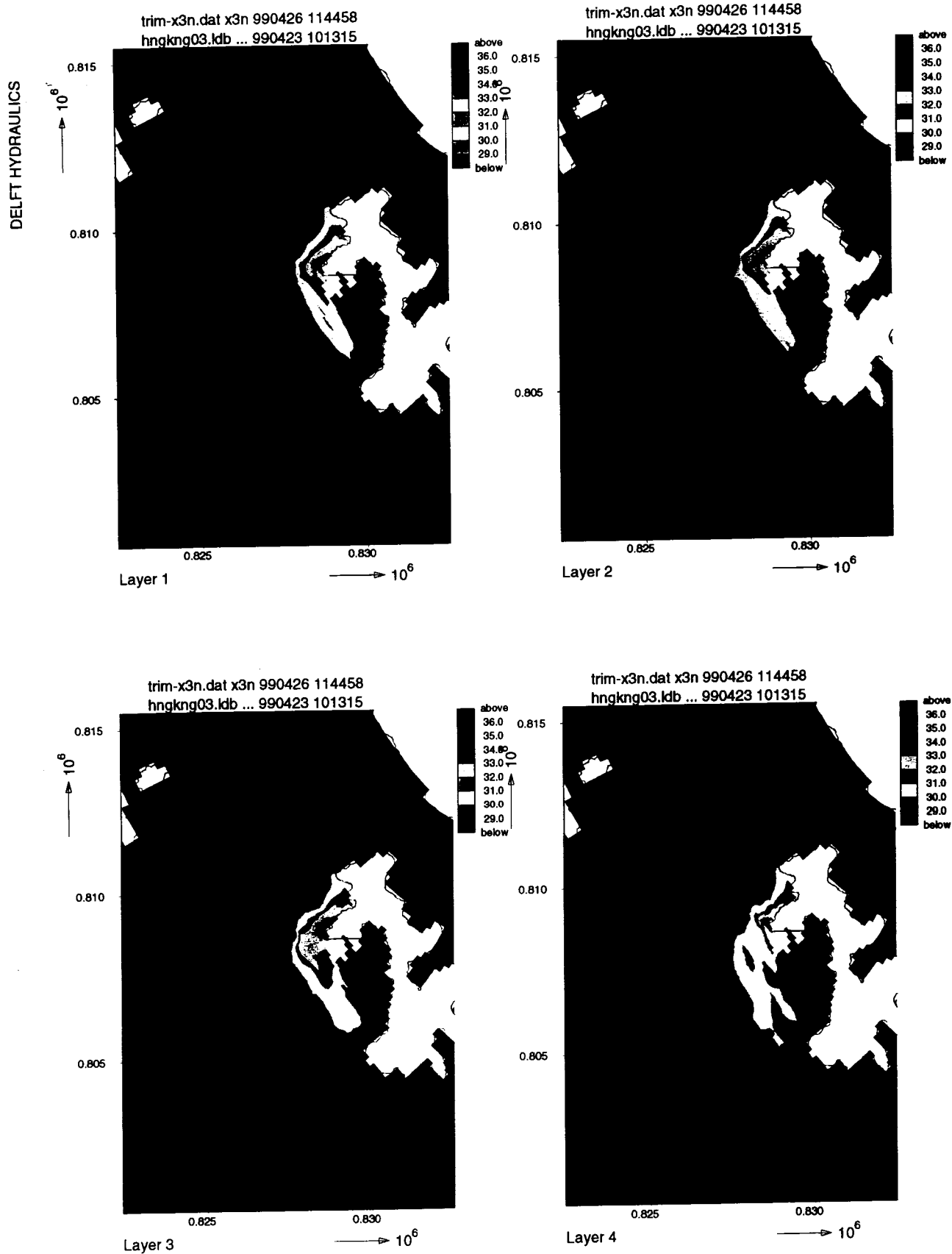


FIGURE A1

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

Environmental
Resources
Management



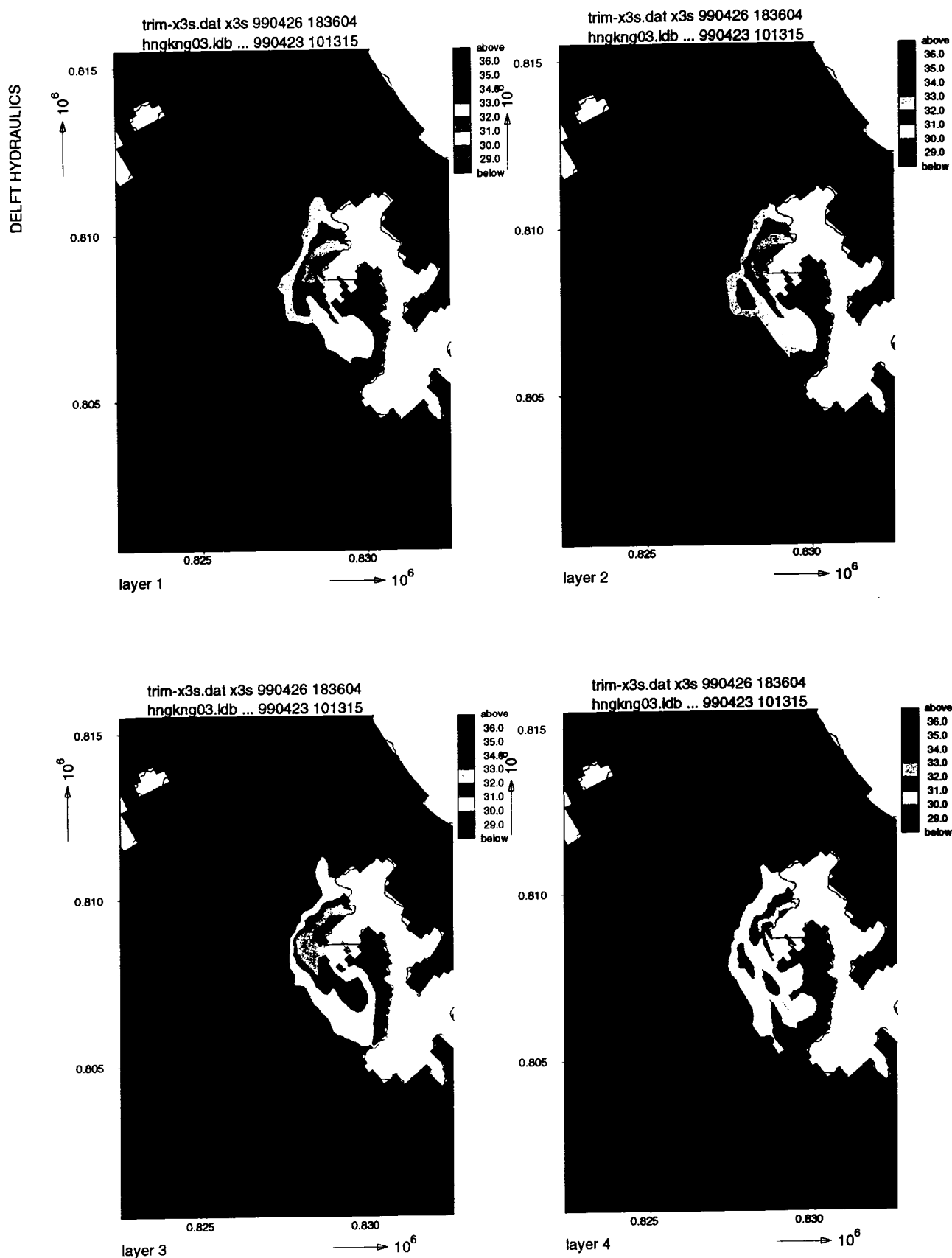


FIGURE A2

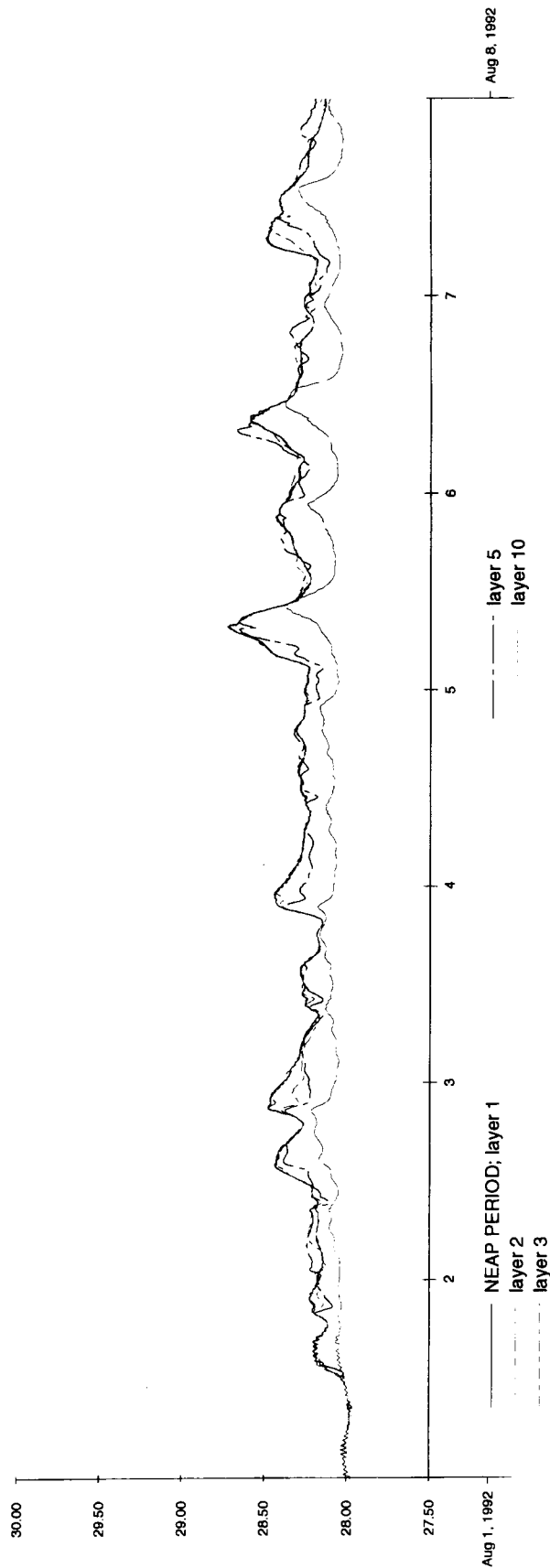
MAXIMUM TEMPERATURE FOR LAYERS 1 TO 4
SCENARIO 1 - WET SEASON SPRING TIDE

Environmental
Resources
Management



DELFT HYDRAULICS

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trih-x3s.dat x3s 990426 183604

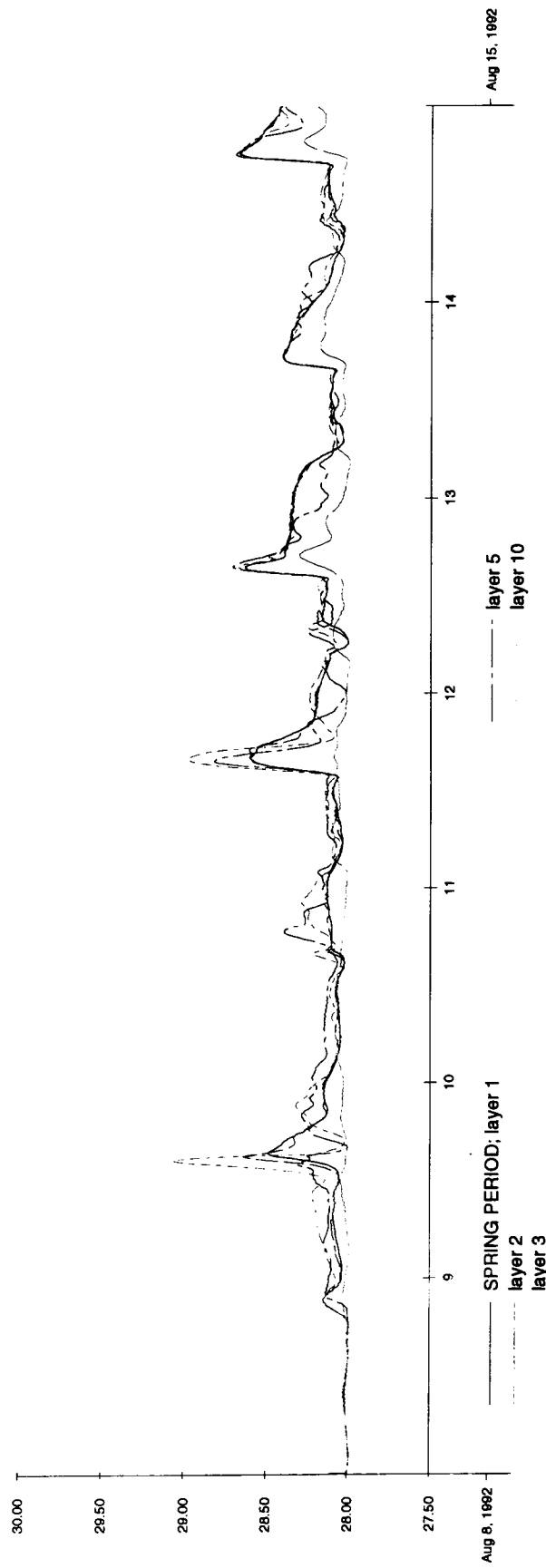


FIGURE A3

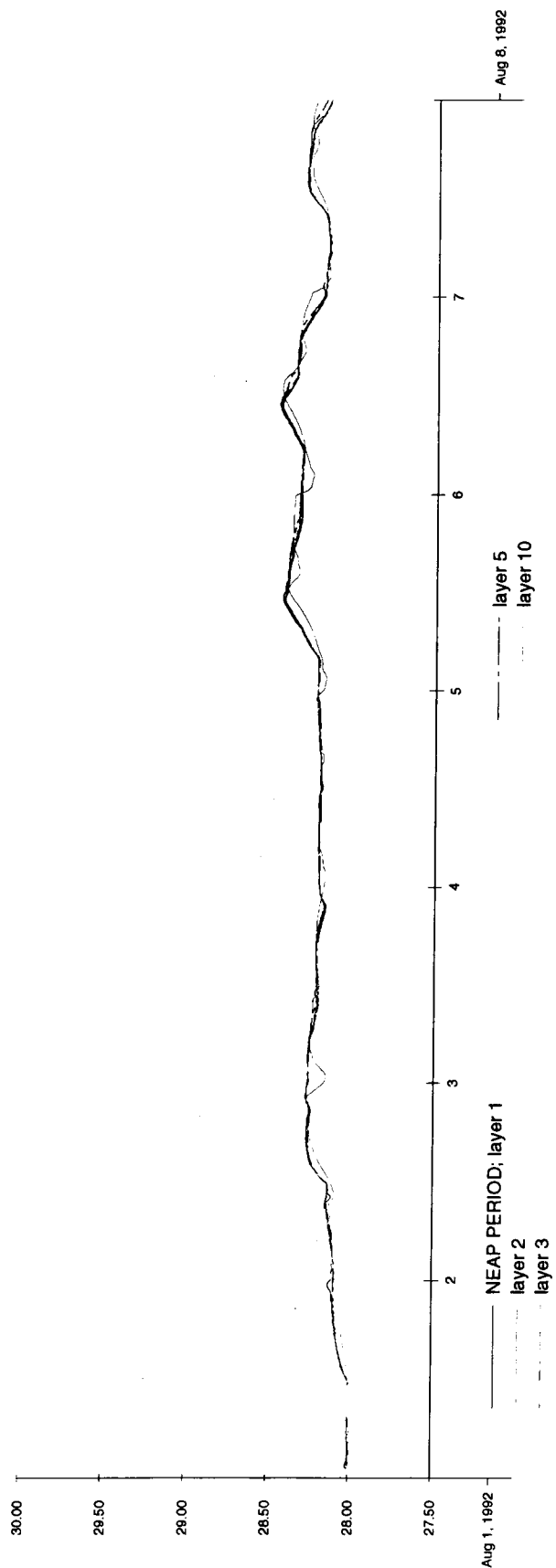
TIME SERIES OF TEMPERATURE AT LAMMA POWER STATION
INTAKE SCENARIO 1 - WET SEASON SPRING AND NEAP TIDES

Environmental
Resources
Management



DELFT HYDRAULICS

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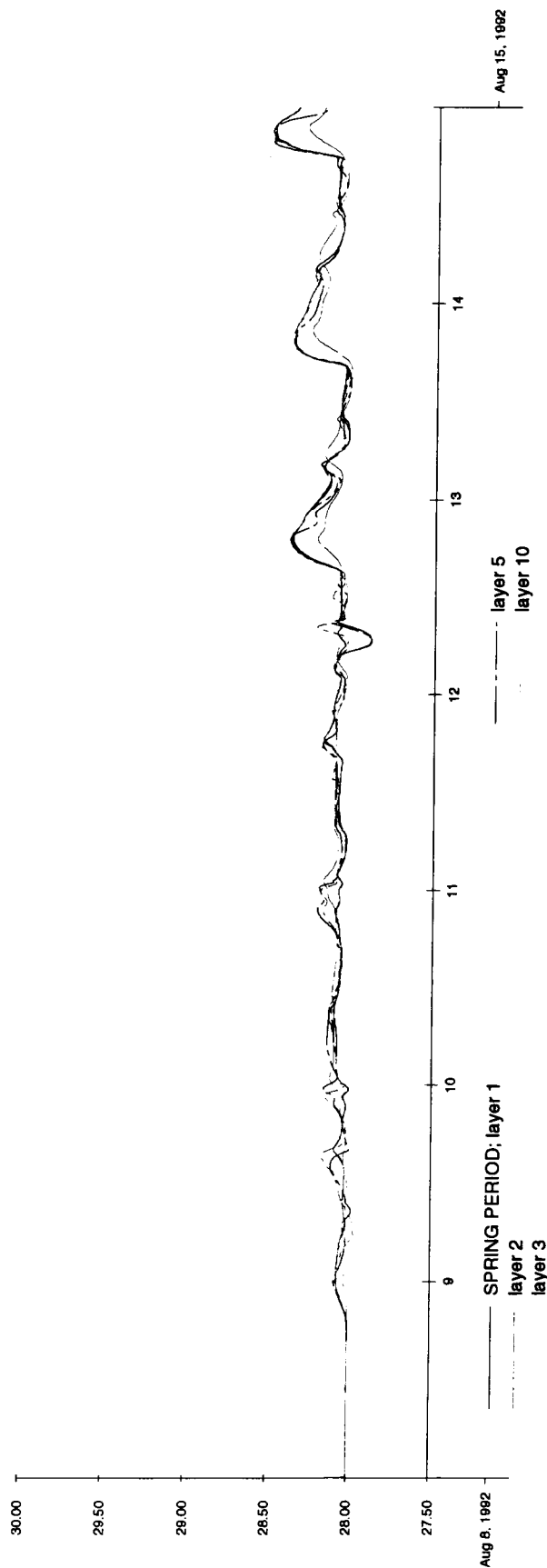


FIGURE A4

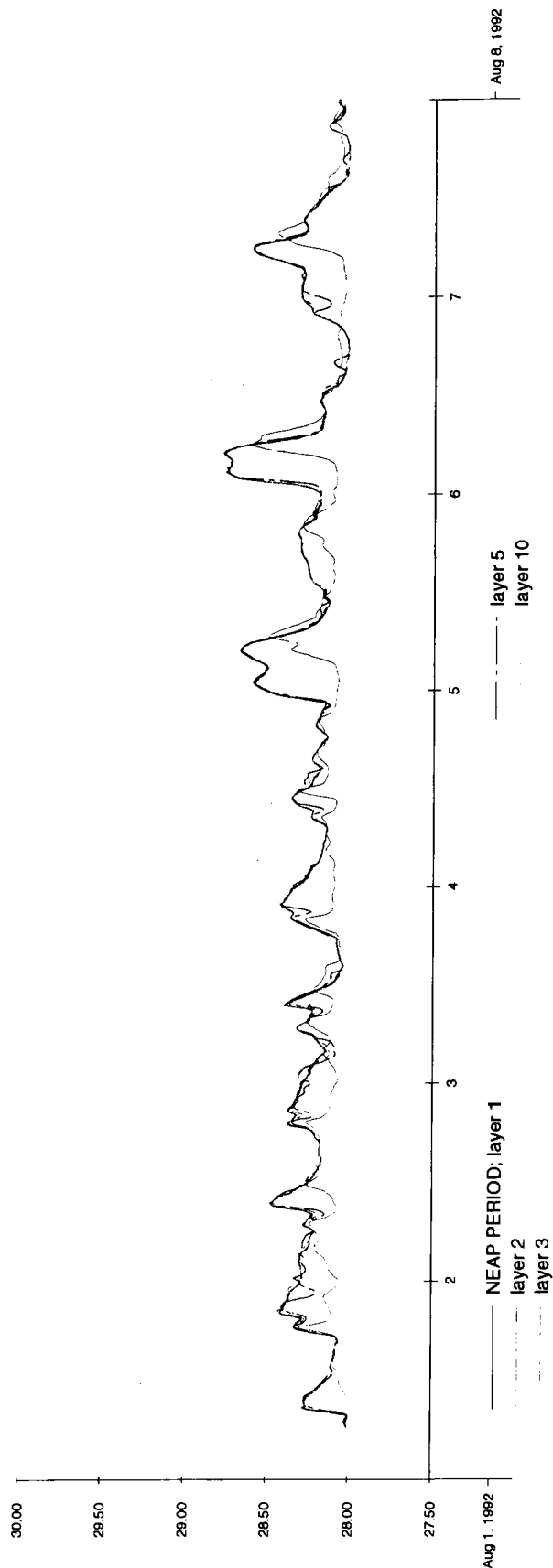
TIME SERIES OF TEMPERATURE AT HUNG SHING YE BEACH
SCENARIO 1 - WET SEASON SPRING AND NEAP TIDES

Environmental
Resources
Management



DELFT HYDRAULICS

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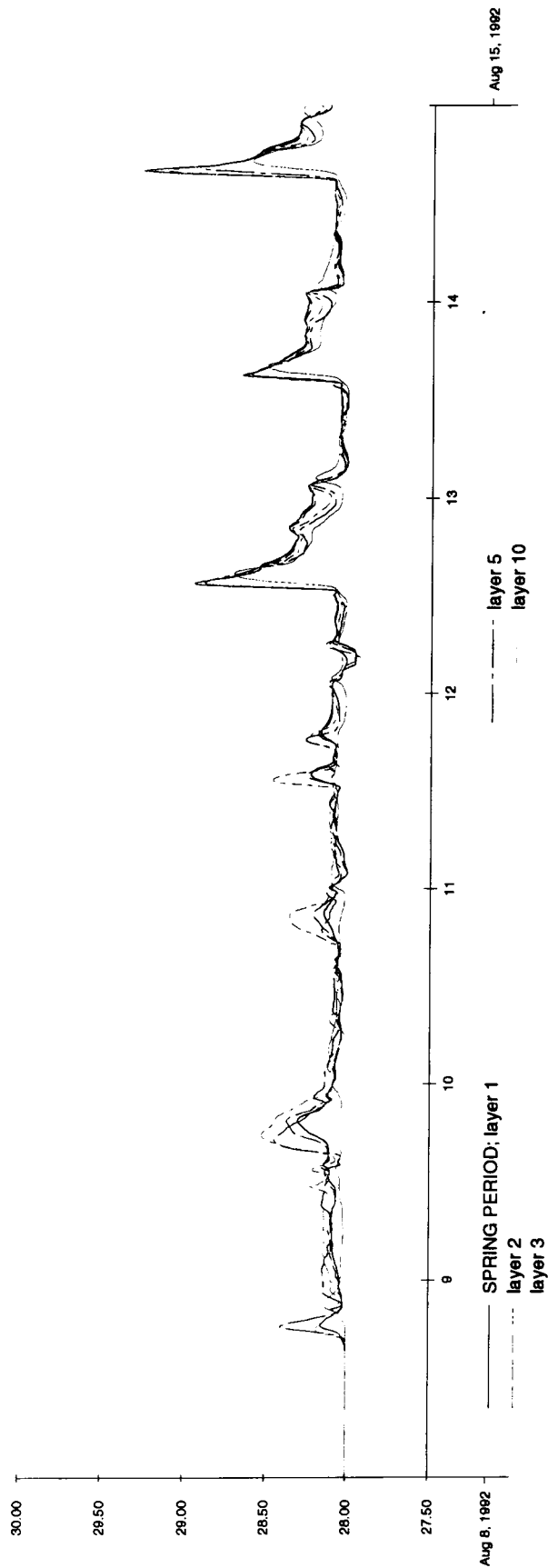


FIGURE A5

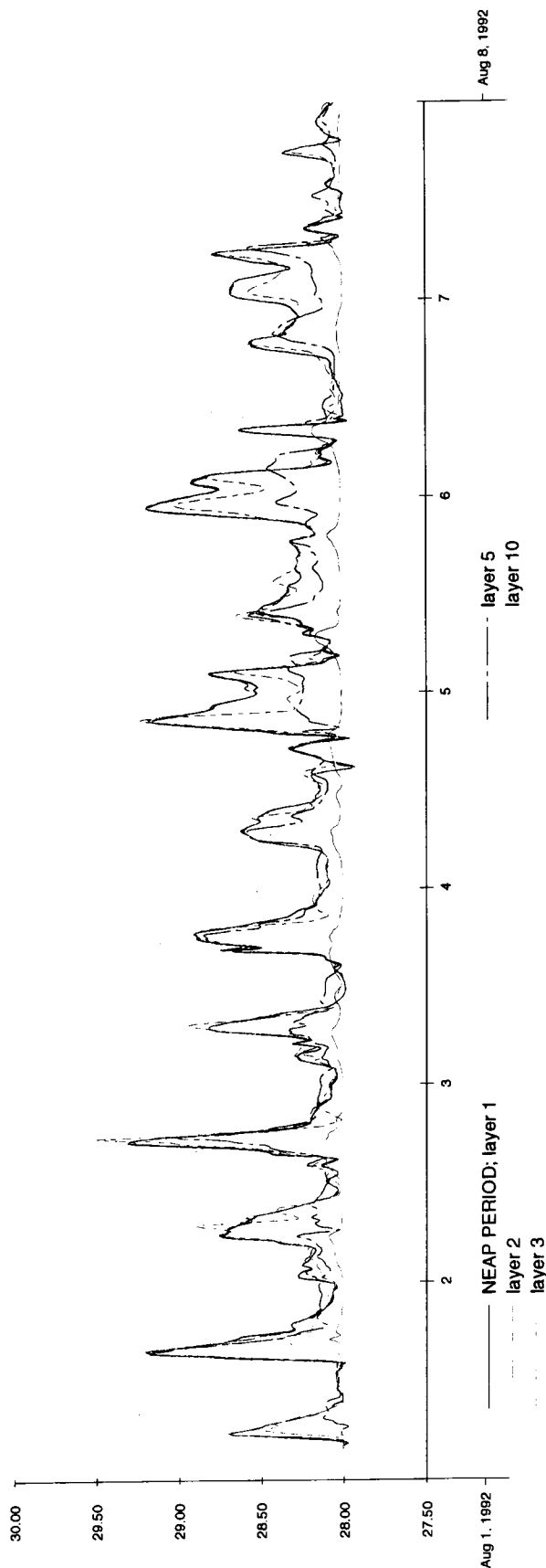
TIME SERIES OF TEMPERATURE AT LO SO SHING BEACH
SCENARIO 1 - WET SEASON SPRING AND NEAP TIDES

Environmental
Resources
Management



DELFT HYDRAULICS

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trih-x3s.dat x3s 990426 183604

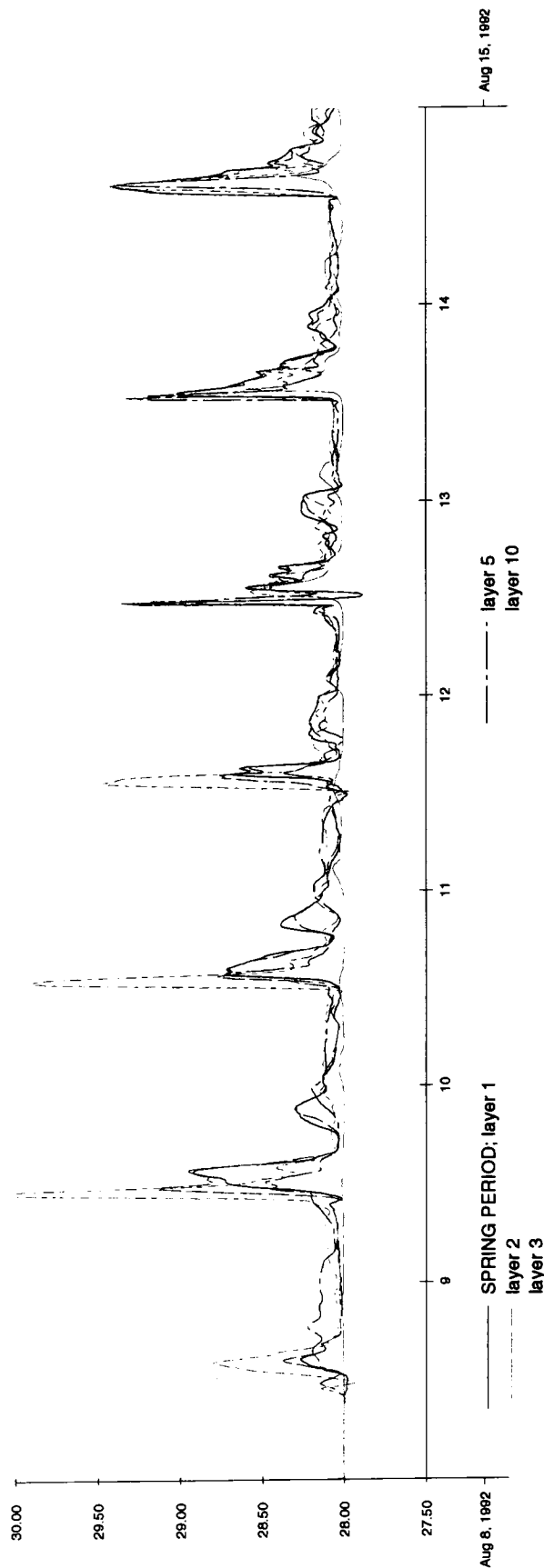


FIGURE A6

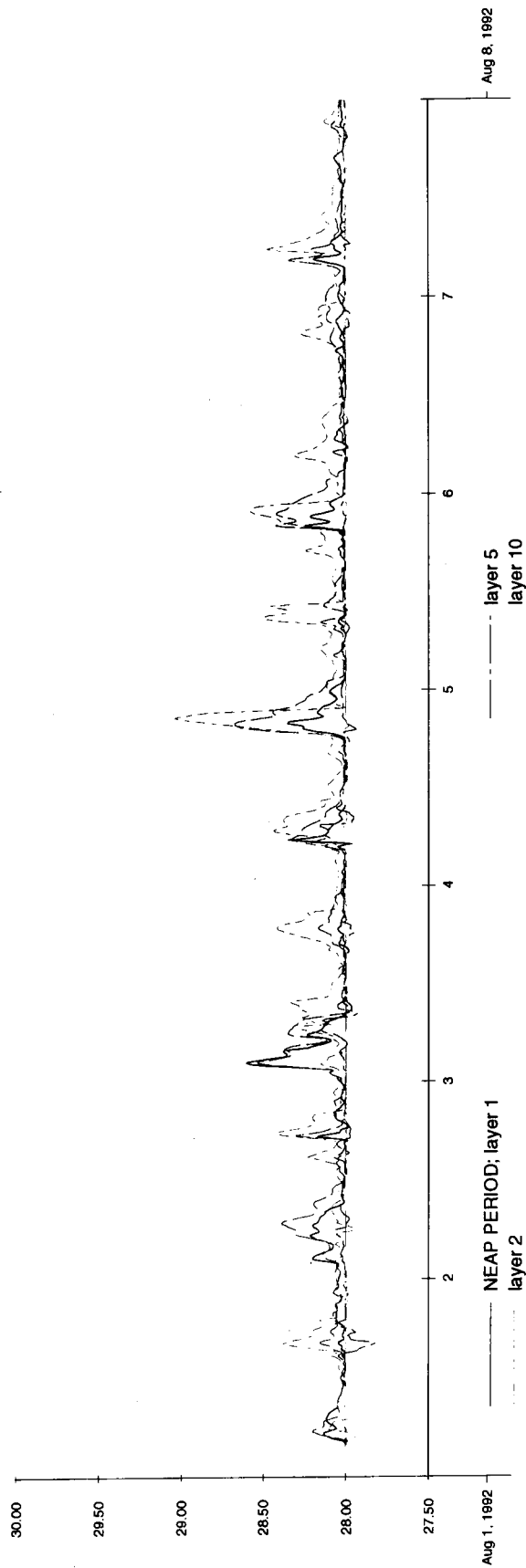
TIME SERIES OF TEMPERATURE AT SOUTH LAMMA MARINE PARK 1
SCENARIO 1 - WET SEASON SPRING AND NEAP TIDES

Environmental
Resources
Management



DELFT HYDRAULICS

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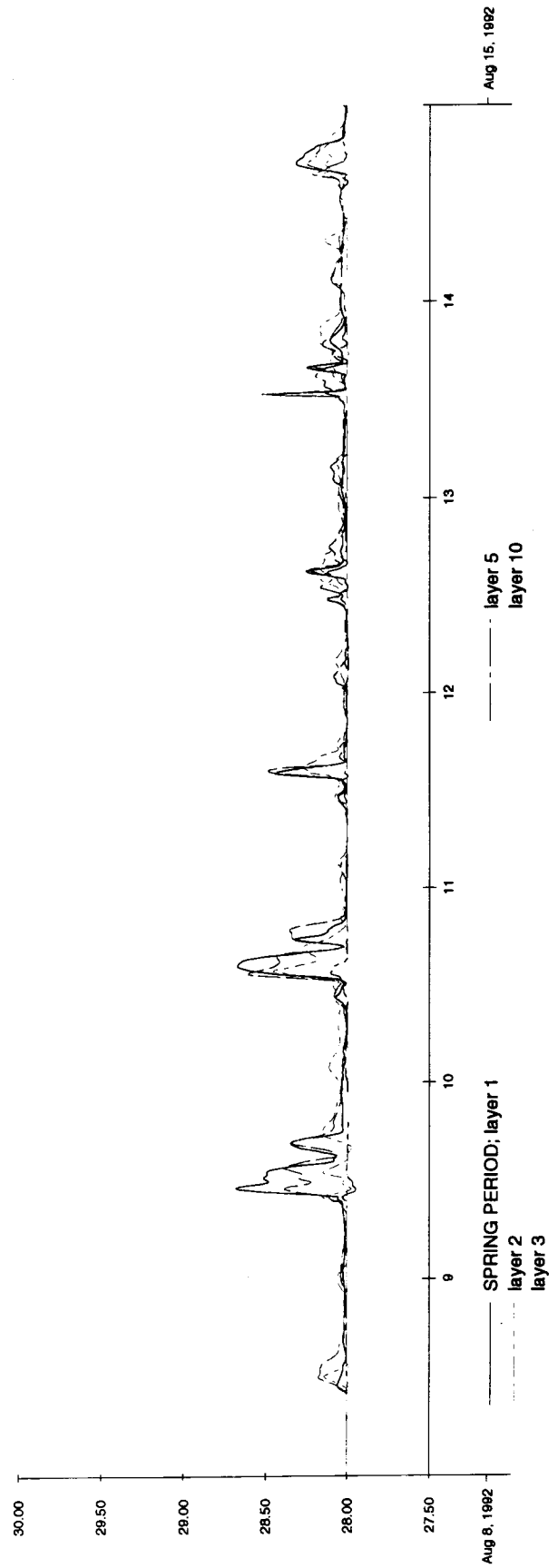


FIGURE A7

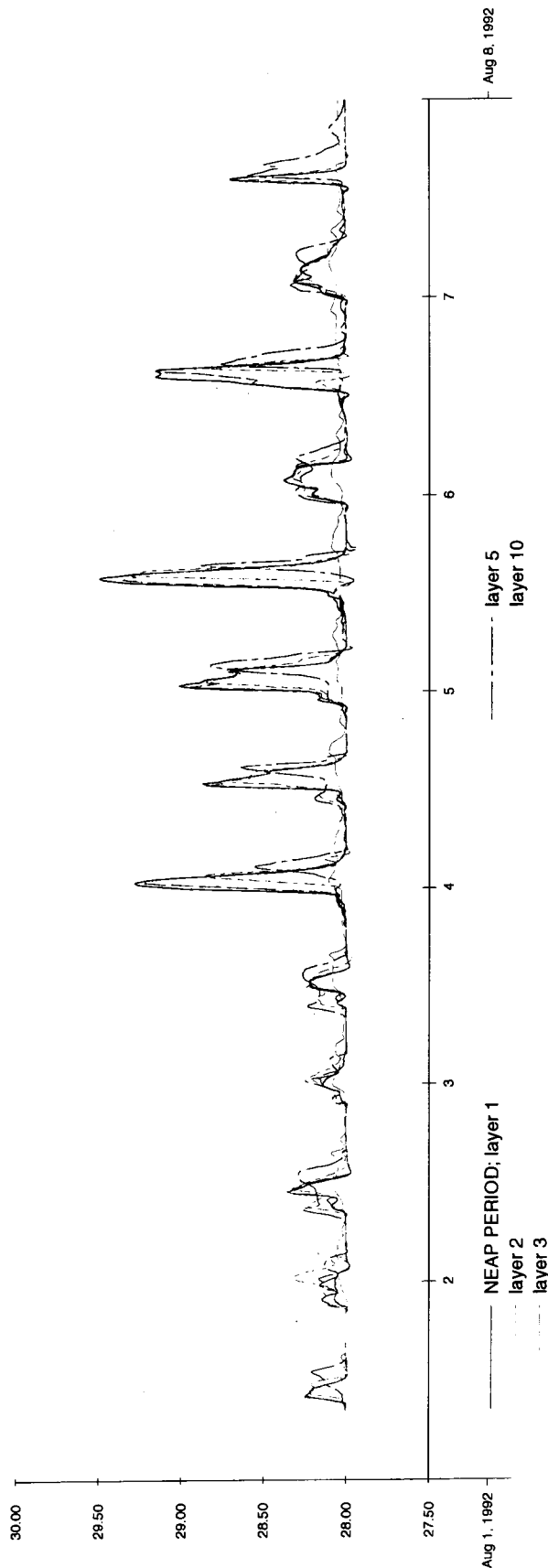
TIME SERIES OF TEMPERATURE AT SOUTH LAMMA MARINE PARK 2
SCENARIO 1 - WET SEASON SPRING AND NEAP TIDES

Environmental
Resources
Management



DELFT HYDRAULICS

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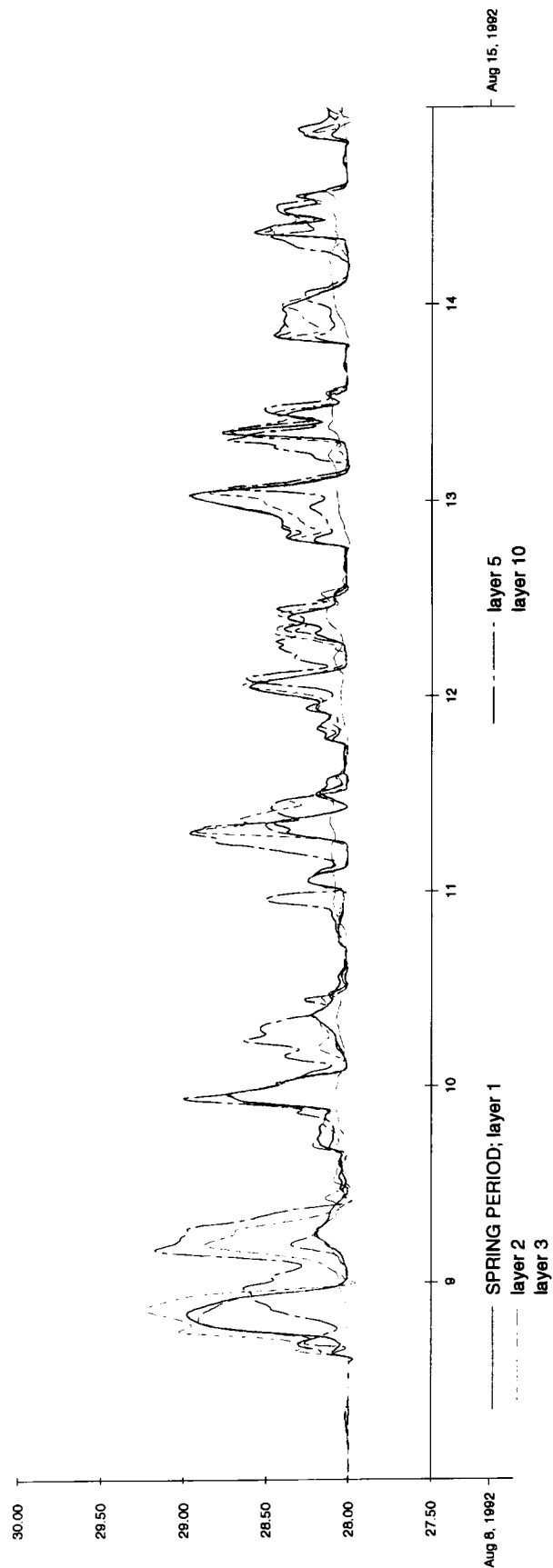


FIGURE A8

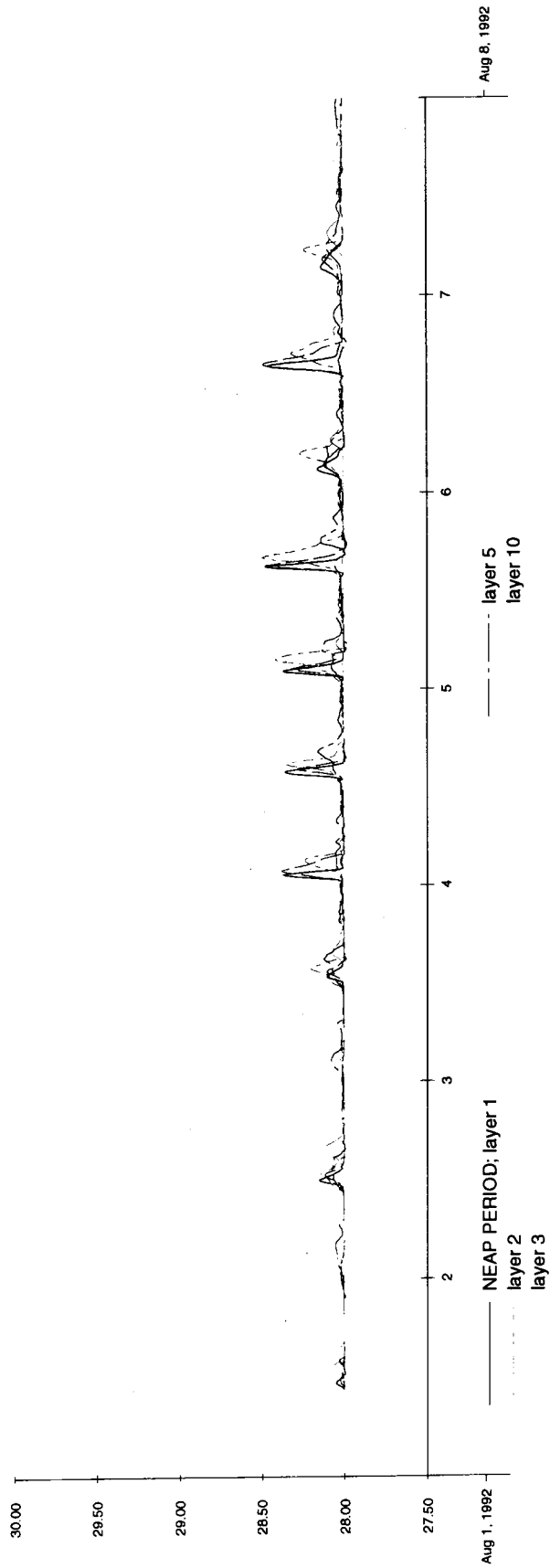
TIME SERIES OF TEMPERATURE AT AHEK KOK TSUI
SCENARIO 1 - WET SEASON SPRING AND NEAP TIDES

Environmental
Resources
Management



DELFT HYDRAULICS

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trih-x3s.dat x3s 990426 183604

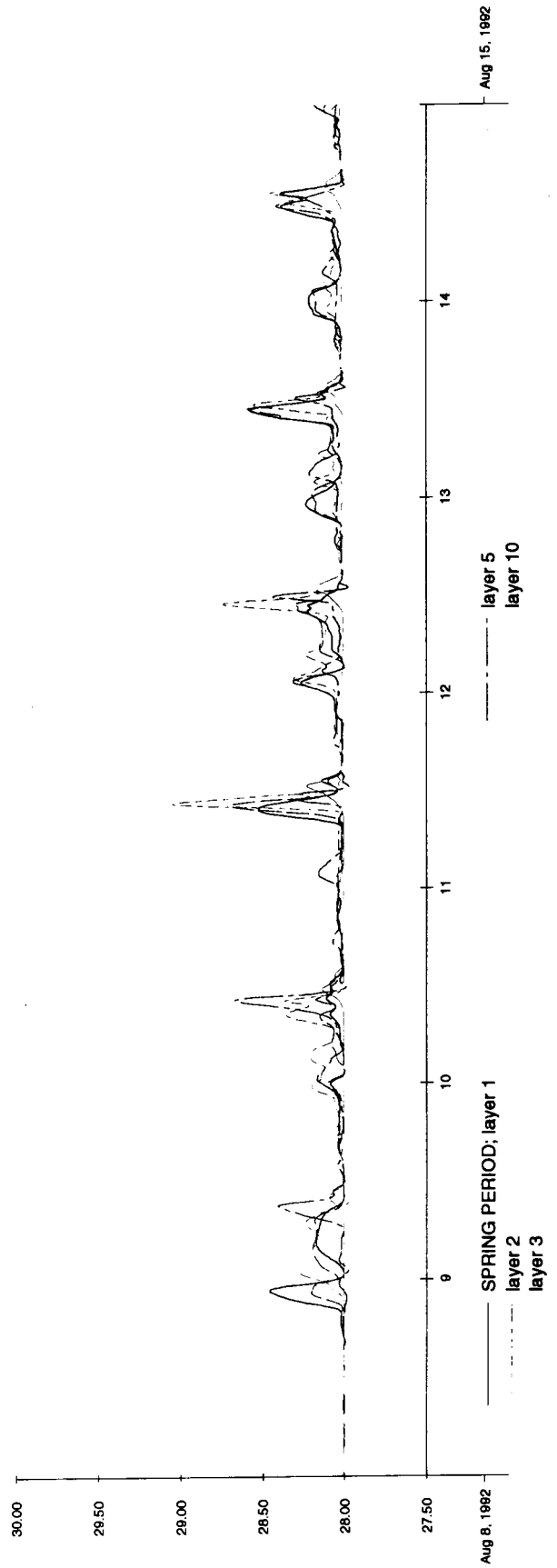


FIGURE A9

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

Environmental
Resources
Management



Annex B

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

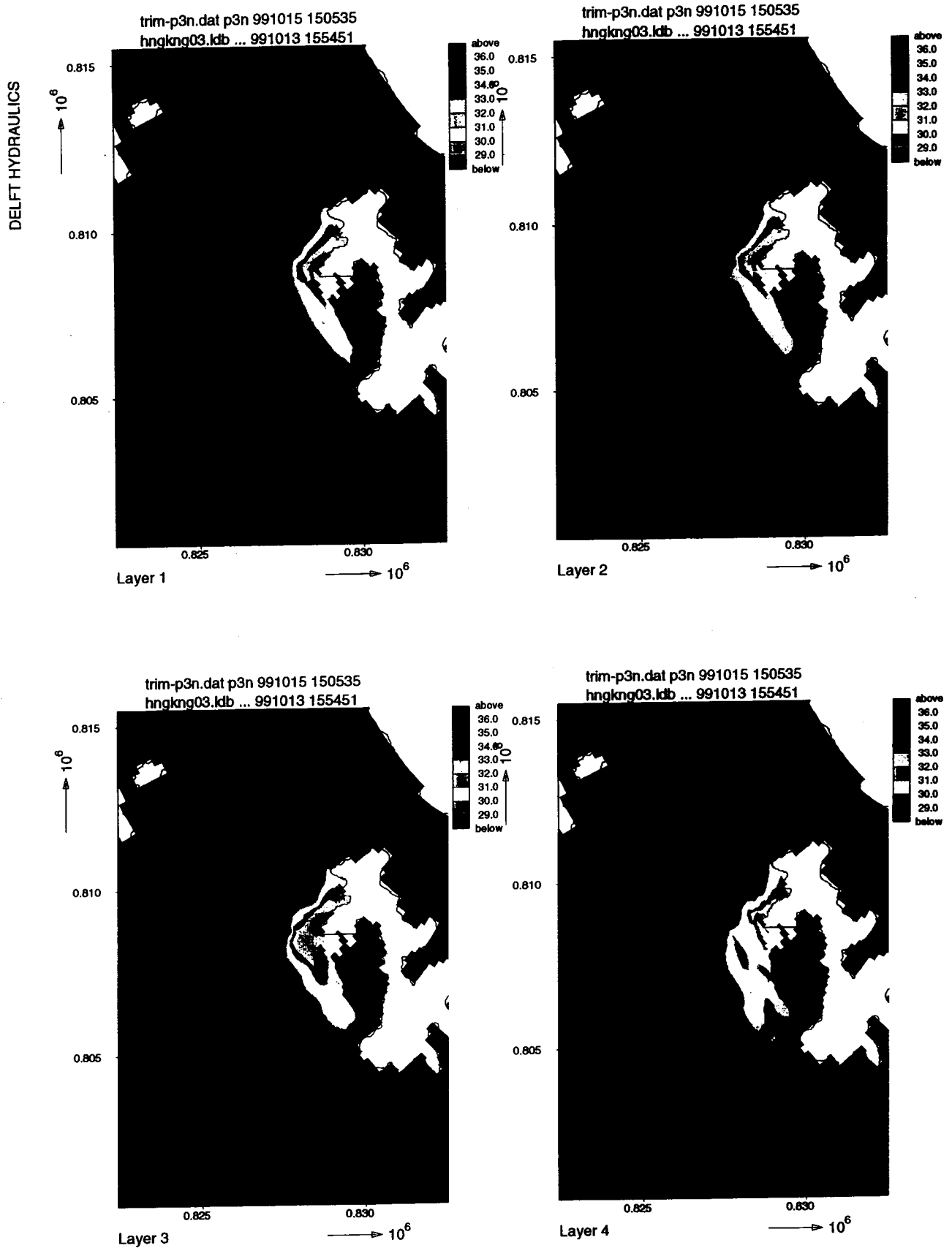


FIGURE B1

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

Environmental
Resources
Management



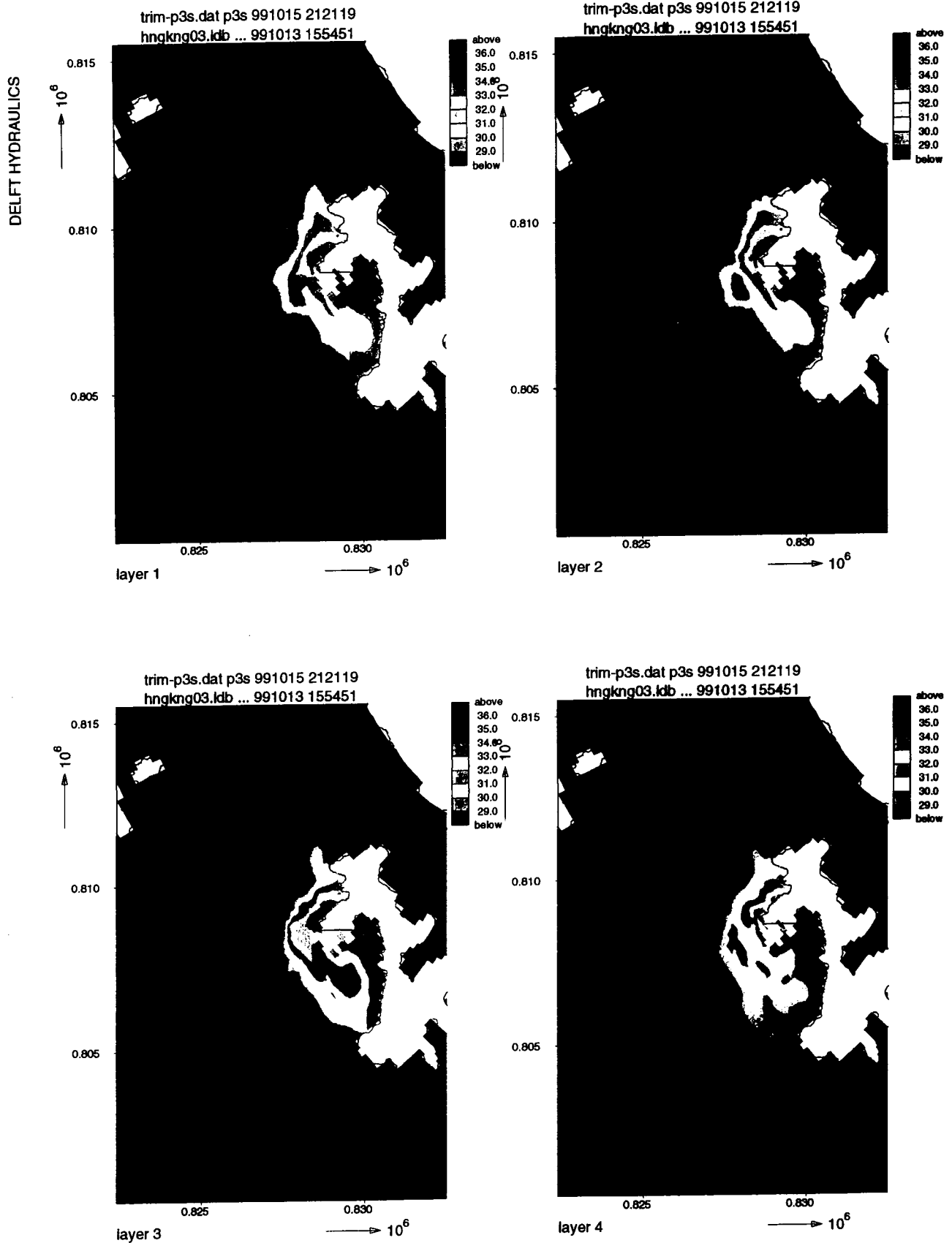


FIGURE B2

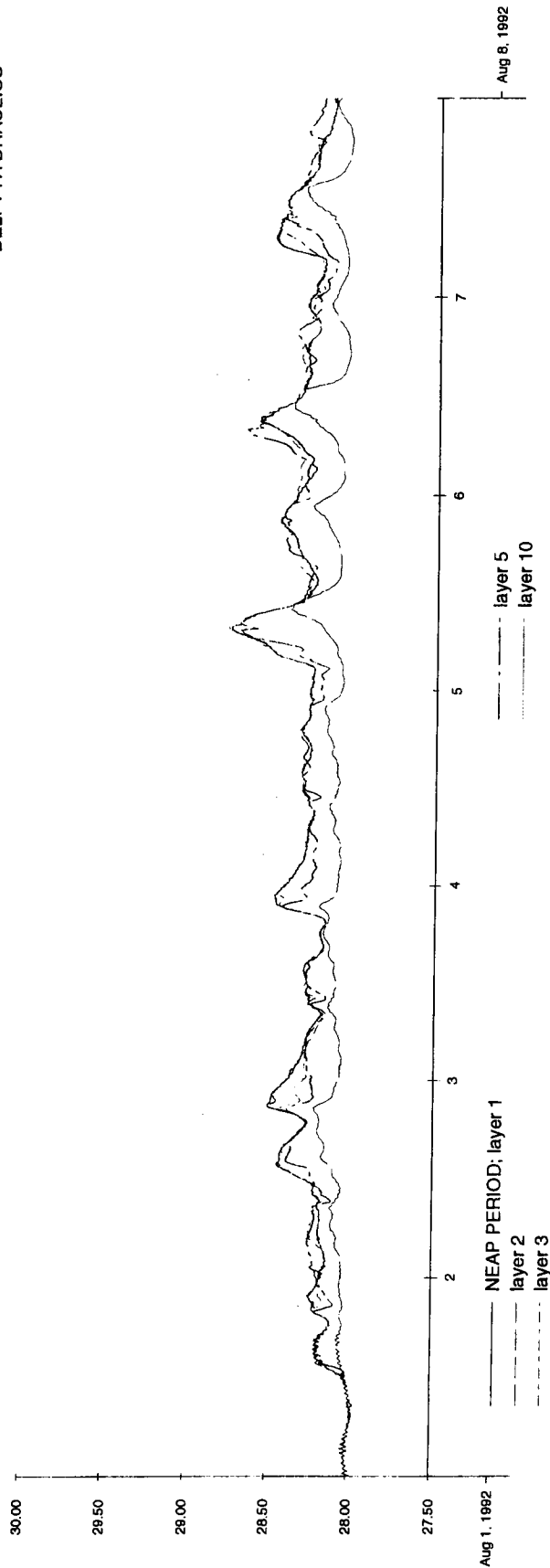
MAXIMUM TEMPERATURE FOR LAYERS 1 TO 4
SCENARIO 2 - WET SEASON SPRING TIDE

Environmental
Resources
Management



DELFT HYDRAULICS

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trih-p3s.dat p3s 991015 212119

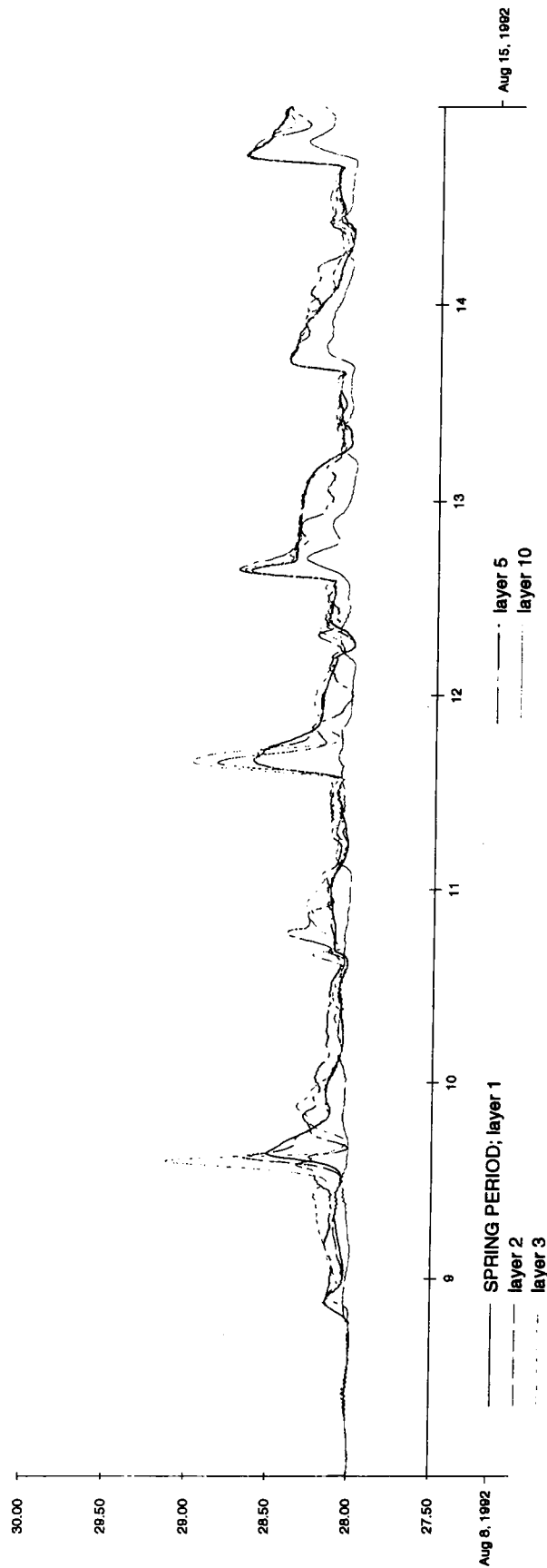


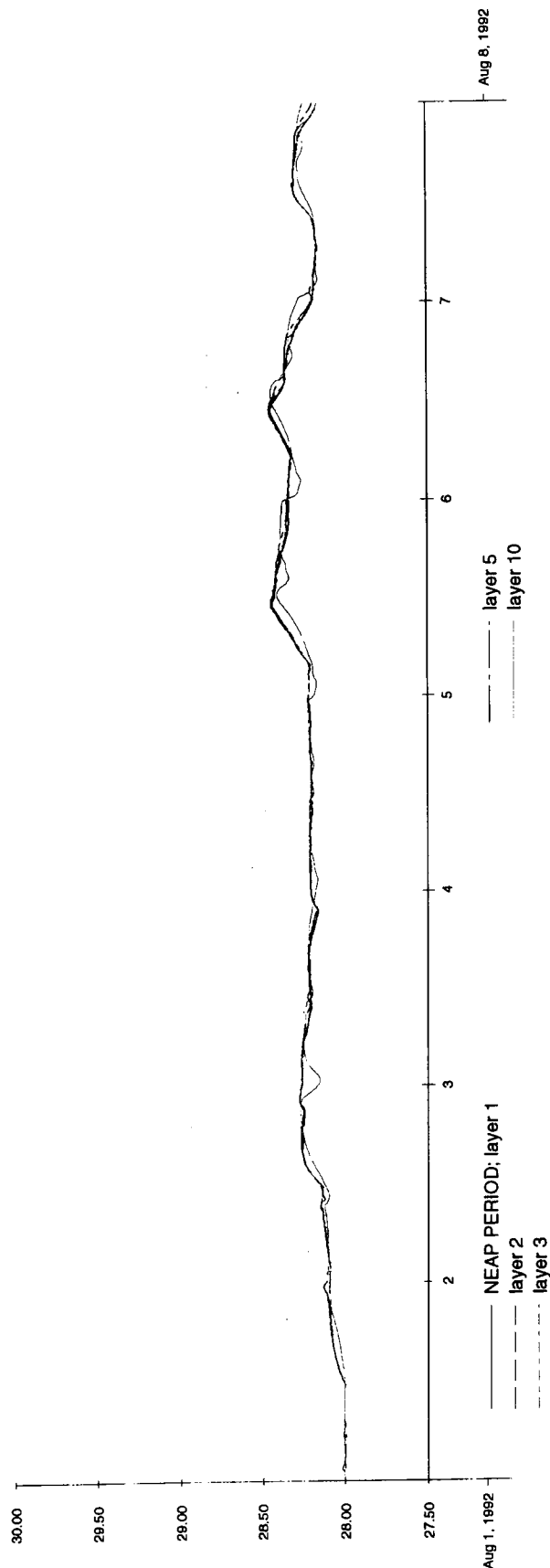
FIGURE B3 TIME SERIES OF TEMPERATURE AT LAMMA POWER STATION INTAKE
SCENARIO 2 - WET SEASON SPRING AND NEAP TIDES

Environmental
Resources
Management



DELFT HYDRAULICS

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trih-p3s.dat p3s 991015 212119

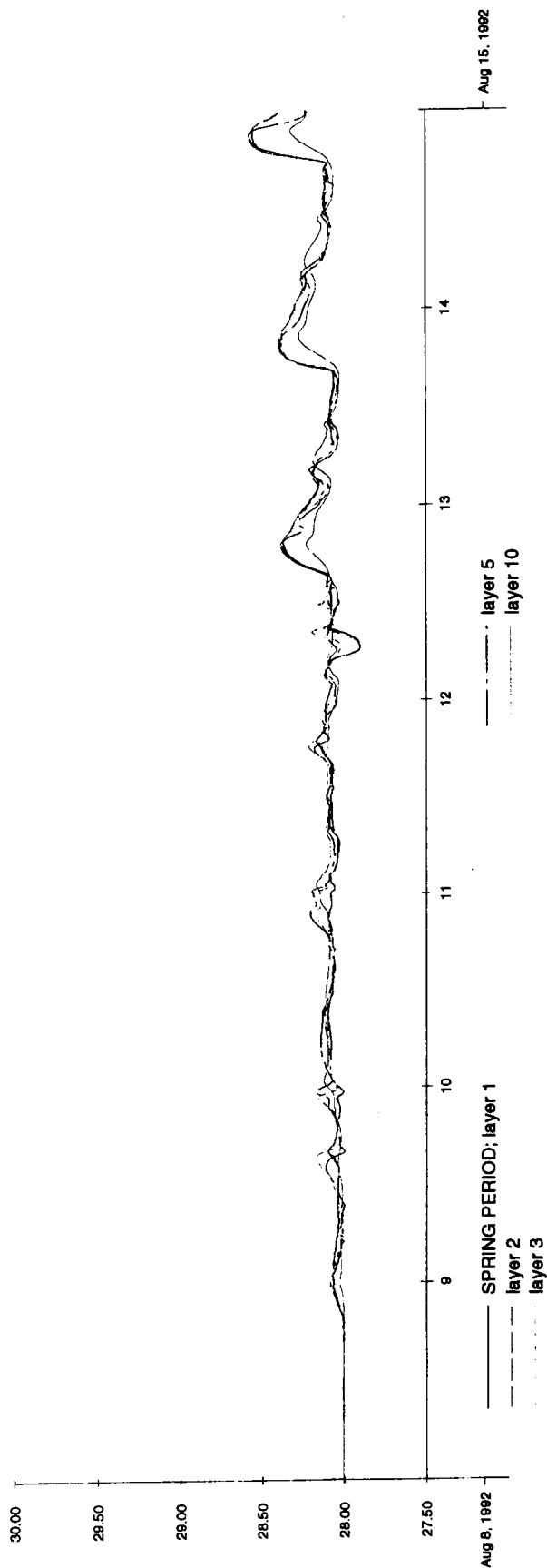


FIGURE B4

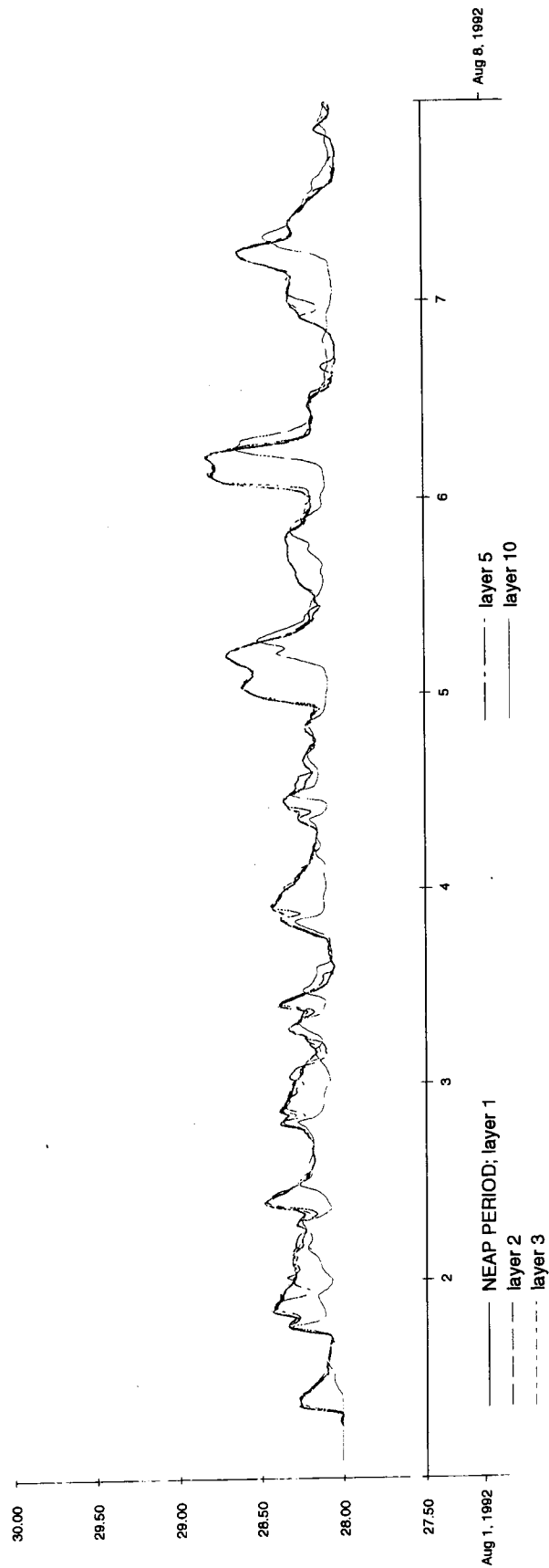
TIME SERIES OF TEMPERATURE AT HUNG SHING YE BEACH
SCENARIO 2 - WET SEASON SPRING AND NEAP TIDES

Environmental
Resources
Management



DELFT HYDRAULICS

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trih-p3s.dat p3s 991015 212119

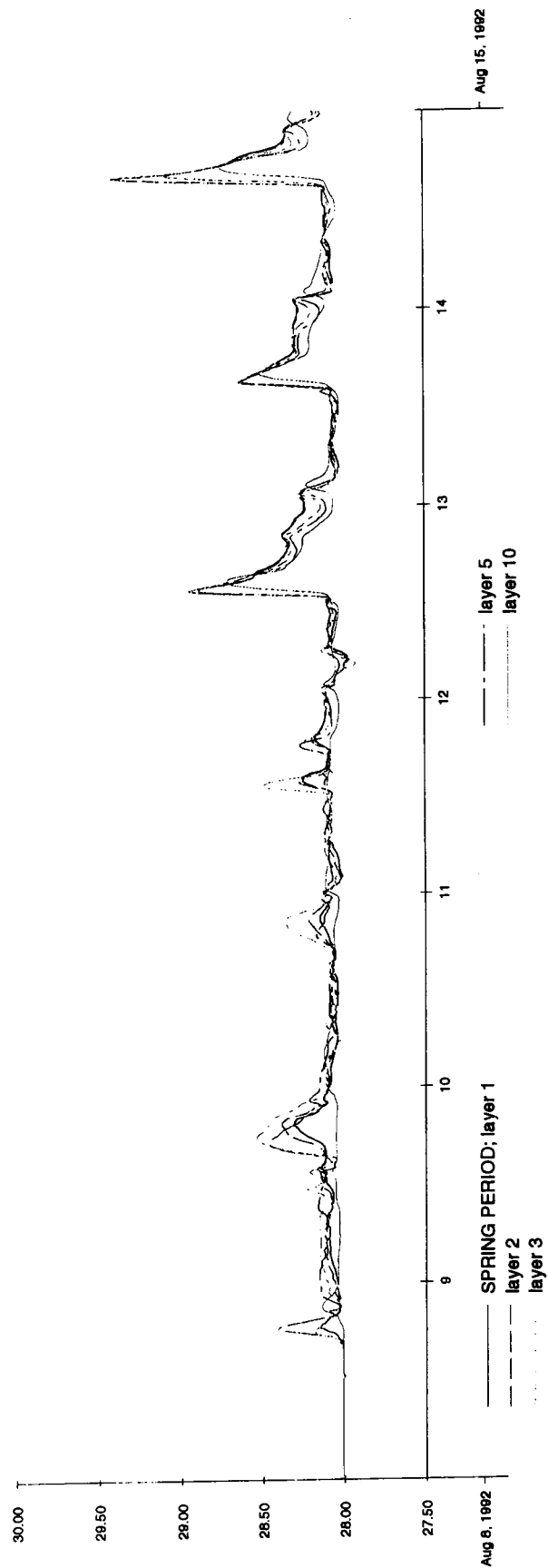


FIGURE B5

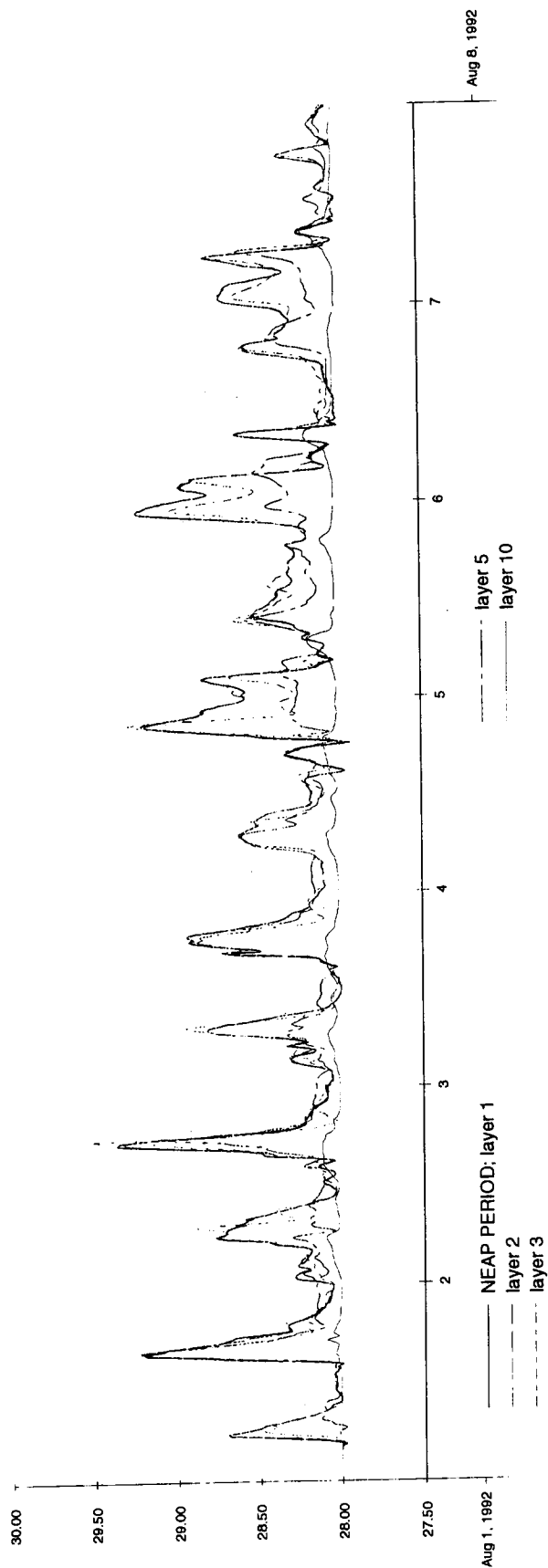
TIME SERIES OF TEMPERATURE AT LO SO SHING BEACH
SCENARIO 2 - WET SEASON SPRING AND NEAP TIDES

Environmental
Resources
Management



DELFT HYDRAULICS

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trih-p3s.dat p3s 991015 212119

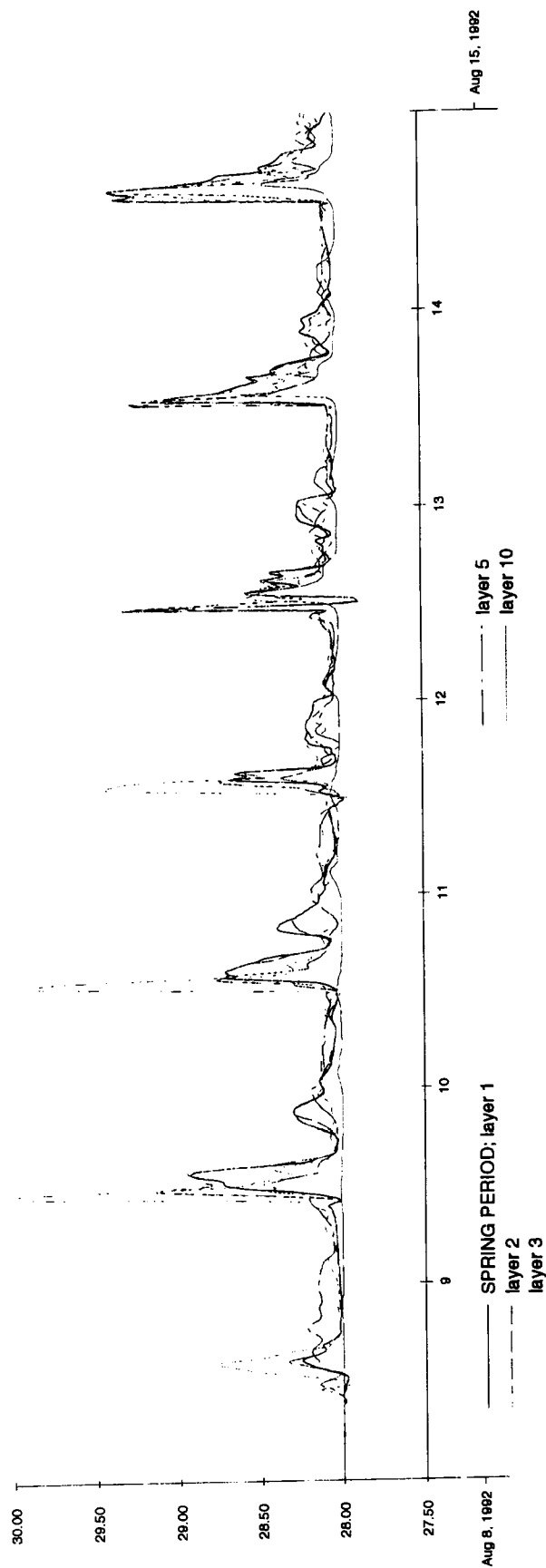


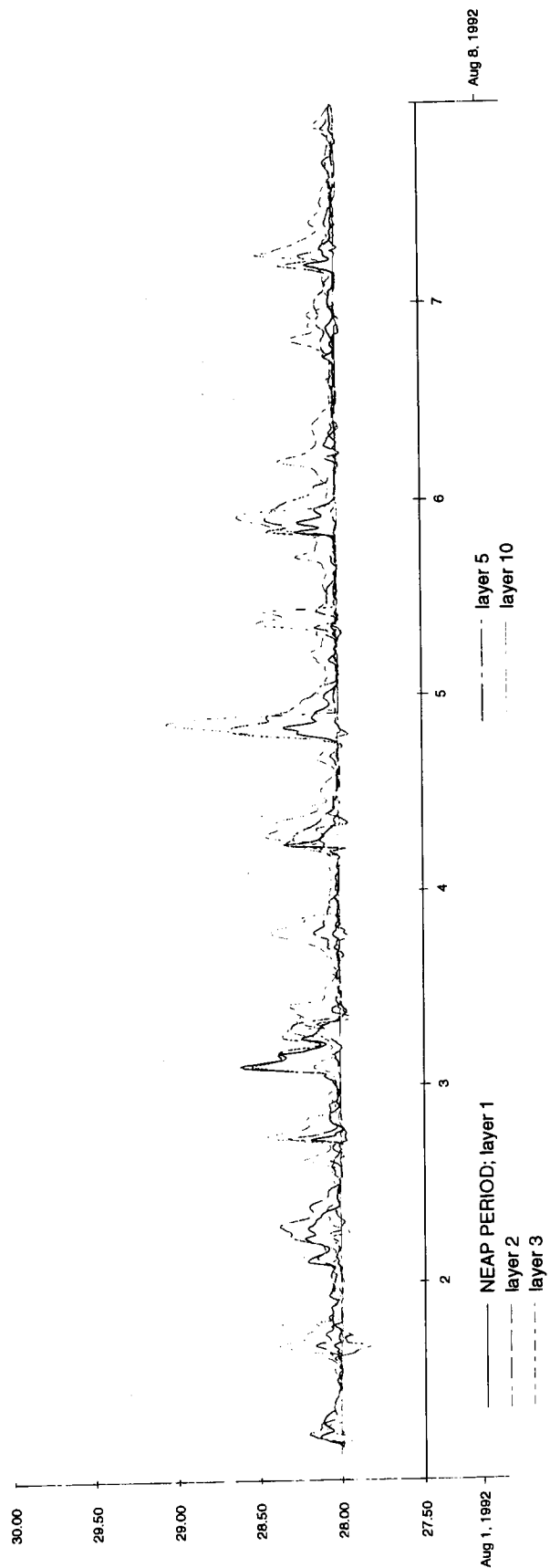
FIGURE B6 TIME SERIES OF TEMPERATURE AT SOUTH LAMMA MARINE PARK 1
SCENARIO 2 - WET SEASON SPRING AND NEAP TIDES

Environmental
Resources
Management



DELFT HYDRAULICS

trih-p3n.dat p3n 991015 150535



trih-p3s.dat p3s 991015 212119

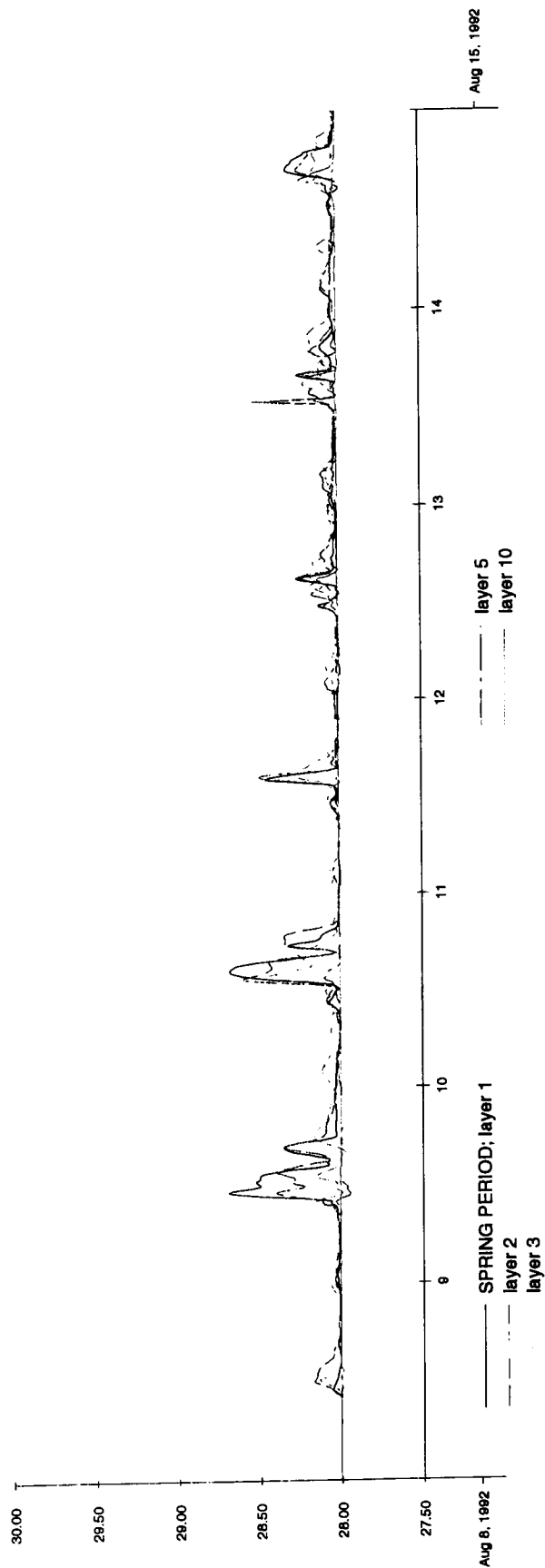


FIGURE B7

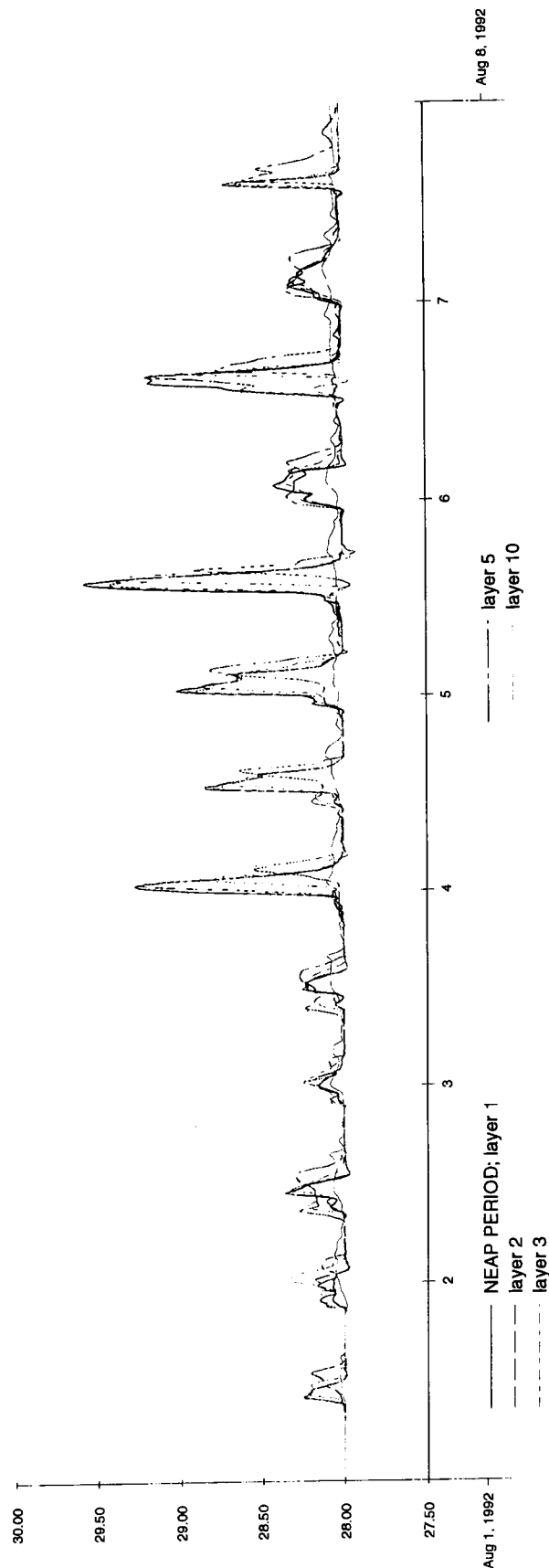
TIME SERIES OF TEMPERATURE AT SOUTH LAMMA MARINE PARK 2
SCENARIO 2 - WET SEASON SPRING AND NEAP TIDES

Environmental
Resources
Management



DELFT HYDRAULICS

trih-p3n.dat p3n 991015 150635



trih-p3s.dat p3s 991015 212119

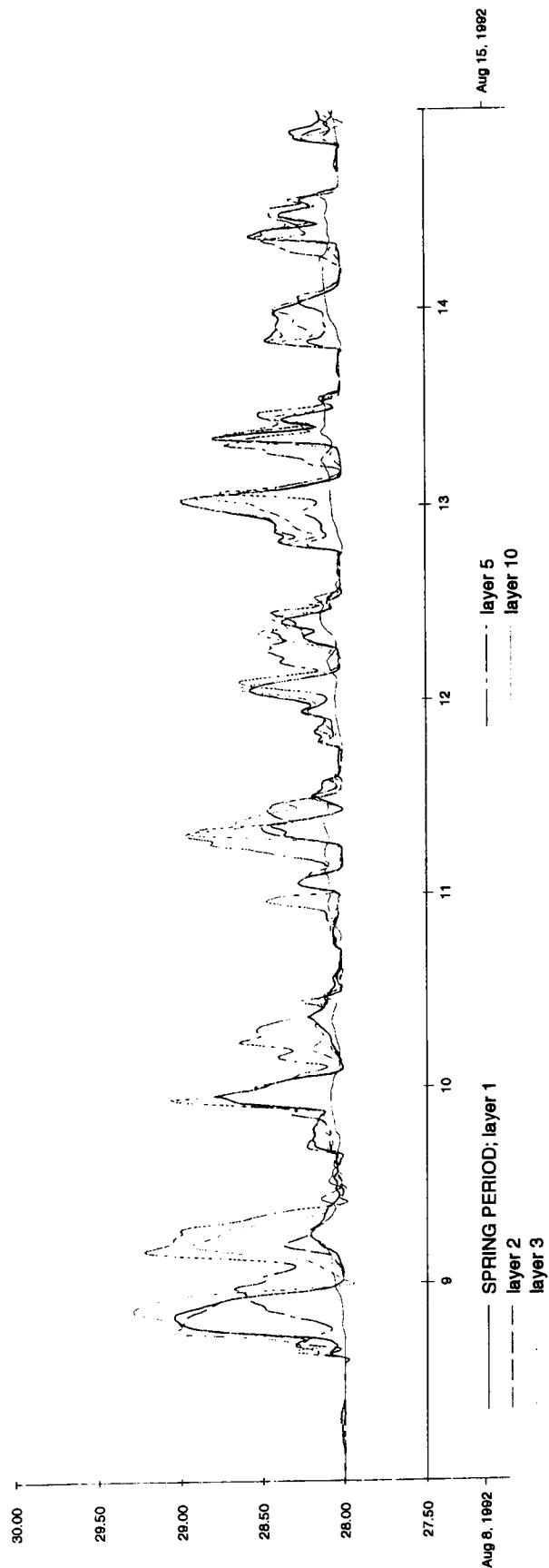


FIGURE B8

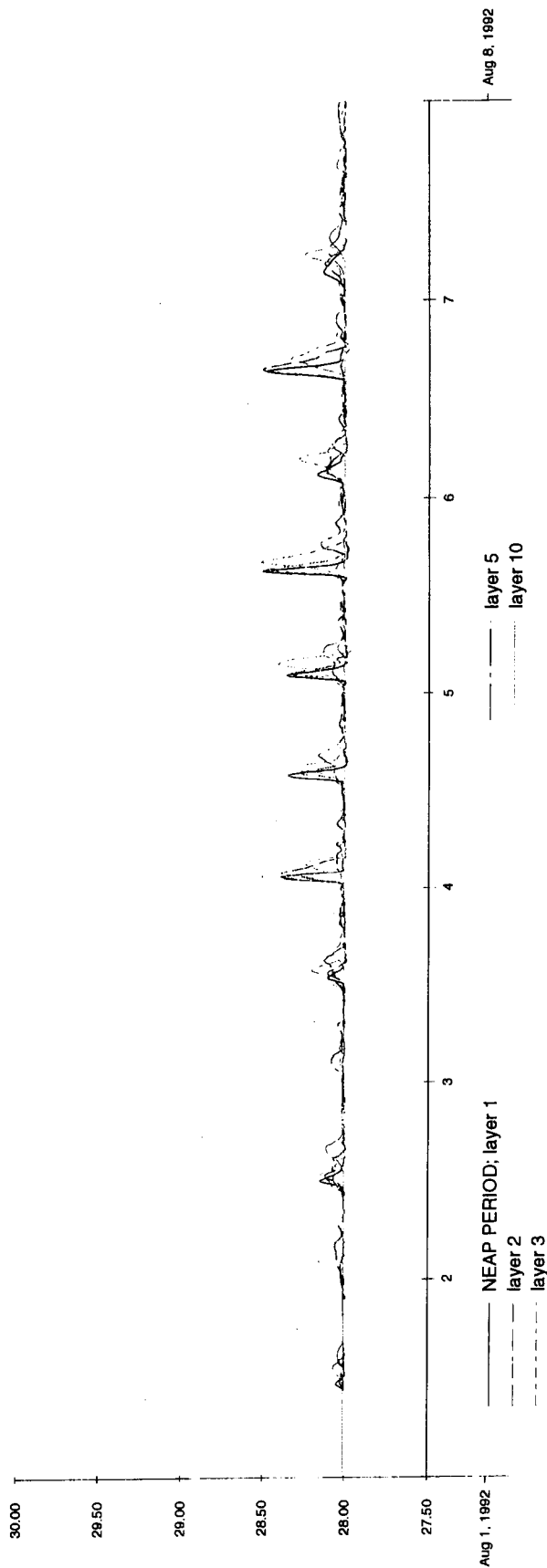
TIME SERIES OF TEMPERATURE AT SHEK KOK TSUI
SCENARIO 2 - WET SEASON SPRING AND NEAP TIDES

Environmental
Resources
Management



DELFT HYDRAULICS

trih-p3n.dat p3n 991015 150535



trih-p3s.dat p3s 991015 212119

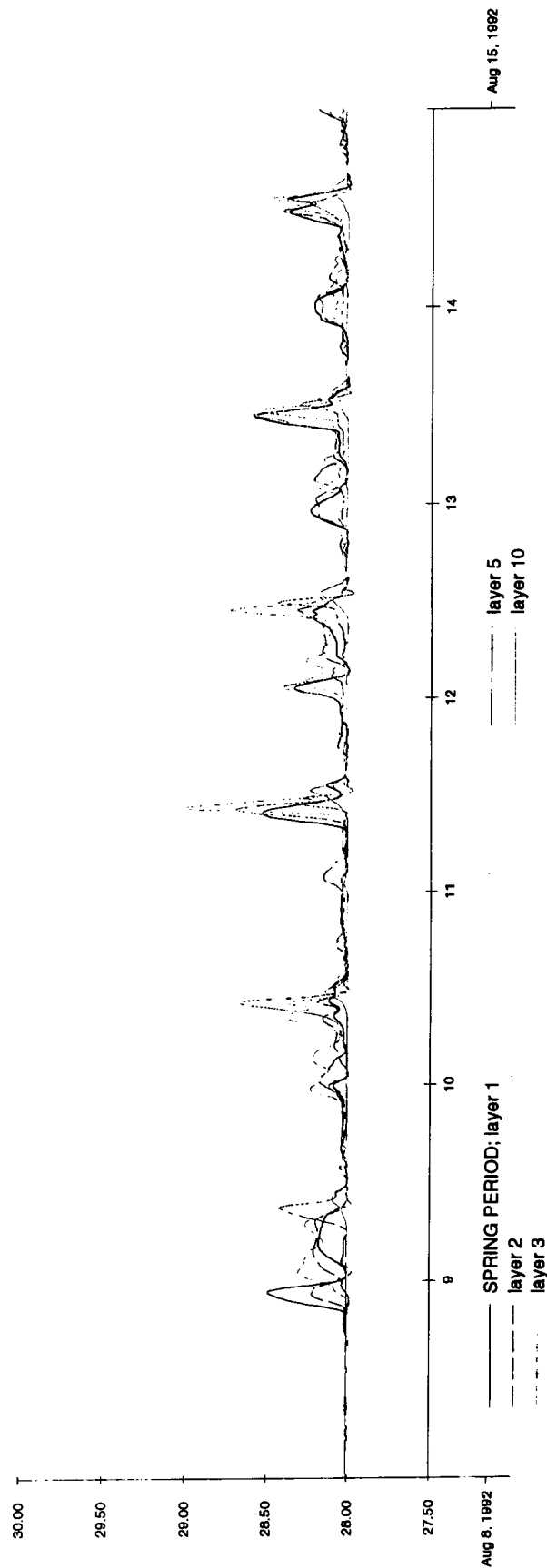


FIGURE B9

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

Environmental
Resources
Management



Annex D

View from West Lamma
Channel of Proposed
Conversion



FIGURE D1

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

Environmental
Resources
Management



ADDITIONAL INSTALLATIONS
FOR THE CONVERSION UNIT



FIGURE D2

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

Environmental
Resources
Management

