PROPOSED INTEGRATED PETROCHEMICAL COMPLEX AT KWINANA

PETROCHEMICAL INDUSTRIES COMPANY LIMITED

Report and Recommendations by the Environmental Protection Authority

Environmental Protection Authority
Perth, Western Australia
Bulletin 31 April 1988
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i SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

The Environmental Protection Authority (EPA) has assessed a proposal by Petrochemical Industries Company Limited to establish an integrated petrochemical complex at Kwinana. The proposal was described in an Environmental Review and Management Programme.

The proposed complex would utilise natural gas and industrial salt to produce a range of products for overseas and local markets. Vinyl chloride monomer and ethylene dichloride would be exported, and caustic soda and hydrogen gas would be sold to other industries already operating in Kwinana.

The Authority has determined that the project is environmentally acceptable, given that the major issues of risks and hazards, atmospheric emissions, and noise emissions can be resolved satisfactorily. Several important issues are still unresolved at this stage, and the Authority intends to deal with them through the mechanism of requiring an Environmental Management Programme (EMP), which will specify in detail the environmental impacts and their management associated with the particular aspect of the proposal with which it deals. The Authority will review the EMP and make it public, along with its review.

The Authority has come to the following conclusions:

- **modern petrochemical plants can operate with minimum pollution and negligible odours;**
- **given that the risk level from the proposed plant is acceptable and given the proximity to infrastructure, the Kwinana industrial area is an acceptable region to locate the proposed petrochemical plant;**
- **the proposed site for the plant within the Kwinana industrial area is environmentally acceptable;**
- **the individual risk levels from the plant are low enough to be acceptable;**
- **the cumulative risk levels from the proposed plant are low enough to be acceptable;**
- **air emissions from the plant could be made acceptable and manageable;**
- **noise emissions from the plant are acceptable;**
- **there is need for a plant emergency plan, and the Authority re-emphasises the need for the development of a Port Safety Management Plan and a Kwinana Emergency Plan;**
- **insufficient information was provided to the Authority on the following matters:**
  - **salt supply;**
  - **organochlorine wastes;**
  - **aqueous wastes;**

- other wastes; and

- export operations.

however, the Authority is satisfied that this additional information can be submitted in the form of an Environmental Management Programme.

Consequently the Environmental Protection Authority has made the following conclusions and recommendations:

RECOMMENDATION 1

The Environmental Protection Authority concludes that the proposal as described in the ERMP (Volumes 1 and 2), the responses given by the proponent (Appendix 2 of this Report), and in the second preliminary risk analysis in those aspects where it supersedes the ERMP, is environmentally acceptable, and recommends that it could proceed, subject to:

. the commitments made by the proponents for environmental management of the proposal, and listed in Appendix 3 of this Report, and

. the provision by the proponent, of a satisfactory Environmental Management Programme which deals with specific aspects of the proposal including:

  - salt supply and storage;
  - construction stage impacts;
  - commissioning stage impacts;
  - organochlorine waste treatment and disposal;
  - disposal of polymeric and caustic wastes;
  - disposal of solid and tarry wastes;
  - air quality;
  - VCM emissions; and
  - export operations; and

. the recommendations in this Report.

CONCLUSION

The Environmental Protection Authority concludes that the Kwinana Industrial Area is an environmentally acceptable region in which to locate the petrochemical complex.

RECOMMENDATION 2

The Environmental Protection Authority recommends that the buffer zone for the Kwinana Industrial Area be preserved so as to protect residential areas and maintain beneficial uses.

CONCLUSION

After considering the risks and hazards profile of the plant, expected air and noise emissions, and the commitments made by the proponent, the Environmental Protection Authority concludes that the proponent's site for the plant is environmentally acceptable subject to the proponent meeting its commitments and the further requirements of the Authority.

RECOMMENDATION 3

The Environmental Protection Authority recommends that the proponent includes in the Environmental Management Programme (referred to in Recommendation 1) details of the management of salt supply and storage to the Authority for approval before commissioning of the plant.

RECOMMENDATION 4

The Environmental Protection Authority recommends that the proponent carry out a programme of monitoring of the ambient air environment in the vicinity of the plant for a period of not less than three months prior to beginning production. This programme is to be agreed with the Authority within three months of the environmental conditions being set by the Minister for the Environment.

RECOMMENDATION 5

The Environmental Protection Authority recommends that the proponentinclude in the Environmental Management Programme (referred to in Recommendation 1) a plan to minimise construction stage impacts for approval by the Authority and relevant government agencies before the commencement of construction.

RECOMMENDATION 6

The Environmental Protection Authority recommends that the proponent submit comprehensive document describing the precautions to be adopted at the commissioning stage for approval by the Authority and relevant government agencies before the commencement of commissioning of the plant. This document should form part of the Environmental Management Programme.

RECOMMENDATION 7

The Environmental Protection Area recommends that the proponent shall submit storage designs to the Authority at the detailed design stage of each unit in the proposal, for approval by the Authority and relevant Government agencies.

RECOMMENDATION 8

The Environmental Protection Authority recommends that the proponent shall prepare, in stages, a comprehensive hazard identification and risk management programme, to the satisfaction of the Authority and relevant Government agencies.

The programme shall include the following:

. hazard and operability studies (HAZOP) of the process units, to be completed and submitted before mechanical construction commences;

. safety engineering design;

. quantified risk assessments;

. implementation systems; and

. safety reviews during the life of the plant;

at intervals to be determined by the Authority.

The results are to be forwarded to the Authority.

RECOMMENDATION 9

The Environmental Protection Authority recommends that the proponent should develop appropriate training and procedures manuals prior to commissioning, to the satisfaction of the Authority and other relevant government agencies.

RECOMMENDATION 10

The Environmental Protection Authority recommends that the proponent shall:

. maintain the process equipment, instrumentation and alarm systems consistent with the safety and reliability assessment of the plant;

. implement the best practicable technology in the prevention of damage to electrolysers as a result of fire or explosions; and

. install very high integrity instrumentation in the control of the plant and in the detection and response to any unplanned releases;

to the satisfaction of the Authority and other relevant government agencies.

CONCLUSION

The Authority concludes that when:

. the proposed safeguards and the Authority's recommended conditions related to risks and hazards are implemented.

then the likely risk from the plant would be low enough to be acceptable to the Environmental Protection Authority.

RECOMMENDATION 11

The Environmental Protection Authority recommends that the proponent includes the Environmental Management Programme details on the treatment and disposal of a organochlorine wastes, for approval by the Authority before the commencement of plant commissioning. This should include a proposal to extract chlorinated aromatics and their safe transport to a suitable incinerator with an adequate buffer. The EPA WILL not issue a licence to operate the plant until the disposal of chlorinated aromatics has been resolved to the satisfaction of the EPA.

RECOMMENDATION 12

The Environmental Protection Authority recommends that the proponent shall adopt an overall philosophy, for the design, construction and operation of the plant, aimed at achieving a target VCM emission level of zero within the plant and at the plant boundary. The proponent shall submit a comprehensive programme (as part of the Environmental Management Programme) for approval by the Authority before commissioning of the plant.

RECOMMENDATION 13

The Environmental Protection Authority recommends that the proponent establish a monitoring network for the detection of VCM in emissions and in the ambient air environment to the satisfaction of the EPA. A reporting and management policy shall be developed, to the satisfaction of the EPA, to react to all measured emissions. This policy shall have the primary goal of minimising the frequency and concentration of such emissions and eliminating them as soon as possible after detection. The VCM monitoring programme should incorporate the suggestions made in this Report.

RECOMMENDATION 14

The Environmental Protection Authority recommends that the proponent submits, as part of the Environmental Mangement Programme, a proposal for air quality monitoring which incorporates the following elements:

- monitoring and alarm systems for chlorine, hydrogen chloride, ethylene dichloride and flammable hydrocarbons, within the plant and at the plant boundary;

- a leak detection monitoring programme; and

- regular reporting of results with reference to appropriate standards;

for approval by the Authority, prior to commissioning of the plant.

RECOMMENDATION 15

The Environmental Protection Authority recommends that the proponent provide a detailed quantified analysis of all gaseous emissions under 'plant upset' conditions, to the satisfaction of the Authority, prior to plant commissioning.

RECOMMENDATION 16

The Environmental Protection Authority recommends that the proponent submit to the Authority additional information in the Environmental Management Programme, relating to all aqueous wastes and their disposal from the plant at the detailed design stage and before commissioning commences. The proposal must be to the satisfaction of the Authority and relevant government agencies.

RECOMMENDATION 17

The Environmental Protection Authority recommends that the proponent submit further information, as part of the Environmental Management Programme on the handling and disposal of polymeric and caustic materials, to the Authority before commissioning commences. The proposal must be to the satisfaction of the Authority and relevant government agencies.

RECOMMENDATION 18

The Environmental Protection Authority recommends that the proponent submit further information, as part of the Environmental Management Programme, on the characterisation of solid and tarry wastes, and appropriate disposal methods, for approval before commissioning of the plant.

RECOMMENDATION 19

The Environmental Protection Authority recommends that the proponent submit details, as part of the Environmental Management Programme, on export operations for assessment and approval by the Authority before plant commissioning.

RECOMMENDATION 20

The Environmental Protection Authority recommends that the proponent prepare a plant emergency plan, which takes into account all relevant contingencies. This plan should be completed, submitted to the Authority and approved by the relevant government agencies, before plant commissioning. This plan should also conform with the requirements of the Kwinana Emergency Plan and the Port Safety Management Plan.

RECOMMENDATION 21

The Environmental Protection Authority recommends that adequate safeguards be incorporated in the design of the plant to reduce noise emissions so that resultant noise levels in residential areas are acceptable to the Authority.

1. INTRODUCTION

1.1 BRIEF DESCRIPTION OF PROPOSAL

Petrochemical Industries Company Limited (PICL) proposes to establish an integrated petrochemical complex in the Kwinana industrial area. The facility will utilise natural gas and industrial salt to produce a range of products, some for export and others for the local market. Associated with, but separate from the PICL proposal, is a proposal by Wesfarmers LPG Pty Ltd, to modify the liquified petroleum gas (LPG) extraction plant to extract ethane from natural gas. The ethane is to be supplied to PICL as feedstock and is to be stored on the PICL site.

The proposed PICL facility consists of three chemical plants:

- a chlor-alkali plant which will utilise salt and electricity to produce chlorine, caustic soda and hydrogen; and
- an ethylene plant, which will crack ethane feedstock via a thermal process;
- an ethylene dichloride/vinyl chloride monomer plant, which will react ethylene and chlorine to form ethylene dichloride (EDC). The EDC is then cracked to form vinyl chloride monomer (VCM). Further details of the process are given in Chapter 3.

The expected capacities of the plants are given in Table 1.

Table 1. Summary of PICL plant capacities.

PLANT	INSTALLED PLANT CAPACITY (tonnes per annum)		ANNUAL OUTPUT (tonnes per annum)	
1. Chlor-alkali	Chlorine:	230 000	Chlorine:	218 000
	Caustic soda:	260 000	Caustic soda:	245 000
			Hydrogen:	6 400
2. Ethylene	Ethane feed:	250 000	Ethylene:	140 000
3. EDC/VCM	VCM:	300 000	Case 1: VCM	300 000
			Case 2: VCM	240 000
			EDC	100 000

Virtually all chlorine will be used to make ethylene dichloride. Caustic soda will be sold locally for use in the bauxite refining process, and hydrogen will be used on site for fuel and further processing, and the remainder sold to BP refinery as a fuel. Most ethylene dichloride (EDC) will be converted to vinyl chloride monomer (VCM). The remaining EDC, and the VCM, will be exported for further processing overseas. VCM will mostly be converted to polyvinyl chloride (PVC), a widely used plastic, which is produced in many grades oriented to various markets. VCM is a "generic" product, for which there is currently very high world demand. The proposal represents a "world-scale" plant, and will fill a "window" in the world supply situation of EDC and VCM.

The cost of the proposal is expected to be $850 million. The proponent states that the project will have significant economic benefits to the region and the State. Income will be received for export of products, and the import replacement savings for supply of caustic soda to the alumina industry would be substantial.

The proposal has been developed by PICL following the award of an exclusive position to the company by the State Government in 1987, to conduct a feasibility study on the project.

1.2 ASSESSMENT PROCESS FOR THE PROPOSAL

The proponent submitted a Notice of Intent to the Environmental Protection Authority in March 1987, indicating the nature and scope of the project. The Authority subsequently determined that an Environmental Review and Management Programme, as well as a Preliminary Risk Analysis would be required in order to adequately assess the proposal, and subsequently issued guidelines in April 1987. The Authority also determined (in September 1987) that a Notice of Intent was required from Wesfarmers LPG Pty Ltd in respect of the expansion of the LPG facility to extract ethane. The ERMP and the NOI were to be published together in the same document.

The documentation (ERMP, NOI and Preliminary Risk Analysis) was released for a ten week public review period, commencing 2 December 1987 and ending 10 February 1988. The Authority received 23 submissions.

A set of questions (Appendix 1) seeking clarification and/or further information from the proponent was developed after considering the issues identified in the ERMP, the preliminary risk analysis and the public submissions, and forwarded to the proponent for response. The responses (Appendix 2), as well as other information provided by the proponent, the submissions and the EPA's own investigations have enabled the Authority to assess the project. In carrying out its assessment, the Authority sought information from a variety of sources, including the United States Environmental Protection Agency, the Victorian Environment Protection Authority and the NSW State Pollution Control Commission. In addition, the Chairman of the Authority visited an EDC/VCM plant near Houston, Texas, and two officers of the Authority visited polyvinyl chloride manufacturing plants in Victoria and the ICI complex in Botany NSW.

NEED FOR PROGRESSIVE ENVIRONMENTAL ASSESSMENT

At the time the ERMP was prepared, the proponent had not made decisions on specific technologies for the ethylene plant, or the chlor-alkali plant. The proponent had made a tentative decision about the process for the EDC/VCM plant. Decisions about some other issues such as water sourcing, or waste disposal also had not been made.

At the time of this assessment report, decisions on some of the above aspects had been made and are incorporated in the responses given by the proponent. Some decisions, however, are still outstanding, and this will result in the need for further assessment of specific aspects of the project in the future. In the case of major developments, such as the PICL project, it is a common practice for the EPA to report on the overall environmental acceptability of such projects. This is then followed by a requirement for further assessment of outstanding components of the projects when more details (such as design, operation and environmental impacts) become available. This information is submitted to the EPA in the form of an Environmental Management Programme.

In addition, the Pollution Control requirements of the Environmental Protection Act provides a further opportunity for detailed examination of plant safeguards and emission controls.

This sequential environmental assessment and approval process has been adopted for this project and the Recommendations made in this report have been framed in this context.

The Authority has concluded that those decisions still pending are essentially of a management king and do not prejudice the overall environmental acceptability of the proposal.

The scope and quantity of information required from the proponent in order for EPA to carry out the assessment has been extensive. The EPA suggested to the proponent that, in view of the complexity of the project, and the need for as high a degree of safety as possible, and the ongoing decision making that was occurring in respect of the scope of the project, a second opinion on the risks and hazards associated with the proposal was required. The company accordingly engaged a UK firm, Technica, to give a second opinion on preliminary risks and hazards. Their report appears at Appendix 4. The Authority has based its assessment of the plant on the nominated plant capacities in the Technica report, as these are in some cases larger than those in the ERMP, and will take account of some on-going decision making by PICL in terms of plant capacity. It also enables a "worst-case" assessment by EPA. In the past, the Authority has required verifications of preliminary risk analyses. The Technica study has resulted in individual risk contours that are similar to those generated by Bureau Veritas in the first risk assessment.

The Authority has made recommendations that assume there is need for further sequential review of various aspects of the proposal. The proponent will be required to submit an Environmental Management Programme (EMP) to the Authority to include following aspects:

. salt supply and storage;

. construction stage impacts;

. commissioning stage impacts;

. organochlorine waste treatment and disposal

. aqueous waste treatment and disposal

. disposal of polymeric and caustic materials;

. disposal of solid and tarry wastes;

. air quality;

. VCM emissions; and

. export operations.

After review of the EMP, further appropriate environmental conditions will be set which will be in addition to these resulting from the Recommendations of this Report. The EMP and the Authority's reviews of them will be released publicly. Certain components of the EMP may be released for public comment before the Authority completes its review of that Programme.

RECOMMENDATION 1

The Environmental Protection Authority concludes that the proposal as described in the ERMP (Volumes 1 and 2), the responses given by the proponent (Appendix 2 of this Report), and in the second preliminary risk analysis in those aspects where it supersedes the ERMP, is environmentally acceptable, and recommends that it could proceed, subject to:

. the commitments made by the proponents for environmental management of the proposal, and listed in Appendix 3 of this Report, and

. the provision by the proponent, of a satisfactory Environmental Management Programme which deals with specific aspects of the proposal including:

  - salt supply and storage;
  - construction stage impacts;
  - commissioning stage impacts;
  - organochlorine waste treatment and disposal;
  - disposal of polymeric and caustic wastes;
  - disposal of solid and tarry wastes;
  - air quality;
  - VCM emissions; and
  - export operations; and

. the recommendations in this Report.

2. ASSESSMENT OF OPTIONS

2.1 REGIONAL SITE SELECTION

The proponent developed the following set of site selection criteria.

1. Infrastructure:

   . power availability;

   . port facilities for export of EDC/VCM product;

   . rail and shipping facilities for delivery of salt; and

   . residential areas to accommodate construction and operational workforces.

2. Minimisation of transport and handling of chemicals:

   . location of LPG plant (as source of ethane);

   . safety factors involved in the storage and transport of EDC and VCM; and

   . proximity of alumina refineries as consumers of caustic soda product.

3. Availability of industrial zoned land of suitable size (approximately 80 ha).

4. Environmental suitability, particularly a buffer zone allowing adequate separation of potential sources of hazards from residential areas.

5. Cost

Cost considerations indicated the need to locate the ethane cracker close to the LPG plant (the source of ethane). Although gas and salt are available in the Pilbara for example it is not practicable to be a large distance away from the ethane source.

The proponent then examined the possibilities of locating the chlor-alkali plant and the EDC/VCM plant near Bunbury, Pinjarra or Kwinana, as shown in Figure 1.

The Bunbury and Pinjarra options were discounted because of the need to transport ethylene from Kwinana by pipeline, and then in Pinjarra's case the consequent need to transport EDC and VCM to a port facility for export and in Bunbury's case the need to rail caustic soda to an Alumina refinery. The option of transporting ethane to a site on which the complete complex could be located was not discussed. Transport of the raw materials involved in this project needed to be minimised not only because of cost but because of their hazards. The Kwinana option was considered to eliminate the need to transport ethane, ethylene, caustic soda, EDC or VCM in areas which could significantly increase the risk to the public and to the environment. Kwinana also was considered to have all the necessary infrastructure.

The description of the site selection process was sufficient for this assessment.

A major constraint on future large scale industrial development in the Kwinana area will be the availability of water for industrial cooling and process requirements. Existing groundwater resources are heavily committed. It is clear that the water requirements for the PICL proposal could not be met by groundwater alone, should the proposed ammonia-urea plant be constructed and operated.

Combined with the situation of a prospective groundwater shortage for large industry, there will be a need for a new approach to industrial water resources in the area. The EPA understands that the Department of Resources Development is investigating the concept of industrial water treatment and recycling on an across -industry basis in the area, and commends this initiative.

PICL, subsequent to the publication of the ERMP, have made a decision to utilise partially treated domestic waste waters for cooling purposes. PICL propose to further treat this water on-site and to then dispose of the used water to the Cape Peron outfall line. Further water requirements are to be supplied by scheme water. No decisions have been made on disposal of industrial process water. However, whatever proposals are made will be assessed by EPA.

Given the initiative of PICL to treat and re-use very large quantities of domestic waste waters then the use of the Kwinana area is not constrained by water requirements for this project. This proposal to retreat and re-use domestic waste waters for industrial purposes is the first time such a venture has been proposed in Western Australia. The Company is to be commended for this conservation initiative.

Figure 1.   Alternative sites.

It is expected that air emissions will not be a constraint given the commitments made by PICL and the recommendations in this Report.

The relevant risk contours show that acceptable levels of risk, and acceptable ground level concentrations of atmospheric emissions, from PICL are well within the existing buffer zone.

Kwinana has therefore in terms of site characteristics for this project the following attributes:

. access to the basic raw materials;

. necessary infrastructure;

. ready access to other industries for feedstocks and for pipeline transfer of products such as caustic soda and hydrogen;

. minimum land transport of EDC/VCM, ehtane, and caustic soda;

. adequate water; and

. a large enough buffer zone to residential areas.

CONCLUSION

The Environmental Protection Authority concludes that the Kwinana Industrial Area is an environmentally acceptable region in which to locate the petrochemical complex.

IMPORTANCE OF RETENTION OF BUFFER ZONE SURRONDING THE KWINANA INDUSTRIAL AREA

The purpose of the buffer zone is to ensure that people in residential areas are properly protected from potential environmental impacts from industrial development by adequate separation. In order to achieve this aim, and to ensure that no conflict occurs with residential areas, the EPA believes that the current buffer zone must be retained. The current buffer zone allows the area sufficient capacity in terms of air emissions and risks and hazards. In general terms, such zones ensure that the residents of Western Australia will be able to benefit from an appropriate environmental quality.

RECOMMENDATION 2

The Environmental Protection Authority recommends that the buffer zone for the Kwinana Industrial Area be preserved so as to protect residential areas and maintain beneficial uses.

2.2 SITE SELECTION WITHIN THE KWINANA INDUSTRIAL AREA

Site selection in the Kwinana area both generally and specifically has been dictated principally by the location of the Wesfarmers LPG Pty Ltd facility for the supply of ethane, and generally by the availability of other infrastructure requirements.

Identification of a specific location within Kwinana was also contingent on criteria such as:

. proximity to, and access to:

  - rail and port facilities for supply of salt; and

- port facilities for export of EDC and VCM.

- proximity to an alumina refinery for sale of caustic soda; and
- availability of a large (80 ha) site.

The proponent identified a site on BP Refinery land that meets the above criteria, and which it intends to purchase. The location is shown in Figure 2.

CONCLUSION

After considering the risks and hazards profile of the plant, expected air and noise emissions, and the commitments made by the proponent, the Environmental Protection Authority concludes that the proponent's site for the plant is environmentally acceptable subject to the proponent meeting its commitments and the further requirements of the Authority.

2.3 ALTERNATIVE PROJECT OPTIONS

2.3.1 ALTERNATIVE TECHNOLOGY

The potential impacts of proposed industrial developments are highly dependent on the particular technology proposed for those developments. PICL has decided to adopt the safest current technology which will minimise the potential impacts and keep risks at an acceptable level. Some of the main characteristics of the technology are presented briefly in this section.

The electrolysis process in the chlor-alkali plant embodies many improvements over earlier technologies. The main factor is the use of membrane electrolysis cells. The alternative diaphragm cell technology has been associated with many environmental and health problems due to use of mercury. The proposed technology will be maintained under slightly negative pressure to avoid any chlorine gas leakage.

There are few options available for ethylene and EDC/VCM production technologies. PICL proposes to employ the Stone-Webster technology for ethylene production and the B F Goodrich process for EDC/VCM production. Both companies are among the industry leaders and operate similar plants around the world.

Storage is one of the major generators of risk and hazard in chemical plants. PICL proposes to adopt current technology for their major inventories of hazardous materials. The main characteristics of the selected technology compared with former practice are summarised in Table 2.

Table 2. Comparison of storage technologies.

MATERIAL	OLDER TECHNOLOGY	PICL TECHNOLOGY
Chlorine	Ambient temperature pressurised storage, large inventory	Fully refrigerated pressurised storage, special storage design, small inventory
Ethane	Refrigerated storage single integrity, low height (full capacity) bund	Refrigerated storage, double integrity, full height, (full capacity) bund

Figure 2. Location of the PICL facility in the Kwinana area.

2.3.2 WATER SUPPLY AND AQUEOUS WASTE DISPOSAL

The scarcity of available water resources, both in quantity and quality is one of the principal constraints upon the project. Water consumption of the proposed plant will be about 1000 cubic metres per hour for cooling purposes.

Three alternatives exist for sources of cooling water. The first is based on sea water from Cockburn Sound. As Cockburn Sound is an environmentally sensitive locality, the criterion for discharge heat loading would be stringent, and would make sea water cooling unacceptable. Sea water also would lead to extensive corrosion problems in the plant.

The second option is to use groundwater (either deep or shallow) in combination with the scheme water supply. Because of the restricted supply available, it would be necessary to incorporate some form of air cooling which involves higher costs, major technical problems and some environmental implications, particularly in regard to noise. This option was rejected by PICL.

The option preferred by the proponent is to use the waste water from the Woodman Point Treatment Plant, operated by the Water Authority of Western Australia, by drawing it from the main pipeline to Cape Peron.

PICL are to build a secondary and tertiary treatment plant on-site. The water would be treated by a conventional active sludge system with possible denitrification. The water would be used for cooling purposes and returned to the same pipeline for discharge to the ocean via the Cape Peron outfall.

Environmentally, this option is highly preferable, for two reasons. The first is that part of the existing waste waters would be treated before discharge. The second is that the effluent would not be discharged in Cockburn Sound but to the deep open ocean. Dilution of possible contaminants to an acceptable level would be readily achieved. The principal EPA requirement would be that the water re-injected into the line would be of equivalent or better quality than that which entered the PICL site.

3. DESCRIPTION OF PROPOSAL

3.1 INTRODUCTION

The proposal is a world-scale petrochemical project consisting of three integrated components. These components and their annual capacities are:

- an ethylene plant - 145 000 tonnes per annum (tpa) ethylene;
- a chlor-alkali plant - 250 000 tpa caustic soda,
230 400 tpa chlorine,
6500 tpa hydrogen; and
- an EDC/VCM plant - 300 000 tpa VCM.

The EDC/VCM plant will also be designed to allow production of up to 100 000 tpa EDC for export, giving a lower VCM output of 240 000 tpa.

A small amount of hydrochloric acid will also be produced for the local market. There will be large refrigerated storage tanks for ethane, ethylene and VCM. EDC will be stored in ambient temperature atmospheric tanks prior to export. The other products will be either sent directly to the neighbouring industries or will be used internally.

The plant components and their inter-relationships are shown in Figure 3. The layout of these components on the site is shown in Figure 4.

The PICL project lilke any industrial project is still developing in many detailed aspects of process design. Therefore although the proponent was able to provide information sufficient for the Authority to determine overall project acceptability it is acknowledged that some uncertainty is still involved. On the other hand, this has benefits, as any potential impact identified in later parts at this report can be managed and minimised during the final design process.

This section describes the major unit processes without developing any perspective on the various impacts involved.

3.2 UNIT PROCESSES

3.2.1 RAW MATERIAL SUPPLY

SALT: Salt consumption is estimated to be about 410 000 tpa. The proponent has identified three potential sources of salt, but it is likely that the primary supply will be derived from Lake Deborah with possibly a lesser quantity from Dampier. The salt reserves at Lake Deborah are estimated to be sufficient to meet this demand.

The salt from Lake Deborah will be delivered by rail to the complex in Kwinana where a stockpile sufficient for two weeks demand (Appendix 2) will be developed and maintained. Any salt from Dampier would be delivered by ship to Fremantle. An Environmental Management Programme will be required in order for EPA to assess all aspects of the mining, handling, transport and storage of salt.

RECOMMENDATION 3

The Environmental Protection Authority recommends that the proponent includes in the Environmental Management Programme (referred to in Recommendation 1) details of the management of salt supply and storage to the Authority for approval before commissioning of the plant.

GAS: The principal resource is natural gas from the North-West Shelf project. The LPG plant in Kwinana, currently under construction, will extract propane and butane from natural gas. The proponent of the LPG plant is prepared to modify the plant to produce 177 000 tpa of ethane, which will satisfy the principal feedstock requirements of PICL. A Notice of Intent for this plant has been prepared by the proponent and assessed by the EPA. A copy of the Assessment Report (Bulletin 332) has been included with this report (Appendix 8).

WATER: During operation, PICL will be a significant consumer of water. Water will be required for cooling, processing and general purposes. The proposed sources and quantities of water are as follows:

- cooling water : 700 to 900 m^3/h from treated domestic and industrial waste water; and

- process and general purposes : 200 m^3/h from mains supply.

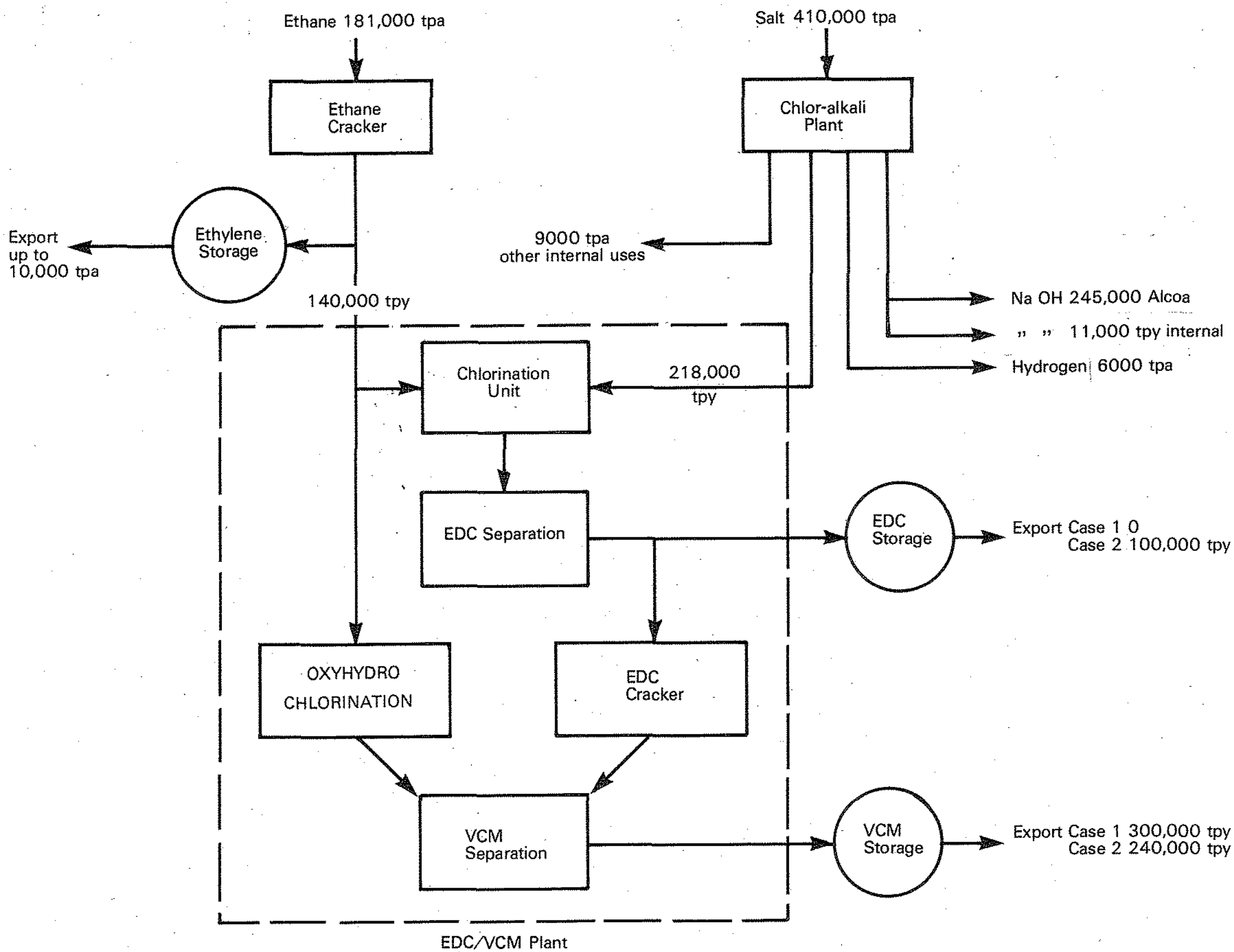


Figure 3. Basic elements of the Petrochemical complex.

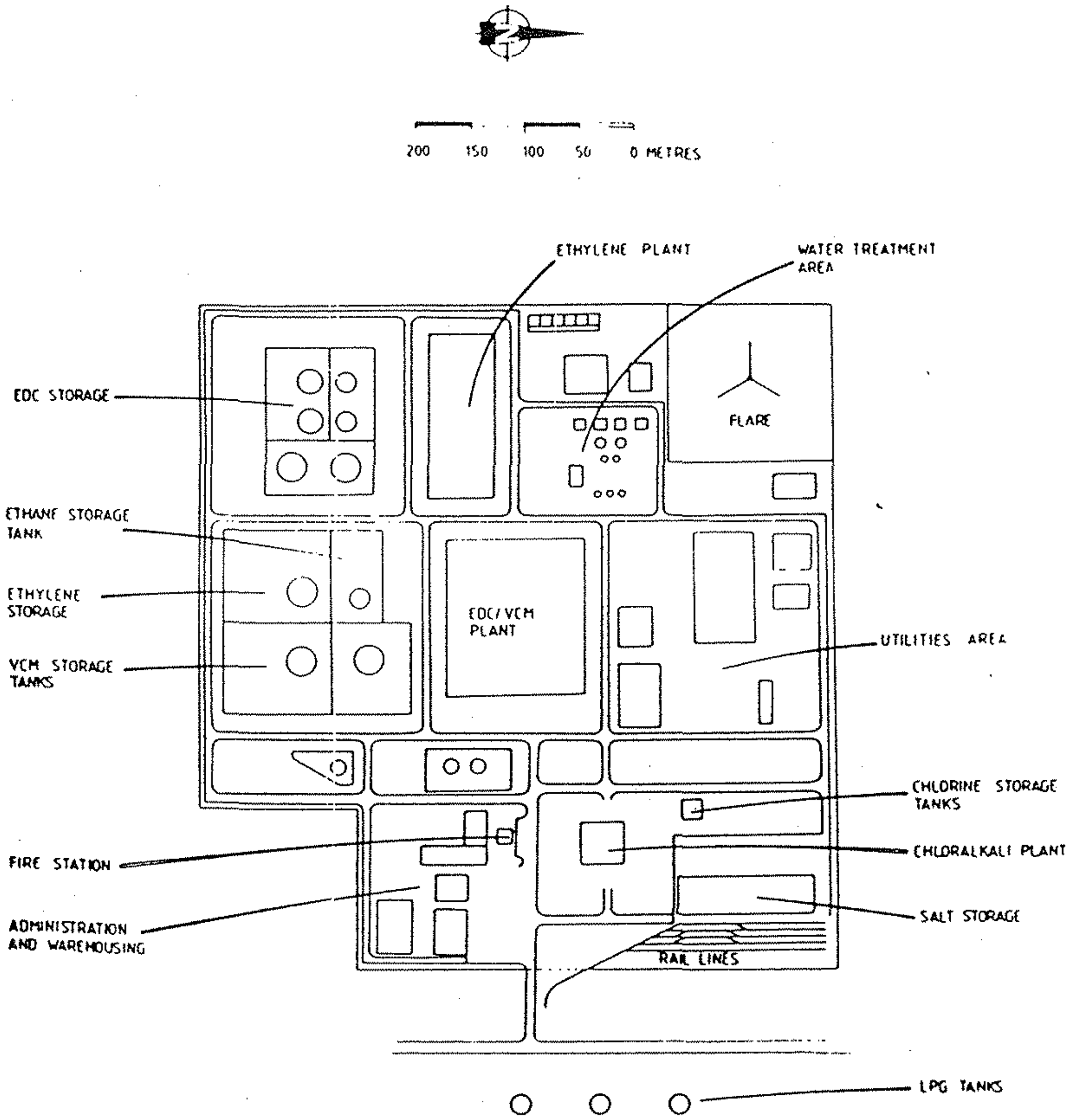


Figure 4. Petrochemical plant layout. Sourc[illegible] PRA

ELECTRICITY: The brine electrolysis process in the chlor-alkali plant requires very large quantities of electrical current, to a degree that electrical power can be considered to be "raw-material". High voltage electricity (132 kV) will be provided from the SECWA grid at a rate of 90 MW.

CHEMICALS: Some additional chemicals other than salt and ethane will be used in the facility. Their consumption is considered to be minor. The main chemicals will be as follows:

- barium chloride;
- sodium sulfite; sodium carbonate;
- sodium hydroxide;
- flocculants;
- cellulose;
- sulphuric acid (98% and 50%);
- catalysts; and
- algicide and desliming chemicals.

The potential impacts of these chemicals are dependent on their use(s) and quantities. Where relevant, their impacts are assessed in Chapter 6.

3.2.2 ETHYLENE PLANT

Ethylene (C_2H_4) is produced from ethane (C_2H_6), which is the main (98%) fraction of the feedstock gas from the LPG plant. The ethylene plant converts the ethane to ethylene. The plant block diagram is shown in Figure 5. An approximate mass balance is included on this figure.

In the first step, ethane is cracked to produce ethylene and hydrogen. This occurs in the presence of steam at very high temperatures. The plant will have four cracking furnaces, three of which will operate at any one time while the fourth will be on standby. Discharge gas, consisting of ethylene, residual ethane, hydrogen, steam and other hydrocarbons, is cooled through primary and secondary heat exchangers and then cooled further in a quench tower to prevent unwanted side reactions. Gas from the top of the quench tower is pumped to the pretreatment unit.

The second step involves pretreatment, which is aimed at producing an acid free gas mixture. The gases also are dehydrated to prevent water freezing in the distillation towers. Quench tower vapour is first compressed to 3.7 MPa in a five stage compressor while being cooled between compression stages to 42°C. Between the fourth and fifth stages, gases pass through a caustic scrubbing tower to remove acid gases. The compressed gas is then chilled rapidly in the propylene heat exchanger, dried, and partially liquefied by refrigeration.

The third and final step is fractional distillation. This proceeds at moderate pressure and very low temperatures. The first column, the demethaniser, separates off a mixture of methane and hydrogen as gaseous phase. The liquids pass to the second column, the de-ethaniser. The

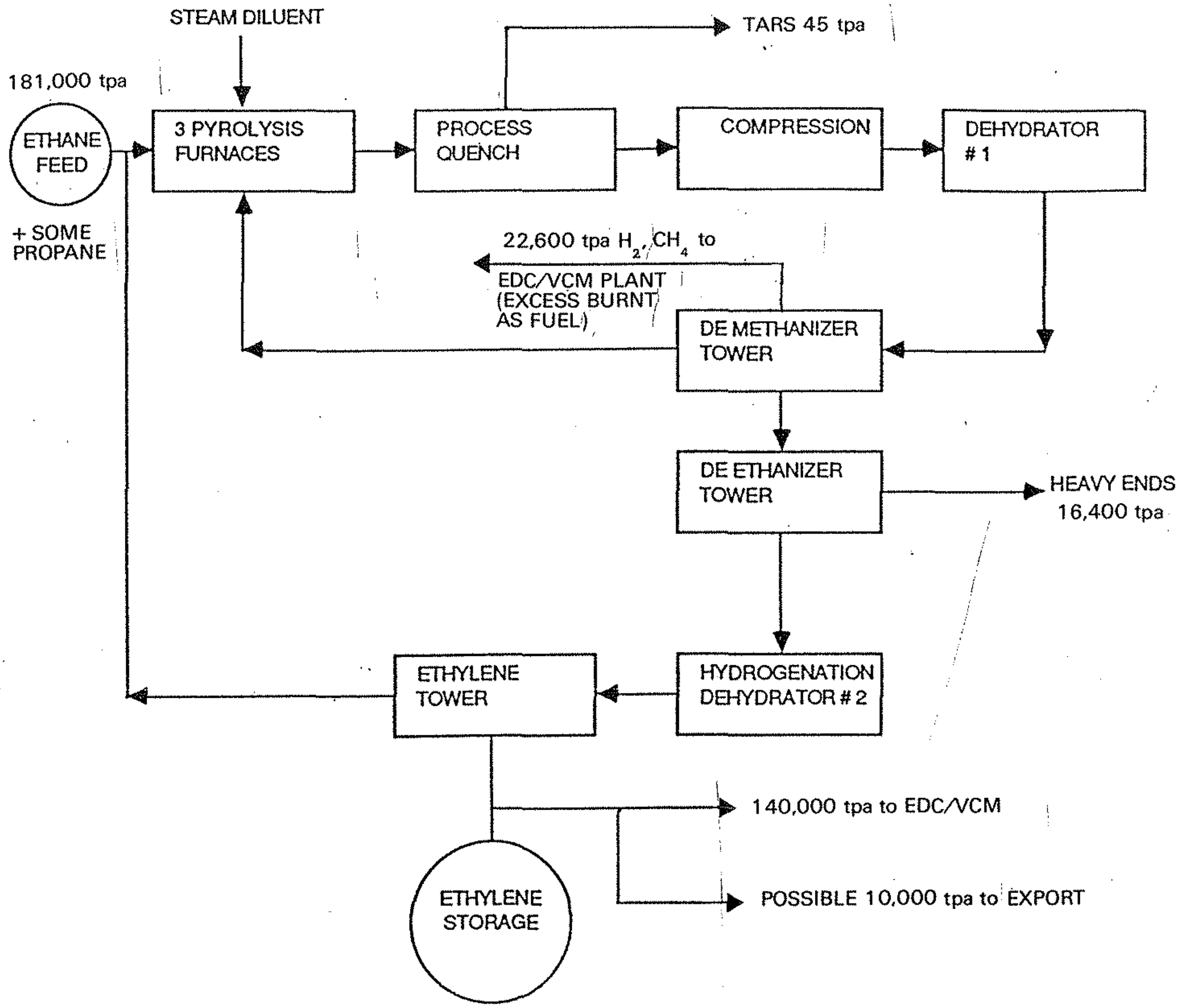


Figure 5. Ethylene plant block diagram.

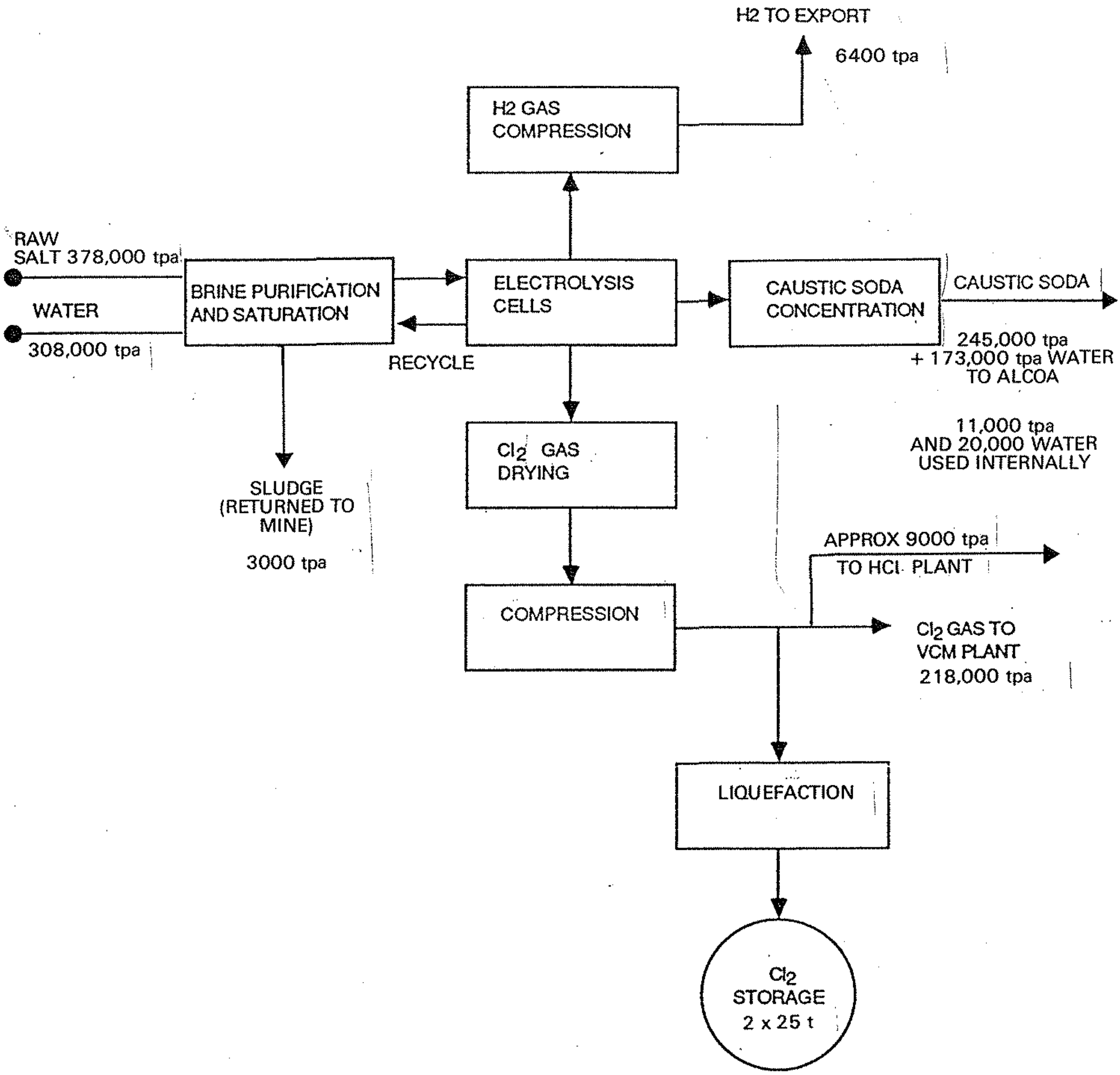


Figure 6. Chlor-alkali plant block diagram.

de-ethaniser separates heavy hydrocarbons from the mixed material. The heavy hydrocarbons are sent to the debutaniser for further separation before being fed back to the LPG plant. The light material passes to a hydrogenation unit, where acetylene is converted to ethane and ethylene by catalytic reaction with hydrogen. The ethane and ethylene are then separated in another column. The ethane is recycled to the cracking furnaces, while ethylene is sent to very low temperature storage or is used immediately in the EDC/VCM plant.

3.2.3 CHLOR-ALKALI PLANT

The chlor-alkali process is based on the electrolysis of purified, saturated brine solution to give the following reaction:

$$2\ NaCl + 2H_2O \rightarrow 2NaOH + H_2 + Cl_2$$

The simplified block diagram is given in Figure 6. The salt is first dissolved in water to form a brine. The brine is then purified by chemical precipitation and then ion-exchange. Electrolysis takes place in membrane cell electrolysers, producing gaseous chlorine and hydrogen, and caustic soda.

The chlorine gas is cooled to 15°C to condense out most moisture before passing through two drying towers where it is scrubbed with chilled sulphuric acid. It is then compressed and sent to the EDC/VCM plant. In an emergency, chlorine production will be diverted to a neutralising scrubber unit using caustic soda for absorption. The plant itself has a small chlorine (2 x 25 t bullets) to ensure continuous operation during interruptions to power supply. The chlorine will be stored at pressurised storage and at low temperature. The storage tanks will be designed to the standard recommended in the second preliminary risk analysis (see Section 6.4).

The hydrogen gas is to be collected and compressed. Some is to be used in the acetylene hydrogenation unit, some to produce hydrochloric acid, some as fuel on-site, and the remainder to be sent to the BP Oil Refinery for fuel. Small amounts of chlorine and hydrogen will be sent to the small hydrochloric acid plant, which will produce up to 40 t/day of 33% hydrochloric acid by direct reaction in an impervious graphite reactor.

Caustic soda from the electrolysis cells will be produced at a concentration of 33-35% but approximately one quarter will be concentrated to 50% prior to storage. Some will be used internally in the caustic scrubbers, but the bulk of production will be sent by pipeline to Alcoa.

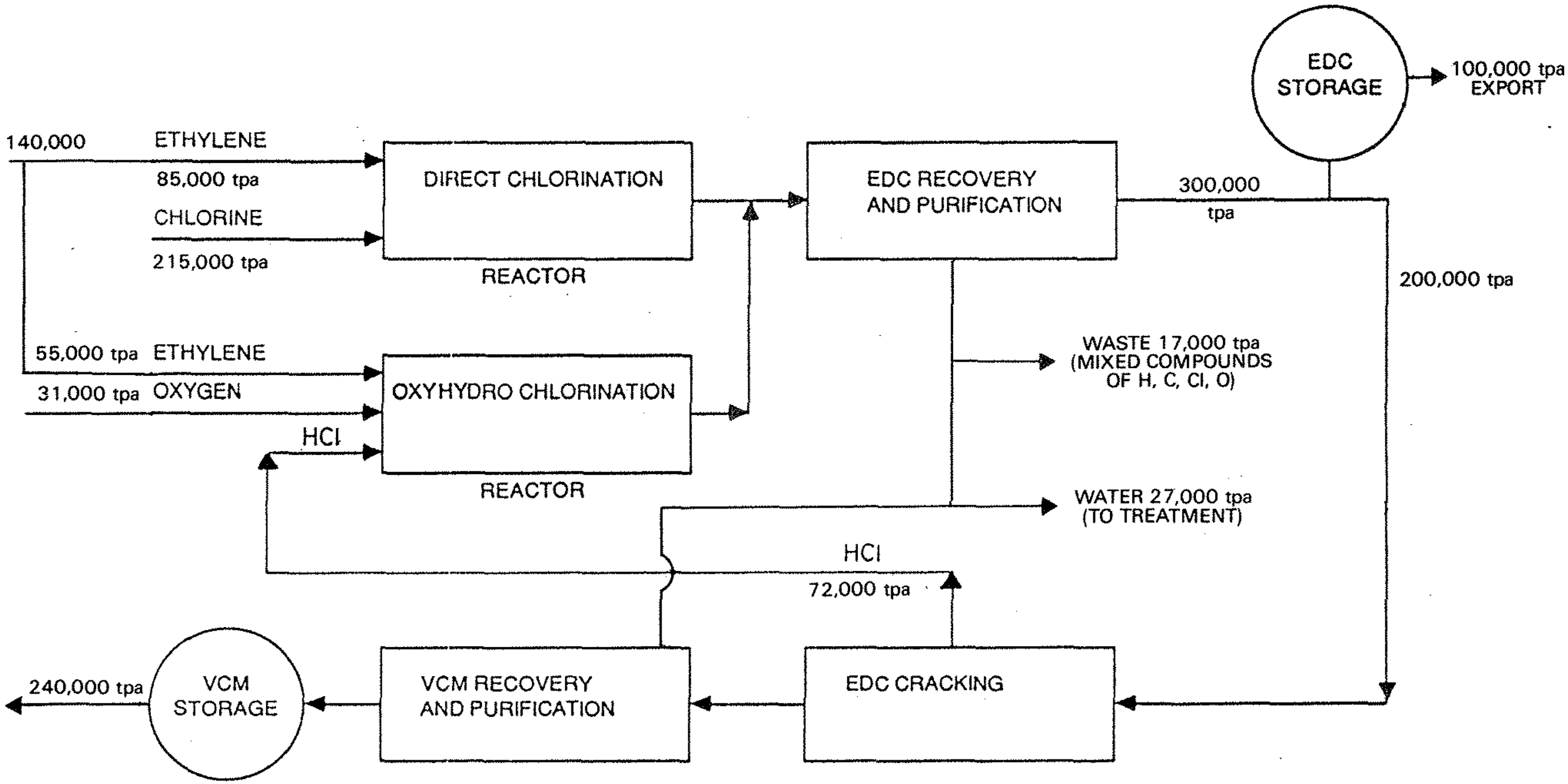
3.2.4 EDC/VCM PLANT

The EDC/VCM plant employs two parallel reactions for manufacturing ethylenedichloride (EDC). These are : direct chlorination (1) and oxyhydro-chlorination (2).

$$C_2H_4 + Cl_2 \dashrightarrow \underset{(EDC)}{C_2H_4Cl_2} \qquad (1)$$

$$C_2H_4 + 1/2\ O_2 + 2\ HCl \dashrightarrow C_2H_4Cl_2 + H_2O \qquad (2)$$

EDC is recovered from the mixture by distillation. Purified EDC is then converted to vinyl chloride monomer (VCM) with hydrogen chloride as a byproduct.



- 240,000 tpa VCM
- 100,000 tpa EDC

Figure 8. EDC/VCM plant block diagram. Mass balance for production of 240 000 tpa VCM and 100 000 tpa EDC.

$$C_2H_4Cl_2 \text{ -----> } \underset{\text{(VCM)}}{C_2H_3Cl} + HCl \quad (3)$$

The hydrochloric acid by product is recycled to the oxyhydrochlorination unit. The block diagram and approximate mass balance for the EDC/VCM plant is shown in Figure 7 for production of 300 000 tpa of VCM which is one production scenario considered by PICL. An analogous diagram and mass balance involving production of 240 000 tpa of VCM and 100 000 tpa of EDC for export is shown in Figure 8.

Conversion of EDC to VCM takes place in furnaces at high temperatures and pressures. The furnace discharge is then cooled and purified. Purification occurs in three distillation columns. In the first, HCl is recovered and sent to the oxyhydrochlorination reactor. In the second, VCM and EDC are separated. The third column is a caustic soda scrubber for final VCM cleaning prior to storage.

The plant has an incineration unit for control of VCM emissions. Further details of this unit are given in Section 3.3.1 of this Report.

3.2.5 UTILITIES

The PICL plant will require various utilities such as:

- raw water treatment plant;
- demineralisation unit;
- steam boilers;
- air separation plant;
- flare;
- effluent treatment plant; and
- central control room.

These are common items of industrial equipment and most have some capacity for environmental impacts.

3.2.6 STORAGE AND EXPORT FACILITIES

The capacities and types of proposed storage facilities are summarised in Table 3.

The large refrigerated tanks will be designed with full-height close-in concrete bund walls, as explained in more detail in the Technica report (Appendix 4). Both EDC and VCM will be exported in ships. The capacity of ships carrying EDC will range in size from 10 000 to 15 000 tonnes, with a frequency of about eight to ten shipments per year. VCM will be exported as a gas/liquid in refrigerated ships ranging in capacity from 3000 to 20 000 tonnes. It is expected that about 20 000 tonnes will be exported each month with loading times of about 48 h.

Figure 8. EDC/VCM plant block diagram. Mass balance for production of 240 000 tpa VCM and 100 000 tpa EDC.

Table 3. Storage inventories and conditions.

MATERIAL	NO OF TANKS	NOMINAL CAPACITY m^3	CONDITION	
Ethane	1	7 066	Atmospheric	Refrigerated
Ethylene	1	11 150	"	"
VCM Product	2	16 150	"	"
VCM Off-spec	1	1 300	Sphere	Pressurised
VCM Shift tank	1	900	"	"
VCM Wet Crude	1	4 880	Cone roof	Ambient
EDC Dry Crude	1	3 115	"	"
EDC Furnace Feed	2	3 500	"	"
EDC Product	2	8 350	"	"
Chlorine	2	18	Bullet	Pressurised Capability and Refrigerated

3.3 WASTE PRODUCTS AND EMISSIONS

3.3.1 ORGANOCHLORINE WASTES

The principal issue regarding wastes in the PICL proposal is that of organochlorine wastes. Chlorinated hydrocarbon wastes are produced in the EDC/VCM plant. Indeed, the ICI complex at Botany NSW is the only source of hexachlorobenzene (HCB) waste in Australia. HCB is an "intractable" waste and is regarded as an environmental contaminant. The HCB is produced in the carbon tetrachloride plant at Botany. This plant is quite separate to the EDC/VCM plant, but takes its feedstock from the latter plant. ICI are changing the process to ensure minor production of HCB in the future.

From information supplied by PICL it would appear that there is potential for chlorinated aromatic compounds to be present in quantities up to 800 tonnes per annum in the dry heavies from the vacuum column bottoms of the EDC/VCM plant. It could be expected that such aromatic compounds would include monochlorobenzene, dichlorobenzene, ... up to hexachlorobenzene. It would appear unlikely that polychlorinated biphenyls (PCBs) would be formed in any significant quantities at all. The bulk of the material is chlorinated aliphatics.

PICL intend to purchase B F Goodrich technology for the EDC/VCM unit. The Goodrich approach to disposing of unwanted organochlorines is to burn them in an on-site high temperature incinerator (in fact two incinerator trains are run in parallel to ensure fail-safe operation). The incinerator also burns VCM given off from all continuous process vents (and EPA will recommend the VCM relief vent be connected to the incinerator).

PICL, in the responses to questions (Appendix 2), indicate that such incinerators on similar plants in the United States achieve destruction efficiences of better than 99.9999% (ie the same required of a PCB incinerator). The products of the incinerator are carbon dioxide, water, and hydrogen chloride, with some traces of chlorine. Exhaust gases are cooled and scrubbed with caustic soda for hydrogen chloride and chlorine removal.

3.3.2 AQUEOUS EFFLUENT TREATMENT AND DISPOSAL

The principal sources of aqueous wastes from operating plants and their proposed treatment or disposal are:

PLANT	TREATMENT
ethylene plant	
water quench	main liquid effluent treatment system
steam generation unit	cooling water system
spent caustic	spent caustic treatment unit
spent caustic treatment unit	
- evaporator drain	main liquid treatment system
- waste water	main liquid treatment system
high pressure steam blow down	main liquid treatment system
chlor-alkali plant	
no aqueous wastes	
EDC/VCM plant	
waste water stripper bottoms	main liquid treatment system
incinerator scrubber bottoms	cooling water effluent

Five independent systems for water treatment and disposal, are envisaged, with the following general characteristics.

(a) SPENT CAUSTIC:

Origin	Ethylene plant (caustic scrubber)
Flow rate	1.7 m^3/h
Characteristics	pH around 14; high BOD, COD, TDC, TDS; high content of carbonate, sulphide oils
Treatment methods	Evaporation
Disposal	To the main liquid effluent treatment system

(b) SANITARY WASTE:

Origin	Sanitary sewer
Flow rate	about 1 m^3/h
Characteristics	Average sanitary water
Treatment method	Conventional activated sludge unit with final chlorination
Disposal	Final effluent basin

(c) MAIN LIQUID EFFLUENT TREATMENT SYSTEM:

Origin	Ethylene plant (water quench, spent caustic, blow down) EDC/VCM plant (stripper bottoms); Storm drainage water
Flow rate	about 50 m^3/h
Characteristics	high BOD, COD, TDC, TDS; oil; phosphate; phenol.
Treatment methods	Primary treatment (equalisation, oil separation, coagulation, air flotation) Secondary treatment (extended aeration clarification, sand filtration)
Disposal	To final effluent basin on-site before discharge

(d) COOLING WATER SYSTEM:

Origin	Steam generation; Cooling tower; Demineralisation unit; VCM scrubber bottoms
Flow rate	150 m^3/h
Characteristics	Temperature; low content : TDS, phosphate, zinc, Corrosion and slime inhibitors
Treatment method	No treatment
Disposal	To final effluent basin on-site before discharge

(e) LIQUID TARS

Origin	Ethylene plant (water quenching, caustic tower)
Flow rate	About 500 kg every 2 to 4 days
Characteristics	Mainly polymers
Treatment Method	No treatment
Disposal	Off-site approved disposal

Rainwater will be collected via a site drainage system. The first 25 mm of rain in any 24 hour period will be directed to the main liquid effluent treatment unit. Rainfall in excess of 25 mm will be collected and tested for EDC. If the levels are below 100 ppb, the proponent proposes to discharge it to the cooling water effluent stream. If it exceeds this value, it will be processed through the main liquid effluent treatment unit until the level falls below 100 ppb.

The salt stockpile area will have a drainage system which will collect and recycle brine.

The demineralisation unit, which will treat service water, will also provide effluents (from the reverse osmosis units, backwash water from the filter, and the unit bed demineraliser) to the waste liquid effluent treatment unit.

3.3.3 ATMOSPHERIC EMISSIONS

This section deals with normal atmospheric emissions associated with chemical industry such as SO_x, NO_x etc. According to the proponent in their Responses to Questions (Appendix 2) there are six sources of atmospheric emissions under normal operating conditions. These sources are summarised in Table 4.

Table 4. Atmospheric emissions.

	ETHYLENE PLANT		CHLOR-ALKALI PLANT		EDC/VCM PLANT	
	CRACKING FURNACE	SPENT CAUSTIC TREATMENT	CHLORINE SCRUBBING	HCl SYNTHESIS	CRACK FURNACE	INCINER-ATOR
FLOW RATE (Nm^3/h)	77 600	2 350	2 400	30	63 500	42 500
TEMP. (°C)	160	80	40	35	160	63
SOx (g/Nm^3)	0.070	nil	nil	nil	0.100	nil
NOx (mg/Nm^3)	350	nil	nil	nil	350	nil
Cl_2 (mg/Nm^3)	nil	nil	9.5	nil	nil	<15
HCl (mg/Nm^3)	nil	nil	nil	80	nil	<30

3.3.4 SOLID WASTES

The proponent's response to questions (Appendix 2) states that the plant will generate three types of solid wastes with the following characteristics:

(a) BRINE SLUDGE:

Origin — Brine preparation in the chlor-alkali plant

Quantity	400 kg/h
Constituents	solid; 50% inorganic salts Moisture: 50% as brine (25% NaCl)
Disposal	Backload to origin of salt

(b) WATER TREATMENT SLUDGE:

Origin	Liquid effluent treatment system Cooling water treatment plant Sanitary waste treatment plant
Qanitity	About 100 m^3/day
Constituents	Organic matter
Disposal	Under consideration

(c) CLEANING WASTES/CATALYST

Origin	Decoking of the cracking furnaces; Spent catalyst from the oxychlorination and acetylene hydrogenation units; Cleaning bottoms of storage tanks, column reboilers etc.
Quantity	Varies depending on actual work practice. USA data indicate range of 300 to 1000 tpa.
Constituents	Ferric chloride Heavy hydrocarbons Tetrachlorethylene (TCE).
Treatment methods	TCE recovery is under consideration;
Disposal	Under consideration.

3.3.5 NOISE EMISSIONS

Noise will be generated during both the construction and operation phases of project. Standard operations and equipment will be employed during the construction phase. Activities during this phase will be restricted, to 0700-2200 hours on weekdays, and are proposed to meet the requirements of the Environmental Protection Act. The individual noise levels are presented in Tables 5 and 6 of the ERMP.

PICL commissioned a further study on noise emissions (see Appendix 2). The principal equipment sound power levels are listed in Table 5.

3.3.6 ODOURS

Although the ERMP does not mention potential odours, it is possible that odours could arise through the use of some chemicals and through some wastes. For examples, should the proponent use mercaptans or disulphide compounds to slow down the build-up of coke in the ethane cracker furnace

Table 5. Equipment sound power levels.

AREA & EQUIPMENT	SOUND POWER LEVEL LwdB(A)	
	INDIVIDUAL	SUB TOTAL
1. CHLOR-ALKALI/STORAGE		
- Hydrogen compressor	108	
- Pumps 43 off	115	
- Crane	105	
- Pay loader	114	
- Conveyors	108	
2. ETHYLENE		
- Cracking furnaces	116	
- Blowers	107	
- Refrig compressor	113	
- Charge gas compressor	113	
- Propylene compressor	113	
- Pumps 15 off	112	119
3. EDC/VCM		
- Crackers 2 off	114	
- Recycle compressor	114	
- Pumps 36 off	115	
- Storage refrig compressor	107	117
4. UTILITIES AREA		
- Boiler 1 off	103	
- Feed pump	104	
- Inst Air compressor	108	117
5. COOLING TOWER		
- Fans 6 off	117	
- Water fall	112	
- Pumps	110	119
6. WATER TREATMENT		
- Pumps 6 off	105	
- Reg Air Blower	110	111
7. FLARE TOWER	100 (140)	100 (140)

tubes appropriate management of these chemicals is required to prevent atmospheric release of odorous compounds. This should be considered by the proponent in its atmospheric emissions programme (see Recommendation _).

4. DESCRIPTION OF THE EXISTING ENVIRONMENT

4.1 BIO-PHYSICAL ENVIRONMENT

The proposed location of the petrochemical complex is in the Kwinana industrial region, the State's major industrial area. The site is east of the existing BP oil refinery. The climate of the area is basically hot, dry summers with easterly winds and cool, wet winters with westerly winds. Climatic data, which are adequately described in the various support documents, were largely derived from the Kwinana Air Modelling Study (Department Conservation and Environment, 1982). This information was used to carry out the preliminary risk analyses and the air pollution study, assessed later in this Report.

The present vegetation on the site is a scattered distribution of coastal sand plain associations, with introduced grasses and weed species. The Authority has assessed the ecological value of the vegetation as low.

Four aquifers underlie the site. The groundwater varies in quality from generally low salinity at the surface to salinities up to several thousand milligrams per litre in the deeper formations. A lack of sufficient quantity of adequate quality groundwater was a determining factor in the proposal to use treated waste water for cooling water.

The hydrogeology of the site has not been investigated by the proponent. However, the decision not to use groundwater, and the commitments to management of water on-site means that the hydrogeology is not a factor in this assessment.

4.2 LAND USE, ZONING AND TRAFFIC

Figure 2 (taken from the ERMP) shows the general land use and zoning around the project area. The site is appropriately zoned as industrial. The relative locations of other industrial developments are shown in Figure 2.

Kwinana townsite is located 3 km east-southeast. The southern boundary of the Hope Valley residential area is some 2.5 km to the northeast of the site boundary. Regional population distribution, trends and the socio-economic profile are described in the ERMP.

Rockingham Road is the present major highway link from Perth and Fremantle to Kwinana and other areas to the south. Access to the site from Rockingham Road is along Mason Road.

A rail line is immediately adjacent to the site.

4.3 MARINE WATER QUALITY

Water quality in Cockburn Sound has been described in the ERMP, in the 'Cockburn Sound Environment Study' (DCE 1979), and in EPA Bulletin 309 'Proposed Ammonia-urea Plant at Kwinana' Assessment Report (1987). Given that the defined beneficial uses of Cockburn Sound include commercial and recreational fishing, stringent discharge criteria need to be defined to protect this use. This factor, and the confined nature of the water body, led to the proponent's preference for the Cape Peron Outfall as the method of discharge for cooling water blowdown.

The EPA considers that Cockburn Sound has reached its capacity to absorb pollutants and this is one of the reasons government has begun to critically examine the future sources and disposal of water in the Kwinana industrial area. In particular, the option of all future disposal to the open ocean, rather than the confines of the Sound, needs to be examined.

Water quality in the open ocean environment in the vicinity of the Cape Peron Outfall has been described in the ERMP prepared by the (then) Metropolitan Water Supply, Sewerage and Drainage Board, for the Cape Peron Outlet 1982.

4.4 AIR QUALITY

The proponent has adequately detailed the present air quality of the Kwinana area where information is available. Air quality is generally within accepted criteria for those parameters measured to date. However, ambient levels of some of the potential emissions have never been measured; and monitoring by the proponent will be required prior to start-up to establish background levels. Non-methane hydrocarbons are of particular concern to the Authority, as these lead to the generation of photochemical smog.

RECOMMENDATION 4

The Environmental Protection Authority recommends that the proponent carry out a programme of monitoring of the ambient air environment in the vicinity of the plant for a period of not less than three months prior to beginning production. This programme is to be agreed with the Authority within three months of the environmental conditions being set by the Minister for the Environment.

4.5 RISK LEVELS AND PUBLIC SAFETY

'Kwinana Cumulative Risk Analysis - Main Report' (1987) prepared by Technica for the Department of Resources Development, indicates the Individual Risk levels due to present, and proposed (at that time), industrial developments in the Kwinana area. It shows that background risk levels in residential areas due to industrial developments are below the one-in-one-million per year level which is considered to be within the range of risk that has previously been determined to be acceptable by the Environmental Protection Authority (see EPA Bulletin 278).

4.6 NOISE LEVELS

The proponent has indicated background noise levels at the site in the ERMP. Additional information (see Appendix 2) was provided at EPA's request to give background noise levels in the potentially affected residential area of Hope Valley. These were found to be:

- Daytime - 41 dB(A); and
- Night time - 34 dB(A).

These levels are below those considered acceptable in residential areas, namely 45 dB(A) and 35 dB(A) respectively.

5. REVIEW OF SUBMISSIONS

The ERMP and the Preliminary Risk Analysis were released on 2 December 1987, for a public review period of ten weeks, which ended on 10 February 1988.

A total of 23 submissions were received, 10 from government departments and 13 from the public.

The principal issues raised in the submissions are outlined below.

SITING

- Inappropriate basis for selection.
- Pre-emption of the planning process - there is a need to release the Kwinana Regional Strategy.
- There is a need for long term planning for the Kwinana area, and for the siting of WA's heavy industries.
- Hydrology and hydrogeology have not been investigated.

RISK ASSESSMENT

- Inadequate and internally inconsistent.
- Need for cumulative risk study for the region.
- Insufficient emphasis put on toxicity of VCM and EDC.
- Need to consider earthquakes, cyclones, terrorist attacks and the proximity of HMAS Stirling.
- Further information on gas dispersion models and fatal accident rates (to employees).

SALT SUPPLY

- Need to be firmed up, to assess impacts.

COOLING SYSTEM

- Inadequate details - current water supply is already overstretched.

NOISE

- Little emphasis on occupational noise.

WASTE STREAMS

- Overall mass balances for the plant are required, in order to characterise the types and quantities of wastes.
- Types and quantities of wastes in liquid effluent, and in solids (for disposal off-site) are required.
- Liquid effluent should be disposed of to ocean, not to Cockburn Sound.
- Characterisation and disposal of organochlorine wastes (from EDC/VCM unit) needs addressing.
- Removal of specific chemicals (eg phenols, EDC) from liquid effluent before disposal.

INCINERATOR FOR EDC/VCM UNIT WASTES

- Design parameters not specified.
- Emissions - types, and concentrations not sufficiently specified.

ATMOSPHERIC EMISSIONS

- Release of VCM, which is carcinogenic.
- Emission standards and TLVs quoted incorrectly.
- EPA to set standards.

MONITORING PROGRAMME

- Non-existent.
- Who will monitor wastes and emissions?

CONTINGENCY PLANNING

- Need for consultation with emergency services at a State level.
- Evacuation routes and access routes - inadequacy of Mason Road.
- Compatibility of PICL emergency equipment with emergency services equipment.
- The analysis of shipping should relate to the expected life of the plant.
- Need to develop the emergency response plan before any development approval is finalised.

EMERGENCY SHUTDOWN

- Venting of EDC and VCM to flare stack?
- Excess emissions in emergency shutdown.

SHIP LOADING

- Spillage of EDC into sea could occur.
- Recovery of EDC from the sea not developed.

TRAFFIC

- Need for further study of traffic impacts on Mason Road/Rockingham Road.
- Inadequacy of Mason Road for access and evacuation.

MEDICAL DATABASE

- Need for local medical database.

DECOMMISSIONING

. Commitments are required.

ADEQUACY OF DOCUMENTATION

. Many comments on the (in)adequacies of specific parts of the documentation were made, and some on its overall inadequacy.

COMMONWEALTH EIS

. Draft EIS should be prepared for the Commonwealth Government.

6. ASSESSMENT OF ENVIRONMENTAL IMPACTS

6.1 INTRODUCTION

Inspection and investigation by the Authority of similar plants in the Eastern States and in the United States of America, has shown the Authority that such plants can be built to, and operated to, very high standards indeed, with minimal environmental impact.

The Authority considers that as the principal issues of risks and hazards, noise and air emissions can be satisfactorily controlled, general environmental approval can be given to the proposal, but with a requirement for a follow-up Environmental Management Programme (EMP) to deal with other aspects of the proposal in more detail. This EMP must be to the satisfaction of the Authority, and this requirement will be reflected in the works approval and licence conditions imposed by the Authority. The EMP will be made public by the Authority, together with the Authority's review it. Selected components of the EMP may be released for public information prior to the EPA review.

6.2 CONSTRUCTION STAGE IMPACTS

The construction phase is planned to take 38 months. It is expected that the principal impacts during this period will result from:

. generation of dust;

. generation of noise; and

. water run off and waste effluents.

The proponent has made commitments covering all of the above aspects during construction.

Dust is to be controlled by restricting vehicle movements to construction areas and restricted areas, and watering of unsealed roads and construction areas when necessary. Where appropriate, artificial soil binding mixtures will be used.

Noise generation will be restricted by confinement of construction activities to 0700 to 2200 hours for five days per week.

Waste effluents are to be minimised by channelling storm water to settling ponds for treatment before discharge to Cockburn Sound. Oily wastes will be disposed off-site in an approved manner. The EPA considers that a specific construction stage waste management programme should be developed, and submitted to EPA for approval before construction commences. This should be done in conjunction with the application for works approval.

To minimise construction stage and operational stage visual effects, a tree planting programme is proposed by PICL. This programme should be compatible with that currently in place in the Kwinana industrial area.

The Authority considers that the proponents should liaise closely with relevant agencies during the construction phase to ensure that no adverse impacts on the environment or the local populace occur.

The Authority considers that the commitments given by PICL for the construction phase are appropriate. (These commitments are listed in Appendix 3.)

RECOMMENDATION 5

The Environmental Protection Authority recommends that the proponentinclude in the Environmental Management Programme (referred to in Recommendation 1) a plan to minimise construction stage impacts for approval by the Authority and relevant government agencies before the commencement of construction.

6.3 COMMISSIONING STAGE IMPACTS

The commissioning stage of a project is usually a difficult one, in that the plant is being 'tried out' for the first time. It is at this stage that various untoward emissions (atmospheric, liquid and noise) may occur. The Authority requires details on and should address among other things way of coping with such impacts potential commissioning stage impacts to be submitted to it for approval before commissioning. These details are to be included in the Environmental Management Programme.

RECOMMENDATION 6

The Environmental Protection Authority recommends that the proponent submit comprehensive document describing the precautions to be adopted at the commissioning stage for approval by the Authority and relevant government agencies before the commencement of commissioning of the plant. This document should form part of the Environmental Management Programme.

6.4 RISK AND HAZARD IMPACTS

6.4.1 INTRODUCTION

The Authority's position on the issue of risks and hazards due to industrial developments has been discussed in detail in Bulletin 278 (1987). The quantitative assessment of risk to individuals in the community is an important part of the environmental impact assessment procedure for major proposals. Industrial accidents do occur, and technical safeguards do have limitations. However, with proper controls at all stages of plant design, development and operation, risks and hazards usually can be reduced to a level that the community is prepared to tolerate.

The proponent must calculate the cumulative risk from the proposal to the community so that the EPA can assess fully the acceptability of a project. The method is called Preliminary Risk Assessment (PRA) and consists of the following steps:

* PROJECT DESCRIPTION - to give an inventory of hazardous materials and processes;

* INCIDENT IDENTIFICATION - detailing potential unwanted events that could lead to injury or death;

* FREQUENCY ESTIMATION - determining the likely frequency of each event;

* CONSEQUENCE PREDICTION - determination of the likely severity of the of effects of each unwanted event;

* RISK ESTIMATION - summing the risk to an individual of all the unwanted events and adding this to pre-existing risk levels; and

* EVALUATION OF RISK - comparison with established criteria.

As detailed in Bulletin 278, the Authority has set criteria for assessing the risk acceptability of new industrial projects. A small level of risk in residential areas, set at less than one in a million per year, is acceptable to the Authority. A high risk level in residential areas, taken as greater than ten in one million per year, is unacceptable to the Authority and warrants rejection of the proposal. A level of risk which is between these two values requires further evaluation and safeguards, and may then be considered acceptable to the Authority.

Two Preliminary Risk Assessment reports have been prepared for this project. The second report, by Technica, was commissioned because design changes and further information from the proponent superseded much of the data on which the first report was based. It is common practice to seek a 'second opinion' on risks associated with such a world-scale plant. The Authority accepts that the second report adequately assesses the maximum likely individual risk level due to the proposed plant. The EPA's assessment of risk due to the plant is largely based on the latter report.

6.4.2 INCIDENT IDENTIFICATION

The proposed petrochemical complex generates risks and hazards due to possible releases of flammable or toxic materials because of failure of containment, either in the manufacturing processes or in the various storages. There is also the potential for interaction between this proposal and surrounding industries to create greater risks through so-called 'domino' effects.

The plant processes and major storage inventories have been described earlier in this Report. The hazardous materials available in sufficient quantities to pose off-site risks are ethane (flammable), ethylene (flammable), chlorine (toxic), hydrogen chloride (toxic), vinyl chloride (toxic and flammable), ethylene dichloride (toxic and flammable), and hydrogen (flammable).

Off-site risks need to be evaluated for the following types of events:

(i) explosion or fire following release of flammable substances;

(ii) dispersion of toxic gas clouds; and

(iii) complex interaction between hazards.

The Technica Preliminary Risk Assessment (PRA) has identified 21 incident cases with a potential for off-site impact. These are listed in Table 6.

Table 6. Incidents used in the Technica Preliminary Risk Analysis.

	STORAGE AREA INCIDENTS
S1	Ethane tank major failure giving flammable cloud
S2	Ethylene tank major failure giving flammable cloud
S3	VCM tank major failure giving flammable/toxic cloud
S4	VCM sphere major failure giving flammable/toxic cloud
S5	Chlorine tank major failure giving toxic cloud
	PIPELINE INCIDENTS
P1	Ethane import pipeline release of 6.1 kg/sec for 10 minutes
P2	Ethylene transfer pipeline release of 6.1 kg/sec for 3 min
P3	Ethylene export pipeline release of 42 kg/s for 10 min
P4	VCM export pipeline release of 139 kg/s for 10 min
P5	Chlorine transfer pipeline release of 7.2 kg/s for 3 min
P6	Hydrogen transfer pipeline release of 0.2 kg/s for 10 min
	PROCESS UNIT INCIDENTS
U1	Large instantaneous release of 20 tonnes of ethylene from ethylene plant
U2	Small instantaneous release of 5 tonnes of ethylene from ethylene plant
U3	Short duration chlorine neutraliser release of 8.3 kg/s chlorine for 3 minutes
U4	Long duration chlorine neutraliser release of 8.3 kg/s chlorine for 15 minutes
U5	Smaller chlorine release from HCl unit of 0.23 kg/s of chlorine for 15 minutes
U6	Instantaneous release of EDC from EDC-VCM plant of 12 tonnes Instantaneous release of VCM from EDC-VCM plant of 12 tonnes
U8	Instantaneous release of HCl from EDC-VCM plant of 4 tonnes
U9	Release of ethylene of 42 kg/sec for 10 minutes at the jetty (usage 7 times per year)
U10	Release of VCM of 139 kg/sec for 10 minutes at the jetty (usage 12 times per year)

In carrying out this preliminary risk assessment, a number of assumptions were made as to safeguards incorporated to minimise probabilities of failure and reduce potential consequences in all aspects of the process, pipelines and storages. The proponent has made a commitment to incorporate these assumptions as the minimum level of risk control. A list of these assumptions is provided in Appendix 3 to this report.

The method of deriving the incidents for each of the major process units and for all significant hazardous materials has been detailed in the Technica report (Appendix 4). The EPA is satisfied the cases considered are adequate to give a sufficiently accurate assessment of risks having off-site consequences for the complex.

6.4.3 RISK ESTIMATION

The next step in assessment is to estimate the risk due to each of the failure incidents. This is a combination of the consequence (which is the damage resulting from an incident outcome) with the likelihood (which is a measure of the expected occurrence of an event). Risk is then a measure of loss in terms of both the incident likelihood and the magnitude of the loss.

The Authority agreed, for consistency and comparability, that the frequencies used for the failure incidents of this proposal should generally be the same as those used in the 'Kwinana Cumulative Risk Study'. The failure frequencies used are listed in Table 7. Those for process unit failures are derived from the accident record and known performances of such plants around the world.

Table 7. Failure frequencies for incidents in Table 6.

INCIDENT	FREQUENCY (per year)
Storage	
S1,S2,S3	1.1 x 10-4
S5	9.6 x 10-5
Pipeline	
P1,P2,P5	1.2 x 10-5 per 10 m
P3,P4	2.0 x 10-6 per 10 m
P6	2.6 x 10-6 per 10 m
Process Plant	
U1	2.4 x 10-4
U2	6.0 x 10-4
U3	1.0 x 10-4
U4	1.0 x 10-5
U5	1.0 x 10-5
U6,U7	1.0 x 10-4
U8	0.5 x 10-4

The SAFETI computer programme was used to calculate consequences from the failure cases. The Authority has been advised of the principles and methods used in SAFETI, and agrees with them. The SAFETI programme is in use for this purpose world-wide, including Australia, and has been used and found to be acceptable by statutory authorities. It has been used in Western Australia for individual projects and for the Kwinana regional study.

Toxicity information for chlorine, hydrogen chloride and phosgene, as used in the calculation of consequences, is given in Figure 9. Phosgene is of concern because it is a highly toxic combustion product from pool fires involving chlorinated hydrocarbons such as EDC and VCM. Hazard and toxicity data for other materials are contained in both preliminary risk assessments.

The ethane, ethylene, and VCM product storages should comply with the relevant construction code (API 620) as a minimum safety requirement, and be of true double integrity design. Chlorine storage should comply with Australian Standard 1210 as a minimum construction standard, and should be designed in accordance with the "best modern standard" as identified in the second preliminary risk analysis, and as fully described in Harris (1987). This means that any spills of chlorine from storage will be directed to a closed well, from which chlorine vapour is vented to a caustic scrubber for destruction.

The design, quality assurance system and the testing of all tanks and their associated works should be to the satisfaction of the Mines Department, which has statutory responsibilities in this area.

RECOMMENDATION 7

The Environmental Protection Area recommends that the proponent shall submit storage designs to the Authority at the detailed design stage of each unit in the proposal, for approval by the Authority and relevant Government agencies.

6.4.4 COMPLIANCE WITH EPA GUIDELINES

Figure 10 shows the total individual risk contours from the PICL plant and associated export jetty. It can be seen that the one in a million fatality risk contour does not impinge on any residential areas. Mason Road is included in the area covered by this contour, but this road is used for access to industrial plants by employees and suppliers. This analysis shows clearly that the risk due to the PICL plant itself is such that it is acceptable to the Authority.

Technica also extended their cumulative risk study of the Kwinana area (Technica 1987), to include the PICL proposal, and with slight changes to the LPG plant data to account for recent plant changes. Their report is at Appendix 5. Figure 11 shows the updated cumulative risk contours for the Kwinana area. The one in a million fatality risk contour does not reach residential areas, and therefore meets the EPA's criteria. The contour does include Rockingham Road, Mandurah Road and the Transperth bus station at the junction of Thomas Road. The Authority has not formulated criteria for impact of risk from industrial facilities on non-residential activities, but interstate and overseas experience suggests that levels higher than one in a million could be acceptable for non-residential activities. The bus station is just inside the contour, but the Authority considers that the risk is acceptable.

The proponent has demonstrated that the predicted cumulative individual risk levels fall within the EPA guidelines and has indicated to the EPA that it intends pursuing high safety standards in the subsequent detailed design and operation of the plant. **The EPA is satisfied that the predicted risks are acceptable and that the plant as generally described in the PRA can be built and operated safely at the location proposed.** Total cumulative risk is only affected in the general vicinity of the PICL plant. The proponent must still demonstrate that the safety and integrity of the as-built plant will be consistent with predictions.

6.4.5 RISK MANAGEMENT STRATEGY

It is normal practice for major industrial plants for a Hazard and Operability Study (HAZOP) be commissioned at an appropriate stage, or stages, of the project. This is an effective rigorous technique for discovering potential hazards and operating difficulties at the design stage. Significant reductions in hazards are possible as a result of such studies.

It is also usual to update the quantified risk study after the HAZOP has been carried out. This Quantitative Risk Assessment (QRA) considers all possible failure incidents which could cause injury on the site, and for a project of this size and complexity several hundred incidents would be considered. It is expected that the off-site risk levels calculated by the QRA would be at least as low as, and probably better than, those estimated from the smaller number of cases used for the Preliminary Risk Analysis.

RECOMMENDATION 8

The Environmental Protection Authority recommends that the proponent shall prepare, in stages, a comprehensive hazard identification and risk management programme, to the satisfaction of the Authority and relevant Government agencies.

The programme shall include the following:

- **hazard and operability studies (HAZOP) of the process units, to be completed and submitted before mechanical construction commences;**
- **safety engineering design;**
- **quantified risk assessments;**
- **implementation systems; and**
- **safety reviews during the life of the plant;**

at intervals to be determined by the Authority.

The results are to be forwarded to the Authority.

In the ERMP, the proponent made a commitment "to further reduce the risks and hazards identified with the project by implementing a risk management programme as part of an overall environmental management and contingency planning policy."

A detailed description of an appropriate risk management and accident prevention policy was given in Volume 2 of the ERMP (Bureau Veritas, 1987). The key features are as follows:

* Screening prospective employees;

* Establishment of comprehensive occupational health facilities;

* Provision of comprehensive induction training in safety and emergency procedures;

* Recording and analysis of unplanned events, with policy alteration as necessary; and

The implementation of a 'Permit to Work' system for contractors is also required, as many accidents are caused by non-site personnel, who are not "caught up" in the training requirements for those working in the site full time.

The proponent should follow good engineering and management practices and employ suitably qualified personnel as part of the total safety package for the design, construction and operation of the proposed plant. Rigorous operator and maintenance personnel training for the plant is also requisite.

The proponent should develop detailed written procedures covering all process work, including start-up, shutdown, plant testing, plant modification, inspection and emergency action. These shall be made available on request for inspection by relevant government agencies.

In ensuring the safe operation of the complex, the proponent should liaise with the Safety Coordinator in the Mines Department.

RECOMMENDATION 9

The Environmental Protection Authority recommends that the proponent should develop appropriate training and procedures manuals prior to commissioning, to the satisfaction of the Authority and other relevant government agencies.

In addition to "software" issues such as training, it is essential to ensure the reliability and safety of process equipment, instrumentation and alarm systems.

RECOMMENDATION 10

The Environmental Protection Authority recommends that the proponent shall:

. **maintain the process equipment, instrumentation and alarm systems consistent with the safety and reliability assessment of the plant;**

. **implement the best practicable technology in the prevention of damage to electrolysers as a result of fire or explosions; and**

. **install very high integrity instrumentation in the control of the plant and in the detection and response to any unplanned releases;**

to the satisfaction of the Authority and other relevant government agencies.

6.4.6 CONTINGENCY PLANNING

The proponent is to prepare a contingency plan in conjunction with the relevant authorities, including the State Emergency Service (see Section 6.10). Some discussions have already taken place.

The Western Australian Government, through the Department of Resources Development, is presently developing a contingency plan for the whole Kwinana industrial area. PICL is cooperating in the development of this plan.

The proposed new plant should be incorporated into the fire and emergency plan being developed for the Kwinana area to take account of both off-site and on-site risks (see Recommendation in Section 6.10). PICL should update and practice these emergency procedures in conjunction with other industries and government agencies.

6.4.7 CONCLUSION

The Authority concludes that when:

- **the proposed safeguards and the Authority's recommended conditions related to risks and hazards are implemented.**

then the likely risk from the plant would be low enough to be acceptable to the Environmental Protection Authority.

6.5 ORGANOCHLORINE WASTES

The principal issue concerning wastes in the PICL proposal is that of organochlorine wastes. The Authority considers that the approach taken by B F Goodrich technology, in incinerating all organochlorine wastes on-site is technically sound. The principal waste streams fed to the incinerator are VCM emissions from all continuous process vents and emergency vents, and chlorinated aliphatic and aromatic compounds from the wet lights and dry heavies streams in the EDC/VCM plant.

If such an incinerator were to be allowed to be used to burn chlorinated aromatics strict monitoring requirements would be required. It would be necessary for PICL to monitor air emissions, at the stack, at the boundary fence, and beyond, for chlorinated aromatics and potential byproducts of combustion, such as dibenzofurans and dioxins. Only the strictest technical safeguards could be allowed.

The Authority considers that chlorinated aromatic compounds should be disposed of by way of incineration in a facility which has a sufficiently large buffer zone, to allow for any untoward circumstances. The Authority is of the view that although it is technically feasible to dispose of these compounds at Kwinana there is a need to be extremely conservative in these matters. The EPA report on a government proposed incinerator for PCB wastes (EPA Bulletin 297) considered that a buffer zone of 2 kilometres was required. Given that the throughput of PICL organochlorine wastes is much larger than that envisaged for the PCB incinerator, a larger incinerator and the Authority considers that, the required buffer zone would be in excess of that available at Kwinana. Consequently the Authority considers that chlorinated aromatic compounds should be separated out from the waste stream and disposed of in a remote, government run and supervised high temperature facility designed to take this and similar wastes. As storage of such chemicals is increasingly a threat to the environment, the EPA believes that the final licence to commence operations should not be issued until a suitable facility is operational.

RECOMMENDATION 11

The Environmental Protection Authority recommends that the proponent includes the Environmental Management Programme details on the treatment and disposal of a organochlorine wastes, for approval by the Authority before the commencement of plant commissioning. This should include a proposal to extract chlorinated aromatics and their safe transport to a suitable incinerator with an adequate buffer. The EPA WILL not issue a licence to operate the plant until the disposal of chlorinated aromatics has been resolved to the satisfaction of the EPA.

6.6 IMPACT OF ATMOSPHERIC EMISSIONS

6.6.1 AIR QUALITY CRITERIA

The emissions expected from the plant during normal operation have been presented in Section 3.3.3 of this report. The proponent's commitment to develop and implement a management system for fugitive emissions based on best practicable means world-wide has been noted.

PICL has adopted the requirements set down by the Victorian EPA State Environmental Policy on the Air Environment. This document adopts a three tiered approach to controlling air quality.

Firstly, air quality objectives are set for certain air pollutants eg carbon monoxide, nitrogen dioxide etc. These substances are common pollutants in the urban environment and it is essential to consider background levels from other sources when designing plants emitting these pollutants.

Secondly, design ground level concentrations are set for a wide range of pollutants. These ambient concentrations are intended to be applied as criteria when calculating stack heights and designing control equipment.

Finally, a schedule of emissions standards is provided for stationary emission sources.

The EPA requires that new plant be designed in a manner that takes account of all three elements of the Victorian policy. The design ground level concentrations are intended to limit the potential exposure of people living or working near the plant. The levels are cumulative, being concentrations resulting from all emissions in a local area. They are designed to protect the health of people, animals and vegetation, aesthetic enjoyment and local amenity, and the useful life and appearance of buildings, structures, property and materials. The emission standards are intended to ensure that the plant incorporates appropriate technology.

Relevant Air Quality Objectives are:

Carbon monoxide	30.00 ppm	(1 hour average)
	10.00 ppm	(8 hour average)
Nitrogen dioxide	0.15 ppm	(1 hour average)
	0.06 ppm	(24 hour average)
Sulphur dioxide	0.17 ppm	(1 hour average)

Relevant design ground level concentrations are:

Chlorine	0.033 ppm (ie 0.1 mg/m^3)	(3 minute average)
Hydrogen chloride	0.2 ppm (ie 0.2 mg/m^3)	(3 minute average)

Relevant emission standards are:

Oxides of Nitrogen	0.35 g/m^3
Carbon Monoxide	2.5 g/m^3
Chlorine	0.2 g/m^3

Under the Victorian EPA policy, the design ground level concentration for VCM is 0.033 ppm (or 0.1 mg/m^3) for a 3 minute averaging time. However, there is an additional requirement that emissions shall be reduced to the maximum extent achievable by technology, or emissions may be prohibited if they are considered to constitute a significant threat to public health.

The Environmental Protection Authority considers that the Victorian design ground level concentration of 0.033 ppm of vinyl chloride monomer should not be exceeded at any residential premises.

Ambient concentrations and design ground level concentrations nominated by the proponent are considered by EPA to be appropriate for plant design purposes.

6.6.2 VINYL CHLORIDE MONOMER EMISSIONS

The proponent has adopted a policy of zero ground level concentration of VCM, to be achieved by reducing emissions under normal operating conditions to below detectable levels. In practice this means establishment of an on-site emission and ground level monitoring network, and development of a reporting and management policy which reacts to any measured emissions.

In addition, design requirements are such that all vents where VCM or EDC may be emitted are to be vented to the incinerator for on-site combustion. The Authority requires that emergency relief vents are also to be vented to the incinerator. The incinerator installed at the B F Goodrich plant at La Porte, Texas has been shown to be 99.999996% efficient, according to information supplied by the proponent. An incinerator of at least 99.9999% efficiency is required for this operation. To assume fail safe operation, a twin incinerator, operating in parallel is required.

In VCM and polyvinyl chloride plants in Australia the plant operator is required to monitor emissions within the plant as well as at, and outside the plant boundary, and respond to relevated levels of VCM. Victoria and New South Wales have adopted the following response regimes for within plant VCM emissions:

5 ppm - Alert level. Requiring the company to report the result with an explanation as to the cause, and the action taken to rectify any problem.

30 ppm - Alarm level. This level raises an alarm at the operator's console and requires immediate action to locate the source of the leak and stop the emission.

The EPA requires that the proponent develop a monitoring strategy incorporating the following elements:

- installation of monitors at specified sites within the adjacent residential areas. All non zero levels are to be reported to the EPA.

- installation of a dual coninuous, automatic, multipoint, sequential sampler analyser using gas chromatographs or an equivalent technology approved by the EPA to monitor the VCM levels at 15 points within the plant and 15 points on the plant boundary. Each sampling point shall be sampled for a minimum of 1 minute in every 15 minute period.

The results from the analyser are to be logged in the control room continuously and the following responses made:

For within plant monitoring points:

- any reading above 5 ppm shall register on the plant operator's console and shall be reported to the EPA together with a description of the action taken to identify the source and rectify the leak; and

- any reading above 30 ppm shall raise on audible and visual alarm at the operators console and shall result in immediate action to locate and rectify the leake. Full details of the incident shall be reported to the EPA.

For plant boundary monitoring points:

- any non zero reading shall be reported to the EPA together with an exploration of the cause; and

- any reading above 5 ppm shall raise an audible and visual alarm on the operator's console and result in immediate action to locate and rectify the source. In addition any adjacent industries shall be notified within 5 minutes of the alarm being raised.

A routine leak detection programme should be developed annd implemented, to the satisfaction of the EPA, prior to commissioning.

A programme of personal monitoring for assessment of occupational exposure of workers acceptable to Department of Occupational Health, Safety and Welfare, shall be developed and implemented prior to commissioning.

It should be noted that whilst alarm levels are specified above it is expected that the proponent will, in keeping with the commitment to zero VCM emissions from the plant, respond positively to rectify leaks whenever they are located, even if alarm levels are not achieved at monitoring points.

RECOMMENDATION 12

The Environmental Protection Authority recommends that the proponent shall adopt an overall philosophy, for the design, construction and operation of the plant, aimed at achieving a target VCM emission level of zero within the

plant and at the plant boundary. The proponent shall submit a comprehensive programme (as part of the Environmental Management Programme) for approval by the Authority before commissioning of the plant.

RECOMMENDATION 13

The Environmental Protection Authority recommends that the proponent establish a monitoring network for the detection of VCM in emissions and in the ambient air environment to the satisfaction of the EPA. A reporting and management policy shall be developed, to the satisfaction of the EPA, to react to all measured emissions. This policy shall have the primary goal of minimising the frequency and concentration of such emissions and eliminating them as soon as possible after detection. The VCM monitoring programme should incorporate the suggestions made in this Report.

6.6.3 ASSESSMENT OF OTHER AIR EMISSIONS

The gaseous emission concentrations and flow rates for the range of pollutants emitted under normal plant operationg conditions, as detailed in Section 3.3.3, are acceptable to the EPA.

The proponent engaged a consultant to revise the analysis of the effects of plant emissions on ambient air quality. The revised analysis was based on information which has become available since the production of the ERMP. A recommendation has been made to improve the data as design proceeds.

The modelling results, which have been derived using techniques which are acceptable to the EPA, show that even in the worst cases of dispersion conditions, ground level concentrations are unlikely to exceed the goals beyond the plant boundary. Concentrations at residential areas are predicted to be well below the goals. There is still uncertainty about the configuration of the furnaces, hence predicted ground level concentrations may be inaccurate. The modelling should be updated when design and emissions data become available. Such calculations should be based on final determinations of the height of emissions, and must include the influence of building types and other structures on atmospheric dispersion. These calculations must demonstrate that the cumulative ground level concentration of each pollutant at any location outside the plant boundary is acceptably low to the satisfaction of the Authority.

The Authority therefore concludes that with proper plant design the effect on air quality from the proposed plant during normal operations will be low enough to be acceptable. The proponent will be required to verify predicted emissions prior to construction and to monitor plant emission performance and ambient air quality to verify that the relevant goals will be achieved during plant operation.

The Authority considers that concentrations, flow rates and associated mass emission rates for the range of gaseous pollutants emitted by the plant shall not exceed the values nominated by the proponent without the prior approval of the Authority.

The proponent shall comply with standards specified by the Authority and other relevant government agencies. The requirements of the NHMRC "National Guidelines for the control of air pollutants from new stationary sources", or the Victorian EPA guidelines for ground level concentrations, whichever is the more strict for particular pollutants, are to be implemented.

The proponent has made a commitment to meet the requirements of the Victorian EPA Schedule F-5 for VCM specifying methods for monitoring VCM at the boundary of the plant. The Authority's requirements for monitoring VCM emissions have been detailed in Section 6.6.2. Undertakings have also been given to monitor hydrogen chloride and chlorine emissions. The Authority sees these statements on monitoring as incomplete. There is no mention of monitoring for fugitive emissions within the plant. A continuous monitor may also be required on the incinerator vent stack. Other monitoring systems connected to alarms are required to detect chlorine and flammable gas emissions within the plant.

RECOMMENDATION 14

The Environmental Protection Authority recommends that the proponent submits, as part of the Environmental Mangement Programme, a proposal for air quality monitoring which incorporates the following elements:

- **monitoring and alarm systems for chlorine, hydrogen chloride, ethylene dichloride and flammable hydrocarbons, within the plant and at the plant boundary;**

- **a leak detection monitoring programme; and**

- **regular reporting of results with reference to appropriate standards;**

for approval by the Authority, prior to commissioning of the plant.

This Programme should also include such aspects as final calculations of total ground level concentration of each pollutant emitted from each item of plant which emits gaseous pollutants, taking account of all other significant sources of the pollutants within and outside the plant.

Any additional emissions identified in the course of final design should also be identified in the EMP, or in an update of the EMP, prior to construction of that part of the plant which is the source of the emission.

6.6.4 ASSESSMENT OF EMERGENCY EMISSIONS

Emissions of various pollutants, notably VCM and chlorine, under 'plant upset' conditions have not been adequately identified or quantified by the proponent. The EPA considers that, prior to commissioning, the proponent should prepare a detailed quantified analysis of all gaseous emissions under abnormal conditions. The analysis should be based on an event tree/fault tree analysis of the full range of potential emergencies or upsets to normal operations (including power loss, incinerator outage etc). The analysis should provide estimates of occurrence frequency for each emission and estimates of maximum ground level concentrations at the plant boundary. EPA may then require additional safeguards to be incorporated in the design prior to commissioning.

RECOMMENDATION 15

The Environmental Protection Authority recommends that the proponent provide a detailed quantified analysis of all gaseous emissions under 'plant upset' conditions, to the satisfaction of the Authority, prior to plant commissioning.

6.7 AQUEOUS WASTES

6.7.1 POTENTIAL IMPACTS

In its responses to EPA questions (Appendix 2), the proponent has identified the sources of various liquid wastes, and their approximate composition, and given some indication of flow rates and durations. This information has been summarised in Chapter 3. The impacts of these wastes on the environment will depend not only on the characteristics noted above, but also on the extent of removal of those products in the proposed on-site effluent treatment system. A further factor will be the sources of water used for various plant operations, since scheme water, primary effluent from Woodman Point treatment plant, and sub-artesian water all have different chemical and temperature characteristics, which affect their utility and the quantities required.

PICL have made a commitment to dispose of cooling water blowdown via the Cape Peron outfall. This is an important initiative, as it will ensure that a large thermal load will not be imposed on Cockburn Sound. There is still, however uncertainty about corrosion inhibitors and specific quantities of water involved. The EPA requires that the beneficial uses of the ocean in the Cape Peron outfall area be not changed by PICL's activities. This means that the quality of the effluent from PICL must be at least as good as, if not better than, the quality of the input to the PICL plant from the Woodman Point Treatment Plant. In its assessment of the Cape Peron outfall in 1982 (DCE, 1982) it was noted by the Authority that further environmental assessment would be required if there were to be any substantial change in the characteristics of the outflow. The Authority considers that the impact of the proposal on receiving water quality is managable, and considers that the proponent should submit further information to cover the impacts of cooling water disposal.

PICL have not made a decision with regard to final destination of wastes from the liquid effluent treatment unit. The options are disposal via Cape Peron outfall, or to Cockburn Sound. Again, the same environmental constraints apply as above, and information to be included in the Environmental Management Programme is required for industrial process water as well with the primary aim of ensuring that beneficial uses of the receiving area suffer minimal change.

RECOMMENDATION 16

The Environmental Protection Authority recommends that the proponent submit to the Authority additional information in the Environmental Management Programme, relating to all aqueous wastes and their disposal from the plant at the detailed design stage and before commissioning commences. The proposal must be to the satisfaction of the Authority and relevant government agencies.

PICL has proposed that waste liquid tars from the ethylene plant caustic tower and tar drum, which contain polymers (polyethylene and polypropylene) be disposed of to land fill. Further details on these materials are required, so that the Authority can assess the appropriateness of the proposal and determine the conditions under which such disposal can be made.

RECOMMENDATION 17

The Environmental Protection Authority recommends that the proponent submit further information, as part of the Environmental Management Programme on the handling and disposal of polymeric and caustic materials, to the Authority before commissioning commences. The proposal must be to the satisfaction of the Authority and relevant government agencies.

6.8 SOLID WASTE DISPOSAL

6.8.1 SPENT CATALYSTS AND TARRY WASTES

Spent catalysts from the oxyhydrochlorination unit (copper based) and the acetylene hydrogenation unit in the EDC/VCM plant require disposal to land fill. In addition cleaning wastes from decoking of the ethane cracking furnaces, and heavy hydrocarbons in solid residues removed from the bottoms of storage tanks will be generated on an intermittent basis. It is understood that the latter residues contain small amounts of highly chlorinated hydrocarbons (specifically tetrachloroethylene).

The Authority requires more detail on these wastes than have been supplied so far. The proponent has suggested secure land fill as a disposal method, but will have to show why the tarry materials cannot be charred in an approved incinerator followed by disposal of char to land fill. Should the wastes include chlorinated aromatics to levels over those set by the USEPA for PCB in solids in land fill (10 ppm) or for PCBs in liquids set by the Authority (50 ppm), these solids must be incinerated in an approved high temperature incinerator. This means that the proposal cannot go ahead unless and until this issue is resolved to the satisfaction of the Authority.

The Environmental Protection Authority concludes that the issue of solid waste disposal must be resolved to the Authority's satisfaction before plant commissioning.

RECOMMENDATION 18

The Environmental Protection Authority recommends that the proponent submit further information, as part of the Environmental Management Programme, on the characterisation of solid and tarry wastes, and appropriate disposal methods, for approval before commissioning of the plant.

6.8.2 BRINE SLUDGES

Brine sludges are to be back loaded to the area in which the salt was mined, ie Lake Deborah East. This operation is to be included in the Environmental Management Programme describing the management of salt (see Section 3.2.1).

6.8.3 SLUDGE FROM WASTE WATER TREATMENT

The Authority expects that the waste water treatment process will produce approximately 100 m^3/day of sludge. The disposal of this sludge must be to the Authority's satisfaction, and should be referred to in the EMP management of liquid wastes.

6.9 IMPACT OF PRODUCT EXPORT OPERATIONS

6.9.1 LOADING OPERATIONS

PICL intend to export EDC and VCM. PICL have not made a decision regarding which jetty they will use for loading out, but are considering using the BP Refinery Jetty or the BHP No 1 jetty. There would be dedicated loading arms for each jetty, with vapour return lines on the VCM and ethylene loading arms to return vapour for recompression into the appropriate storage.

Bureau Veritas have identified the causes of potential spills of product during loading and these are:

- for the pumping station:-
  - major release from pump when operating;
  - valve rupture at normal flow rate;
  - major valve leakage;
- for the export pipe:-
  - pipe failure;
  - leakage of the isolation valve activated by the emergency shut down system;
- for the marine loading arm or flexible hose:-
  - failure of the connecting pipe;
  - failure of the shore to ship connection.

The consequences of spills are dependent on the product and its quantity. EDC will sink to the seabed, but VCM would evaporate relatively quickly.

The Authority considers that the potential causes of spills can be minimised by good design and good safety management practices. It is anticipated that design and management will ensure a sufficiently low probability of spillage that the operation would be environmentally acceptable. The Authority also considers that it is incumbent on the proponent to institute appropriate consequence management practices. It is not sufficient to state that EDC would fall to the sea bed. All of these issues should be detailed in the Environmental Management Programme for further assessment by the Authority.

RECOMMENDATION 19

The Environmental Protection Authority recommends that the proponent submit details, as part of the Environmental Management Programme, on export operations for assessment and approval by the Authority before plant commissioning.

6.9.2 SHIPPING

The Bureau Veritas report has analysed the potential shipping hazards as being due to:

- ship or tank structure failure;
- fire on board;
- grounding, or collision against installations; and
- collisions between ships.

Bureau Veritas conclude that given the engineering and inspection standards in place for the relevant types of ships, the simultaneous failure of a ship's tank and outer hull, leading to a spill is most improbable.

Fires on board can be initiated from the engine room or from external events (grounding or collision). Bureau Veritas conclude that legislated engineering standards, and the low probabilities of any fire affecting the tanks ensure that the risk of spillage (and any subsequent fire) is not significant.

Collisions between jetties and ships occur at low speeds, and Bureau Veritas considers them of no consequence for double hulled ships. Any grounding in Cockburn Sound is considered to be of no risk to the cargo, given the soft sea bottom.

Collisions between ships are possible, and given increasing shipping movements outside Fremantle, Bureau Veritas have recommended that evaluation of probability of occurrence of transversal collisions should be based on a detailed analysis of actual vessel movements in the Port of Fremantle. The Authority endorses this view. This type of study is similar in character and related to the development of the Fremantle Port Safety Management Plan, which was recommended by the Authority in its assessment of the Ammonia Urea proposal (EPA Bulletin 309). The Authority is aware that the Fremantle Port Authority is responding to this earlier recommendation.

6.10 EMERGENCY RESPONSE

Emergency response requirements can be categorised as:

- plant emergency response; and
- regional emergency response.

A plant emergency plan will need to be developed, and this has been recommended by Technica and by Bureau Veritas as a follow-on to a HAZOP analysis of the detailed plant design. The proponent has made commitments with regard to fire protection systems. These commitments include provision of:

. a dedicated ring main system for supply of water for fire fighting in the plant;

. automatically operated, fixed deluge system for hazardous process equipment and for hydrocarbon storage tanks;

. foam extinguishing systems for EDC storage tanks; and

- automatic fire dectectors with audible and visual alarms, as well as manual alarm boxes to be installed in the control building and other nominated utility buildings.

The proponent will be required to liaise with emergency response organisations (State Emergency Service, Police, WA Fire Brigade) in order to ensure that the plant emergency plan is compatible with their equipment and operational requirements. Emergency response requirements for the loading and operations at the jetty will require liaison with Fremantle Port Authority also.

RECOMMENDATION 20

The Environmental Protection Authority recommends that the proponent prepare a plant emergency plan, which takes into account all relevant contingencies. This plan should be completed, submitted to the Authority and approved by the relevant government agencies, before plant commissioning. This plan should also conform with the requirements of the Kwinana Emergency Plan and the Port Safety Management Plan.

Some submissions to EPA noted the potential difficulty of access to, and egress from, the plant site, or to the jetty, in the event of an emergency. Mason Road is the only road servicing a number of industries, including BP Refinery, BHP, Wesfarmers LPG plant, and Nufarm, as well as PICL. It is clear that other access points are required.

Greater effort in regional planning for emergency access (as well as other aspects) is required. This also applies to other aspects of emergency response planning, and in its assessment of the ammonia/urea proposal (Bulletin 309) the Authority recommended the development of an integrated Kwinana Emergency Plan. The Authority emphasises the need for the development of this plan within an appropriate time-frame, and for the inclusion of the PICL proposal in the plant (see Section 6.4.6). The Authority is aware of studies that have been commissioned by the Department of Resources Devlopment which will be addressing the issues mentioned above.

The Authority is also acutely aware of the need for safe shipping operations, and endorses the Bureau Veritas recommendation that a study of shipping movements is required in order to properly assess the actual risks of shipping accidents. This is particularly important in view of the increasing level of chemical industry development in Kwinana involving import/export and the planned expansion of the naval facility at Garden Island. Again, the Authority re-emphasises the need for development of a Fremantle Port Safety Management Plan, and that the study of shipping movements should contribute to that development (see Section 6.9.2).

6.11 OCCUPATIONAL HEALTH AND SOCIAL IMPACTS

6.11.1 INTRODUCTION

Matters which are related to, but are not environmental issues as such, are traffic impacts, visual impacts, and occupational health and safety matters.

6.11.2 TRAFFIC IMPACTS

In its submission, the Main Roads Department was concerned about delays and congestion at the intersection of Mason Road and Rockingham Road, particularly during peak periods (eg shift change overs at BP Refinery). MRD believes that there has been a serious under-estimation in the ERMP of traffic volumes in Rockingham Road and Mason Road, and considers that an upgrading of Mason Road, as well as the Mason Road/Rockingham Road intersection, may be necessary.

The WA Fire Brigade was also concerned about Mason Road being the only means of access to the PICL plant.

It is clear that the issue of regional roads vs local roads will need to be resolved in another forum. The issue of Mason Road being the only access road (not only to PICL, but also to Nufarm, CSBP, BP Refinery and BHP) has emergency response ramifications, and should be addressed in the development of a Kwinana Emergency Plan (see Section 6.10). This aspect is currently subject to study by the Department of Resources Development.

6.11.3 VISUAL IMPACTS

The proposed plant will include a 75 m flare, six stacks between 30 m and 58 m, and three between 20 m and 30 m high. The remainder of the plant will be less than 20 m high. The PICL plant will dominate the skyline, and accentuate the industrial nature of the Kwinana Industrial Area. PICL has made a commitment to develop a landscape plan, which will involve vegetation and painting of high buildings and stacks so as to reduce the visual impact.

6.11.4 OCCUPATIONAL HEALTH AND SAFETY MATTERS

The responsibility for assessing the acceptability of occupational health and safety matters rests with the Commissioner for Occupational Health and Safety. In addition, the Safety Coordinator, located in the Explosives and Dangerous Goods Division of the Mines Department, is also involved in the safe operation of such plants. Accordingly, the Authority notes that the proponent should liaise with the Commissioner and the Safety Coordinator on these matters.

6.11.5 NOISE IMPACTS

The proponent commissioned, at the request of the EPA, a further study of noise impact to supplement the information provided in the ERMP. A copy of the study report is attached to the additional information provided by the proponent (Appendix 2).

The noise source information used in the noise modelling exercise was tabulated in Section 3.3.5 of this report. The EPA accepts that this data will give an adequate representation of the noise expected to be generated by the proposed plant. The modelling techniques used are assessed as being adequate to predict noise levels at residential areas with sufficient accuracy to allow assessment.

The study has shown that under the most adverse conditions resultant noise levels at the closest residential areas of Hope Valley due to this project would be 38 dB(A). Such conditions may occur for up to 5% of the time. Levels up to 30 dB(A) could occur for up to 28% of the time. For the remainder, levels due to this proposal would be less than 30 dB(A).

The EPA considers that, since the maximum noise levels are likely to include a substantial tonal component, the impact of the proposal can be made acceptable only if tonal noise attenuation is incorporated in the plant. Resultant noise levels under the most adverse conditions in residential areas should be less than 35 dB(A) (L90), and should be free from significant tonal or impulsive characteristics. This is readily achievable using commonly available technology.

RECOMMENDATION 21

The Environmental Protection Authority recommends that adequate safeguards be incorporated in the design of the plant to reduce noise emissions so that resultant noise levels in residential areas are acceptable to the Authority.

6.12 IMPACTS OF RELATED PROPOSALS

6.12.1 ETHANE SUPPLY

The supply of ethane is crucial to the petrochemical proposal. A Notice of Intent, submitted by Wesfarmers LPG Pty Ltd, proposing the expansion of the LPG plant to extract ethane from natural gas, has been assessed by the Authority. The Authority's Assessment Report (EPA Bulletin 332) appears at Appendix 8 of this Report.

Wesfarmers LPG Pty Ltd propose to extract 177 000 tonnes per annum of ethane from natural gas. The ethane would be piped (underground) to a refigerated storage tank on the PICL site.

The risks and hazards due to the pipeline and the storage tank have been assessed as part of the PICL proposal. The other potential impacts were due to atmospheric emissions and waste disposal, which the Authority believes can be managed.

The Environmental Protection Authority found the ethane extraction and supply proposal by Wesfarmers LPG Pty Ltd to be environmentally acceptable, subject to the proponent's commitments and recommendations made by the Authority.

7. ENVIRONMENTAL MANAGEMENT AND MONITORING

7.1 INTRODUCTION

The environmental impact assessment procedure places major emphasis on the management of environmental impacts for the life of a project. The proponent is expected to develop management programmes to minimise adverse effects and monitoring programmes to indicate compliance with commitments. The management programmes are expected to respond and adapt to any problem areas identified by the monitoring programmes, which may not have been predicted during the environmental impact assessment process.

7.2 ENVIRONMENTAL MANAGEMENT OUTLINED IN THE ERMP

The environmental management commitments made by the proponent are detailed in Appendix 3 of this report. A summary of the key commitments is given below:

DESIGN

The planning and design phase of the complex will be performed to Australian and International standards, and will incorporate the experience of proven organisations.

The assumptions made in deriving the Technica Preliminary Risk Assessment will be incorporated in the plant design. The major assumption is that the proponent will employ high modern standards for design and management. A HAZOP study will be carried out to verify the safety of the plant at the final design stage.

The plant will be designed to prevent 'domino' effects within the plant and with other industries.

The chlor-alkali plant design will conform with the environmental specifications described by the EPA for the CSBP and Farmers 'chlor-alkali plant'.

The Control Room will be maintained under positive pressure.

A dedicated ring main will be provided for fire fighting.

A fixed deluge system will be provided to protect equipment and storage tanks from heat radiation.

Fixed air foam extinguishing systems will be provided for EDC storage tanks.

Automatic and manual fire alarm systems will be installed.

There will be a comprehensive site drainage system designed to collect the first 25 mm of rainfall in any 24 hour period, and to treat the collected water to an standard acceptable for discharge.

Air quality will be managed by:

- limiting the concentration of emissions using appropriate manufacturing processes and pollution control technology; and

- specifying stack heights and other discharge conditions to meet criteria for ground level concentrations.

A landscape plan will be developed as part of the detailed design for the project.

CONSTRUCTION

The procurement, manufacture and assembly of all key equipment will be covered by a comprehensive Quality Assurance Programme.

Where possible, movements of vehicles will be restricted to the construction areas and formed roads.

Landscaping the site will be commenced during the construction period.

Stormwater runoff will be collected and treated prior to discharge.

Sewage effluent will be disposed of off-site.

Refuelling will be confined to paved areas that are protected by drains and contained. Oily wastes will be retained and disposed of off-site.

Dust from unsealed areas will be controlled.

Noisy activities will be restricted to between 0700 and 2200 on weekdays.

OPERATION

Risks and hazards identified with the project will be further reduced by implementing a risk management programme as part of an overall environmental management and contingency planning policy.

A preventative maintenance programme will be developed for the plant.

The proponent will develop a comprehensive contingency plan for the petrochemical complex. The proponent will cooperate with other agencies and industries in the development of a comprehensive contingency plan for the Kwinana Industrial Area in general.

A fugitive emissions' management programme will be developed to the satisfaction of EPA. In respect of VCM emissions, the proponent has adopted target emission and ground level concentration standards at effectively zero.

All runoff from the salt stockpile area will be collected and used in the process.

Liquid effluents will be treated to a quality acceptable for discharge to the approved receiving waters (yet to be decided).

All solid wastes will be disposed of in an environmentally acceptable manner to the satisfaction of the EPA.

There will be a management programme to reduce noise emissions to acceptable levels.

Atmospheric emissions will be monitored to EPA's satisfaction.

Liquid wastes will be routinely monitored to EPA's satisfaction.

Brine sludge wastes will be backloaded to the supply point.

The flare system will operate only during 'emergency' situations.

A comprehensive monitoring programme will be established, and the results made available to relevant Government authorities. The results of the monitoring programme will be used to regularly review and upgrade management policy where necessary.

7.3 ENVIRONMENTAL MONITORING PROGRAMMES

No decisions have been made by the proponent on final plant designs or disposal of most wastes. Commitments have been made to monitoring by PICL. The Authority considers, however, that given the style of recommendations in the Assessment Report, monitoring requirements are best developed in the follow-up proposals and the Environmental Monitoring Programme, which are required of the proponent.

7.4 COMPLIANCE WITH PART V OF THE ENVIRONMENTAL PROTECTION ACT 1986

Preparation of the ERMP and the follow-up documentation, and its assessment by the EPA represents only part of the formal approval process required by the Environmental Protection Act 1986. In addition to fulfilling the environmental conditions which will be set following publication of this Report, the proponent must also be cognisant of further requirements.

Prior to commencing construction of the plant, the proponent is required under Section 53 of the Environmental Protection Act to lodge an application for "Works Approval". This application must be supported with detailed technical information on all aspects of the plant which may be of environmental concern. If the application is deemed to be acceptable to the Authority, then approval to proceed with construction of the plant will be granted subject to conditions which are designed to ensure that:

. the plant is constructed and operated in a manner which is environmentally acceptable;

. undertakings given by the proponent during the assessment process are fulfilled; and

. environmental conditions set for the proposal by the Minister for Environment are implemented.

Only when the plant has been constructed and commissioned in accordance with the "Works Approval" will the Authority issue a licence to operate the plant. The operating licence may again be subject to conditions which ensure that the plant is operated in an environmentally acceptable manner.

The EPA will continue to monitor the operations of the plant for compliance with the conditions of Works Approval and Licence.

8. CONCLUSION

This Assessment Report to provide an environmental input to decision making on the proposed has prepared in accordance with the provisions of the Environment Protection Act and willl form the basis of setting environmental conditions on the proposed petrochemical plant at Kwinana. In preparing this Report, the Authority has considered a range of documentation and technical information and has been assisted by contributions from the public and other government agencies.

The Authority identified a number of issues regarding the proposal which required detailed assessment. After undertaking its assessment, the Authority has reached the following conclusions:

. **modern petrochemical plants can operate with minimum pollution and negligible odours;**

. **given that the risk level from the proposed plant is acceptable and given the proximity to infrastructure, the Kwinana industrial area is an acceptable region to locate the proposed petrochemical plant;**

. **the proposed site for the plant within the Kwinana industrial area is environmentally acceptable;**

. **the individual risk levels from the plant are low enough to be acceptable;**

- the cumulative risk levels from the proposed plant are low enough to be acceptable;

- air emissions from the plant could be made acceptable and manageable;

- noise emissions from the plant are acceptable;

- there is need for a plant emergency plan, and the Authority re-emphasises the need for the development of a Port Safety Management Plan and a Kwinana Emergency Plan;

- insufficient information was provided to the Authority on the following matters:

  - salt supply;

  - organochlorine wastes;

  - aqueous wastes;

  - other wastes; and

  - export operations;

  however, the Authority is satisfied that this additional information can be submitted in the form of an Environmental Management Programme.

The Authority considers that the petrochemical plant can be built and operated in an environmentally acceptable manner, subject to compliance with the requirements of the Environmental Protection Act 1986 and the Authority's requirements.

9. REFERENCES

EPA Bulletin 278 'Environmental Protection Authority Guidelines for Risks and Hazards of Industrial Developments on Residential Areas in Western Australia'.

EPA Bulletin 309 (1987) 'Proposed Ammonia-urea Plant at Kwinana' Report and Recommendations of the Environmental Protection Authority.

Murdoch University (1986) 'Kwinana Industrial Area Environmental Study - Report 1', Institute for Environmental Science, Murdoch University.

Murdoch University (1987) 'Kwinana Industrial Area Environmental Study - Report 2', Institute for Environmental Science, Murdoch University.

National Health and Medical Research Council (1985), 'National guidelines for control of emission of air pollutants from new stationary sources'.

Technica (1987) 'Kwinana Cumulative Risk Analysis - Main Report' prepared for The Department of Resources Development of the Government of Western Australia.

Victorian EPA Guidelines for emissions and ambient air US EPA Bulletin 34904-15 (1986) VCM emission standards NESHAP.

APPENDIX 1

Further Information sought by EPA from the Proponent including:

a) Clarified guidelines for second preliminary risk analysis;
b) Questions requesting further information, and
c) Summary of issues raised in submissions.

ENVIRONMENTAL PROTECTION AUTHORITY
1 MOUNT STREET, PERTH, WESTERN AUSTRALIA 6000
Telephone (09) 222 7000

Mr N Yellachich
Petrochemical Industries Company Ltd
PO Box 7356
Cloisters Square
PERTH WA 6000

Your Ref:
Our Ref: 54/87
Enquiries:

Dear Sir

PROPOSED PETROCHEMICAL PROJECT - FURTHER INFORMATION

The Environmental Protection Authority in assessing the proposed petrochemical plant, is unable to conclude its assessment without further detailed information from the company. Accordingly, the Authority requests responses from Petrochemical Industries Company Limited on the issues which are raised in the attached documentation. The latter consists of:

(a) Guidelines for the preliminary risk analysis. These are the same as the original guidelines, but various aspects have been clarified. Once the additional information requested under the preliminary risk analysis has been compiled it would be appropriate to rerun the model. This should be discussed in advance with officers of the Authority.

(b) Questions requesting further information, or clarification of information in the ERMP and/or PRA;

(c) Summary of issues raised in submissions;

(d) List of commitments extracted from the ERMP and PRA for your perusal.

In responding to the above, it is expected that PICL will make further environmental commitments, many of which will be more stringent than, and therefore override, commitments made in the ERMP and PRA.

Yours faithfully

R A Field
DIRECTOR
EVALUATION DIVISION

24 February 1988

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PETROCHEMICAL INDUSTRIES COMPANY LIMITED

EPA GUIDELINES FOR THE REVISED PRELIMINARY RISK ANALYSIS

1. SUMMARY

The document should contain a clear and concise summary of the preliminary risk analysis.

2. INTRODUCTION

. Background to this study.

. Study aims and objectives.

. General nature of the project.

. Philosophy and approach to risk assessment.

Include explicit definitions of "risk" (written and mathematically) in the context referred to in the EPA guidelines. Describe the background of the firm performing this risk assessment, particularly the background and previous experience of the members of the firm conducting this study in leading similar risk assessments, with special references to working knowledge of petrochemical plants.

. Risk standards and guidelines.

3. PROJECT DESCRIPTION

. Site location and environment of the project site including topography.

. Meteorology including wind speed and direction, atmospheric stability, surface roughness length and any other parameter relevant to risk analysis.

The wind speed - stability class frequency distributions by wind direction used in risk calculations should be shown. If these have been condensed from a more precise data form, the method of reduction should be described and justified.

. Process description.

Include flow diagrams, storages, inventories of major vessels and overall plant layout with particular emphasis on safety features (eg. bunding of storage vessels, shutoff valves on major process lines, separation distances to avoid domino effects etc.). Details of the proposal should be sufficiently advanced to enable a meaningful risk assessment to be performed.

. Other parameters in the surrounds of the chosen site which need to be considered in the risk analysis.

4. FACTORS AFFECTING SITE SELECTION AND RISK TO PUBLIC AND NEARBY FACILITIES

. Hazardous material properties.

. Hazards associated with petrochemical plants and chlor-alkali plants.

. Hazards of process, storage and transportation.

. Review of safety record of similar facilities.

Discuss documented historical major release incidents involving any of the process chemicals used in this plant and note the recommendations reached by subsequent investigations with the view of avoiding a repetition of the incidents.

. Review of engineering codes and standards.

Identify codes of practice and standards which, in the view of the risk consultant, the proponent should adhere to in the design and construction of the plant. Where more than one code of practice/standard exists covering the same operation/item, recommend the most appropriate for Western Australia and justify.

. Review of safety engineering design.

. Review of other factors such as domino effects, export loading, shipping etc.

5. RISK ASSESSMENT

. Methodology.

Outline the methodology used to quantify risks from the proposal.

. Identification of potential major unwanted events i.e. checklist of hazards, and

. Estimation of likelihood of failure of major units and items in the plant.

The above two guidelines may conveniently be treated together. The "checklist" should contain hazards identified as having consequences leading to possible fatalities outside the plant site and derivation of data for consequence and risk calculation. The contents of this list are given in Attachment 1. All probabilities used in risk calculations should be fully referenced. In the case of probabilities of ignition of flammable vapour clouds, these should vary spatially as a function of land use, as in the "Kwinana Cumulative Risk Study" (Technica, 1987). Probabilities of explosion following ignition also need to be referenced.

. Calculation of consequences of failure including diffusion characteristics.

These consequences should be quantified using tables of distance versus concentration, distance versus explosive overpressure in each direction (if flammable gas release), and distance versus fatality probabilities. Consequence calculations should be presented for hazards with significant potential off-site consequences (i.e. irrespective of frequency of occurrence) and for hazards (or classes of hazards) identified as contributing more than 5 % to off-site risk near the 1 x 10 -6 risk contour (see next guideline). There may be some overlap in the above cases.

. Development of risk levels i.e. relationship between likelihood and consequence of failure.

Presentation of individual risk levels associated with the petrochemical plant and quantitative ranking of those hazards which contribute to the risk near the 1 x 10 -6 /yr individual risk level.

. Discuss EPA guidelines on the "acceptability" of risk levels in W.A.

. Results of cumulative risk analysis.

Incorporation of the individual risk levels for the petrochemical plant into the cumulative risk levels derived in Technica (1987) for existing industry in the Kwinana region, and discussion of these future accumulated risk levels with reference to the EPA guidelines for risk acceptability.

6. CONCLUSIONS AND RECOMMENDATIONS

. Results of risk assessment and conclusions as to site acceptability.

. Discussion of general safety assumptions taken into account including safety engineering design, management and operation aspects, safety auditing etc.

Include a complete list of relevant standards, codes of practice etc. The proponent should be prepared to endorse these assumptions as "commitments". Also, discuss any recommendations/commitments which impact on site acceptability. (Note: Most of this information should ideally accompany identification and quantification of hazards and risks, with a summary of recommendations and commitments at the end of the report.)

. Recommendations of additional safety factors which need to be considered by the proponent.

Discussion on how the hazards contributing most to risk, and the hazards having the most serious potential consequences may be reduced/minimised. Relevant factors to consider include the installation of safety-related equipment, alternative methods of storage (including containment and bunding), minimisation of inventories, plant equipment layout, specific recommendations on aspects to be incorporated in emergency planning etc.

7. REFERENCES

APPENDICES

. Toxicity data.

Review the literature on the toxicity (acute and chronic) of all process chemicals having the capability to cause off-site death/injury. Give data on TLV's, probit coefficients etc.

- Meteorology of the site including stability/wind roses.

- Risk assessment calculation methods.

Provide a comprehensive description of calculation of consequences of failure, describing methods/models, input data, assumptions used, model coefficients and associated references. Describe the risk calculation model in detail (all components) or supply references in which the model is described.

- Table of generic or unit failure frequencies used.

The failure frequencies and associated probabilities (eg. probability of failure on demand of safety devices) should be fully referenced. Tables of failure frequencies and descriptions of their derivation are given in Technica (1987). Should the proponent wish to use failure frequencies other than those used in that study, their source must be clearly stated. In such cases, the EPA will request that the proponent provide to the EPA the relevant literature from which the alternate values were obtained, in order to verify that their use is justified.

- Summary of major release incidents associated with petrochemical plants and their components.

- List of assumptions used in undertaking risk analysis.

- Relevant computer printouts.

CONTENTS OF "CHECKLIST OF HAZARDS"

Item of plant, or class of items (eg. storage vessels, large pipes, small pipes etc.) with similar characteristics which can be treated together. Include details of volumes, flow rates, diameters etc. and details of proposed safety features describing their effect.

Total failure frequency for the item or class of items (not adjusted to reflect any safety features which may fail).

For each significant event which may arise from the failure (eg. dense cloud, explosion etc.) which may extend beyond the plant boundary, provide the following information:

1. Describe event including type of failure, physical state of substance released, subsequent dispersion, ignition etc. Generally treat two cases, full and partial failure for each event type, to capture the full frequency.

2. Frequency of event case. Show calculation using failure frequency for release case multiplied by the probability of subsequent phenomena (eg. ignition/explosion) resulting. For each case, provide the following:

    (1) Event case duration.

    (2) Event case release rate or instantaneous release mass.

    (3) Release rate and duration of contaminants subsequently entering the atmosphere, and

    (4) If safety devices which have a non-zero failure probability are proposed to reduce frequency or release rate/quantity, then provide the following information:

        (i) Failure rate per demand for safety device, and

        (ii) Modified failure frequencies and flow rates for safety device/s working and not working.

PETROCHEMICAL INDUSTRIES COMPANY LIMITED

ENVIRONMENTAL REVIEW AND MANAGEMENT PROGRAMME

Clarification and further information on the proposal to construct and operate an integrated petrochemical plant at Kwinana is required by EPA in order to assess the report.

A. Risks and Hazards:

It is expected that the answers to questions 1-11 would be subsumed in a revised risk analysis carried out according to the "clarified" guidelines (attached) and in a manner acceptable to the Authority.

GENERAL

1. In relation to the Chlor-Alkali plant, the number of failure scenarios which were used to generate the IR risk contours (ref: Table 5.2).

2. The failure rate data used in the estimation of the frequency of release scenarios (ref: Appendix 6).

3. The methodology used for the generation of IR contours (ref: p 6.42).

SPECIFIC INFORMATION

4. What were the frequencies of occurrence of the speed/stability categories (2F, 4E, 7D, 5D, 5C) used? What were the direction distributions used within each of these categories? Why were the above categories not used consistently for the modelling of all consequences from hazards?

5. In what forms has the risk from a hydrogen explosion been considered in the risk analysis?

6. What are all the plant operations which require the use of the chlorine scrubbing system for the neutralisation of chlorine? How has each of these operations been incorporated into the risk analysis?

7. Assessment of storage of ethane, ethylene, hydrogen, chlorine, EDC and VCM, with overall plant diagram including the location of all storage vessels.

8. Diagrams with details of flows, components, and disposal of wastes. There are gaps in the flow diagrams in the ERMP.

9. Description of all safety devices and alarm indicators fitted to pipes containing flammable and/or toxic liquids or gases, both above and below ground. ROV's and their separation distances on the major sections of pipe.

10. How is pressurisation of the control room to be achieved?

11. Description of the fire protection facilities to be provided for the plant:

    - separate (dedicated) ring main system;
    - deluge systems; and
    - foam.

B. Water:

12. Further details on water for process, cooling and general purposes are required:

   - sources (and environmental impacts associated with sourcing);
   - pre-treatment of water, and disposal of effluents from pre-treatment;
   - flows and mass balances on the water circuit;
   - dumping of all cooling circuit water, and its disposal, and
   - proposed inhibitor(s) for cooling water.

   Collection, treatment and disposal of rainwater including surges.

   Cooling option(s) for the plant.

13. Disposal of waste water - which alternative has been chosen?

   - to Cockburn Sound and/or via the Cape Person outfall;
   - quantities and capacities;
   - heat loading;
   - treatment processes prior to discharge;
   - identify chemical constituents (especially nutrients, heavy metals
   - and organic chemicals) and mass flows;
   - outfall design, and
   - dilution.

C. Salt:

14. Further information regarding the source of salt, the management of the salt stockpile and the brine storage. What is the fate of brine wastes?

D. Production

15. Details of specific plant processes, final plant capacities, production quantities and associated mass balances are required to ascertain the likely quantities of waste streams and emissions. This has an important bearing on various issues including risk, waste disposal, etc.

E. Management of Wastes:

16. Table 3 requires more detail. Chlorinated hydrocarbon wastes will be produced by the VCM unit, and a breakdown of components and quantities is required. How are solid by-products to be disposed of?

17. Details of the incinerator, its inputs, operational conditions and emissions are required. Details regarding mass balances. Noise of combustion unit -normally, and in event of shutdown of the plant. If the combustion unit is not available during plant operation, how will the plant handle emissions.

F. Atmospheric emissions:

18. What are the atmospheric emissions based on the plant's ultimate design capacity. Which emissions are to be monitored?

19. Under what meteorological conditions and at what distances were the maximum concentrations of SO_2 and NO_x predicted.

20. A management programme for fugitive emissions of hydrocarbons, SO_2, VCM, NO_x, HCl, Cl_2, and acid gases (from the ethylene cracker) is required. What are the background concentrations of SO_2, NO_x and non-methane hydrocarbons in the vicinity of the project.

21. The mass balances referred to previously should include quantities applicable to air emissions, and include emissions from utilities (eg steam generation).

G. Noise:

22. The modelling of noise emissions does not appear to have used spectral data or meteorological data. Please comment and provide details of revised noise predictions based on answers to questions 22-25.

23. No background noise level survey has been done, particularly with reference to Hope Valley, which will be impacted more than Medina.

24. The modelling does not appear to have taken into account sources such as the flare stack or steam generation or steam dumping.

25. No mention is made of noise during commissioning (eg pressure relief testing).

H. Loading:

26. Further details are required on location and specific facilities for ship loading.

27. The management of spills of EDC, VCM and ethylene during loading needs to be addressed. Any significant changes in the capacity of the loading facility due to changes in production mix will require futher assessment.

I. Monitoring:

28. Is there a commitment to on-going monitoring, by the company, of all emissions and discharges to the requirements of the EPA.

J. Contingency planning:

29. Provide details of proposed emergency planning procedures.

K. Road Traffic

30. Further details of projected traffic movements and their implications for noise, and where appropriate safety aspects relating to potential spills of process materials and wastes.

L. Other

31. As a consequence of interactions between the EPA and the Company over the above it is likely that further issues will emerge that will require clarification and explanation. These will be bought to the Company's attention as soon as possible.

OTH054PICL

PRINCIPAL CONCERNS IDENTIFIED IN THE SUBMISSIONS:

1. **WASTE STREAMS (8 submissions)**

(a) Overall mass balances for the plant are required, in order to characterise the types and quantities of wastes.

(b) Types and quantities of wastes in liquid effluent, and in solids (for disposal off-site).

(c) Liquid effluent should be disposed of to ocean, not to Cockburn Sound.

(d) Characterisation and disposal of organochlorine wastes (from EDC/VCM unit)

(e) Removal of specific chemicals (eg phenols, EDC) from liquid effluent before disposal

2. **INCINERATOR FOR EDC/VCM UNIT WASTES (3)**

(a) Design parameters.

(b) Emissions - types, and concentrations.

3. **ATMOSPHERIC EMISSIONS (8)**

(a) Release of VCM (carcinogenic)

(b) Emission standards and TLV's quoted incorrectly

(c) EPA to set standards

4. **SITING (3)**

(a) Inappropriate basis for selection.

(b) Pre-emption of the planning process - there is a need to release the Kwinana Regional Strategy.

(c) There is a need for long term planning for the Kwinana area, and for the siting of WA's heavy industries.

(d) Hydrology and hydrogeology have not been investigated.

5. **SALT SUPPLY (2)**

(a) Needs to be firmed up, to assess impacts.

6. **COOLING SYSTEM (3)**

(a) Inadequate details - current/water supply is already overstretched.

7. **SHIP LOADING (4)**

(a) Spillage of EDC into sea.

(b) Recovery of EDC.

8. CONTINGENCY PLANNING (4)

(a) Need for consultation with emergency services at a State level.

(b) Evacuation routes and access routes - inadequacy of Mason Road.

(c) Compatibility of PICL emergency equipment with emergency services equipment.

(d) the analysis of shipping should relate to the expected life of the plant.

(e) Need to develop emergency response plan before any development approval is finalised.

9. EMERGENCY SHUTDOWN (2)

(a) Venting of EDC and VCM to flare stack?

(b) Excess emissions in emergency shutdown.

10. RISK ASSESSMENT (4)

(a) Inadequate and internally inconsistent.

(b) Need for cumulative risk study for the region.

(c) Insufficient emphasis put on toxicity of VCM and EDC.

(d) Need to consider earthquakes, cyclones, terrorist attacks and the proximity of HMAS Stirling.

(e) Further information on gas dispersion models and fatal accident rates (to employees).

11. MONITORING PROGRAMME (2)

(a) Non-existent.

(b) Who will monitor wastes and emissions?

12. DECOMMISSIONING (1)

(a) Commitments are required.

13. MEDICAL DATABASE (1)

(a) Need for local medical database.

14. NOISE (1)

(a) Little emphasis on occupational noise.

15. TRAFFIC (1)

(a) Need for further study of traffic impacts on Mason Road/ Rockingham Road.

(b) see 8(b).

16. ADEQUACY OF DOCUMENTATION

(a) Many comments on the (in)adequacies of specific parts of the documentation were made, and some on its overall inadequacy.

17. COMMONWEALTH EIS (2)

(a) There is a need for a draft EIS to be prepared for the Commonwealth Government.

054BPKPICL

NOTE:

Item (d) - List of Commitments:

now included in Appendix 3

APPENDIX 2

Proponent's response to request for further information including:

a) Response to questions;
b) Updated report on noise, and
c) Updated report on atmospheric emissions.

PETROCHEMICAL • INDUSTRIES • COMPANY • LIMITED
INCORPORATED IN WESTERN AUSTRALIA

28th March, 1988

Mr B A Carbon
Chairman
Environmental Protection Authority
BP House, 1 Mount Street
Perth WA 6001

Proposed Petrochemical Complex ERMP and Preliminary Risks and Hazard Analysis.

Dear Sir,

Please find attached our response to questions from The Environmental Protection Authority relating to the proposed petrochemical complex ERMP and Risks and Hazards Analysis. The response consists of

(A) Response to questions.

(B) Updated report on Risks and Hazards Study by Technica.

(C) Updated report on noise by L.J. Storer and Associates.

(D) Updated report on atmospheric emissions by Dr. I Foster.

I trust that these answers and information are sufficient for you assessment purposes.

I reiterate our intention to consult closely with the EPA and other Government agencies during future development of this proposal to ensure that it achieves very high environmental and safety standards.

Your sincerely

Dr Alan Tingay

doc010:kw

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PETROCHEMICAL INDUSTRIES COMPANY LIMITED

PROPOSED PETROCHEMICAL PLANT AT KWINANA

RESPONSE TO QUESTIONS RELATING TO THE ENVIRONMENTAL REVIEW AND MANAGEMENT PROGRAMME AND PRELIMINARY RISK ANALYSIS

MARCH 1988

1. INTRODUCTION

This response addresses questions put by the Environmental Protection Authority (EPA) to Petrochemical Industries Company Limited (PICL) after consideration of the Environmental Review and Management Programme (ERMP) and Preliminary Risk Analysis prepared for the proposed petrochemical complex at Kwinana. The questions seek further information about various aspects of the proposal and arise from submissions made to the EPA by members of the public and other Government agencies, and from the EPA itself.

2. RISK AND HAZARD ANALYSIS

2.1 The principal request from the EPA with respect to the proposal by PICL was that a second Preliminary Risk and Hazard Analysis be prepared to take account of various important design changes that had occurred and to provide verification of the first analysis prepared by Bureau Veritas.

The practice of requiring a second independent assessment of risks and hazards is appropriate for major projects which require careful consideration of safety issues and has occurred for other proposals in Western Australia. PICL has responded by engaging Technica, a London-based company specialising in risk and hazard analyses, to prepare the second assessment. Technica's report has been provided to the EPA and is available from the PICL office at 1 Mill Street, Perth (4th Level), Telephone 481-0229.

In fact, because of design changes the two Preliminary Risk Analyses cannot strictly be compared and the assessment by Technica supersedes that by Bureau Veritas. The most important changes relate to plant design, product storage capacities, and storage design. These changes are all described in this response and the Technica report. The revised site layout is shown in Figure R1.

3. DESIGN

3.1 CHLORINE SCRUBBING SYSTEM

The chlorine scrubbing system, consisting of a vent scrubber and an emergency scrubber, will be capable of neutralizing all chlorine off-gas during the following modes of the chlor-alkali plant operation:

A : Electrolyzer start-up
B : Normal operation
C : Emergency shut-down.

(Refer to the attached simplified flow diagram of chlor-alkali plant, Fig R2).

A. Electrolyzer Start-Up

Electrolyzer will be energised and start production of chlorine gas at the load of 30% of the design rate. The initial production of chlorine gas mixed with air will be sent to the Vent Scrubber.

The Vent Scrubber will be designed and installed to neutralize the produced chlorine gas during this start-up mode (at a rate of 8.5 ton/hr).

The Emergency Scrubber will play the role of a guard absorber for the Vent Scrubber.

B. Normal Operation

During normal operation, chlorine off-gas from all over the chlor-alkali plant will be collected and neutralized in the Vent Scrubber.

The sources of chlorine off-gas are as follows:

- Dechlorinator (stripping of depleted brine).
- Chlorine vented by the pressure controller on the compressor discharge in the event of high pressure.
- Chlorine Water Tank (vent gas)
- Exhaust gas from the chlorine liquefaction system.

The quantity of chlorine off-gas generated during normal operation is quite small compared to that of electrolysis start-up. Therefore the Vent Scrubber will be able to neutralize chlorine gas at the normal operation mode.

A small flow of off-gas may also result from release of chlorine from the chlorine pressure sealer and vent gas from the spent sulphuric acid tank. This will be directed to the Emergency Scrubber. The Emergency Scrubber will therefore be in continuous operation. The Emergency Scrubber will also play the role of a guard absorber for the Vent Scrubber, neutralizing any chlorine gas accidentally flowing from the Vent Scrubber.

C. Emergency Shut-down

(1) In an emergency, the following shut-down sequence will be activated to automatically and instantaneously:

1. Cut-off DC power supply to the electrolysers. (This results in instantaneous interruption of Cl_2 gas production in electrolyzers.)

2. Isolate the plant from the downstream facilities by closing the valves at the chlorine gas compressor.

3. Empty chlorine gas remaining in the plant into the emergency scrubber through the emergency bypass line (refer to the attached flow sheet) Volume of the remaining gas is approx. 200 Nm^3.

   Emptying can be achieved within 2.5 minutes approximately.

4. Open the valve at the bottom of NaOH Head Tank to enable neutralization of a large amount of chlorine gas.

(2) The above emergency shut-down sequence can be regarded as reliable and safe for the following reasons:

1. Chlorine gas stored in the chlor-alkali plant will be sucked into the Emergency Scrubber. The NaOH Head Tanks have a capacity of absorbent (90 m^3 in total) for 15 minutes neutralizing at 100% electrolyzer load.

   Therefore, the Emergency Scrubber can be regarded to have an additional 300% allowance for the maximum absorption capacity, calculated as follows:

   - Required net time for absorption 2.5 min.
   - 50% of allowance for net time 1.25 min.
   - Total required time for absorption 3.75 min.
   - NaOH Head Tank capacity 15.0 min.
   - Allowance = (15.0 - 3.75)/3.75 x 100 300%

   In addition, the emergency scrubber receiver which contains 65 m^3 absorbent will provide a further 10 minutes neutralizing capacity as back-up.

2. The waste gas blower and the emergency scrubber circulation pump are designed to be kept in operation beyond 30 min. in an emergency, with back-up power being provided by emergency generator.

Therefore , even if some chlorine gas accidentally flows into the emergency scrubber after the first 15 minutes, such gas can be absorbed effectively.

3. This system has been employed in the many chlor-alkali plants worldwide and is generally accepted as a reliable and safe shut-down system.

3.2 STORAGE DETAILS

All storage details of the proposed plant are shown on Figure R3. The chemicals and working capacities involved are

Caustic Soda	1,400 m^3	
Ethane	6,800 m^3	
Ethylene	11,300 m^3	
Ethylene dichloride	3,500 m^3	(furnace feed) (x2)
	8,300 m^3	(x2) (product)
	2,600 m^3	(wet)
	3,900 m^3	(dry)
Chlorine	40 m^3	(equals 2 x 25 tonne)
Hydrochloric acid	650 m^3	(33% solution)
Sulphuric acid	63 m^3	(98% solution)
	44 m^3	(70% solution)
Vinyl chloride monomer	690 m^3	(x 2) (rundown tanks)
	1,000 m^3	(off-spec tank)
	17,000 m^3	(x2) (product)

The location of all storage vessels is indicated in Figure R3 which shows the current site plan. This plan may be modified as a result of the HAZOP study of the detailed plant design but the product storage capacities are not expected to change.

The product storage area is proposed to be in the northwest corner of the complex to optimise safety. Safe distances for storage of flammable and combustible liquids have been derived from the Australian Standard AS 1940 (1982), "The Storage and Handling of Flammable and Combustible Liquids" and AS 1596 (1983) "SAA LPG Gas Code". AS 1940 has also been followed for the refrigerated storage of ethylene and VCM. However AS 1596 has been used for the pressurized storage of VCM (run-down and off-spec tanks).

3.3 PRESSURIZATION OF THE CONTROL ROOM

Pressurization of the Control Room will be achieved either by supplying plant air at reduced pressure or by means of a dedicated air blower or compressor.

3.4 FIRE PROTECTION FACILITIES

DEDICATED RING MAIN SYSTEM

1. The fire water main lines will be a grid or looped system and will be buried. The depth of cover will be not less that 0.8m to prevent mechanical injury. The pipes under the road ways will be buried to a minimum of 0.9m.

2. The diameter of fire water main lines will not be less than 6 inches. The pressure drop by piping will be determined by the Hazen and Williams Formula as per NFPA No. 24. Installation will also follow NFPA No. 24.

3. The gate type block valves installed in the fire water ring main system at appropriate points enable the system to be blocked-in locally in the event of a break, maintenance, or extension.

4. Water hydrants will be placed at intervals of approximately 60 metres or less in the required area. Each hydrant will have two 2½" valved hose outlets and one 5½" valved hose outlet (fire truck pumper connection).

   Hose outlet connections equipped with cap/chain will conform to VC-336. A shut-off valve (6" gate type) will be provided at each hydrant connection from the fire main line.

   One hose cabinet containing the following will be placed near each hydrant.

   - Four (4) fire hoses (each 2½" x 75 FT)
   - Two (2) portable water nozzles (each fog to jet type)
   - One (1) portable foam nozzle (Only for the process/tankage areas.)
   - Five (5) foam concentrate containers (each 20 litres capacity) (Only for the process/tankage areas)

5. Portable fire extinguisher(s) and/or portable air foam blanch pipe(s) (stored in fire hose cabinets) will be arranged to extinguish any spill fire on the fuel oil drum(s)/pump(s) in the utilities area.

DELUGE SYSTEM

1. A fixed deluge system will be provided on hazardous process equipment (towers, drums, heat exchangers, furnaces, liquid hydrocarbon pumps) and the hydrocarbon storage tanks to protect the equipment (or tanks) from the heat radiation caused by any adjacent burning equipment (or tank).

2. The water spray rate will be a minimum of 2 litres per minute/m^3 (LPM/m^2) for the shell surface of hydrocarbon storage tanks and a minimum of 10 LPM/m^2 for the process equipment.

3. The API cone roof type hydrocarbon storage tanks will be provided with two semi-circular split ring headers equipped with spray nozzles, near the top of each tank shell. If a stiffener or other projection obstructs the run-down of water on the vertical surfaces, the provision of an additional ring header or suitable splash plate (s) will be provided.

   - An appropriate number of spray rings will be provided for each spherical tank.

   - The deluge systems for the hydrocarbon storage tanks will be operated manually. The valve manifold for the system will be located outside the dike and not less than 15m from the tank shell to be protected.

   - The water supply headers inside the dikes will be buried with a cover of 0.3m as a minimum, and will have a slope of approx. 1/250 to drain.

4. The deluge systems for the process equipment will be activated automatically by using fusible type sprinkler heads and deluge valves each equipped with a pressure switch. Each automatic deluge system when activated will automatically signal at its location and in the central control room. The valve manifolds will in principle be located at 15m or more from the equipment to be protected.

5. An Appropriate number of fire hose connections will be provided in the deluge system so that a fire water can be supplied from the fire truck, as back-up.

FOAM SYSTEMS

1. Fixed air foam extinguishing systems will be provided for EDC storage tanks (cone roof type) in accordance with NFPA No. 11.

2. Fluoroprotein foam concentrate of 3% type will be used in these systems.

3. A pressure proportioning tank equipped with a proportionater(s) will be applied, as a rule.

4. The foam solution piping inside of dikes and within 15m of tanks not diked will be buried under at least 0.3m of earth. The foam solution piping will have a slope of approx. 1/250 to drain. The solution piping will normally be empty.

5. The valve manifold of the foam solution supply piping will be located outside the dike and not less than 15m from the tank shell to be protected.

6. The fixed air foam extinguisher will be operated manually.

7. Portable air foam nozzles stored in the fire hose cabinets will be placed in EDC tankage areas and process plant and utilities areas to extinguish spillage fires.

FIRE ALARM SYSTEMS

1. Automatic fire detectors will be provided and audible alarms, visual alarms and manual alarm boxes will be installed in the following buildings in accordance with NFPA Nos. 72A and 72E.

   - central control building
   - administration building
   - canteen
   - workshop
   - warehouse
   - laboratory
   - electrical sub-stations

   Local fire alarm panels will be provided in all buildings except for the centre control building which will be covered by the main fire alarm panel. A single representative malfunction signal will be transmitted from each local fire alarm panel to the main fire alarm panel installed in the centre control building.

2. The electric motor driven fire siren(s) will be installed outdoors so that the whole plant area can be covered. The fire siren will be controlled from the main fire alarm panel.

3. The activation of each automatic deluge system in the process plant areas will be indicated on the main fire alarm panel.

4. ATMOSPHERIC EMISSIONS

4.1 WASTE STREAMS

4.1.2 Ethylene Unit

There will be two sources of atmospheric emissions in the ethylene unit (Figure R4.)

(1) Flue Gas From Furnace System (A)

Flow Rate	128T/hr (3 furnaces)
Temperature	160°C
Constituents	NO_x : 0.35 g/Nm^3 SO_x : 0.07 g/Nm^3 Dust : 0.2 gr/Nm^3 max. (as Na_2SO_4 & Na_2CO_3)
Method of Disposal	Discharge into atmosphere

(2) Waste Gas from Spent Caustic Treatment Unit (B)

Flow	2,350 Nm3/hr
Temperature	80°C
Constituents	Air and Moisture (O_2 2 wt.%, N_2 74.7 wt.%, H_2O 14.9 wt%, CO_2 8,4 wt%)
Method of Disposal	Discharge into atmosphere

4.1.3 Chlor-Alkali Unit

There will be two sources of atmospheric emissions in the chlor-alkali plant (Figure R2.)

(1) Waste Gas from Chlorine Gas Scrubbing System (B)

Flow Rate	2,400 Nm^3/hr
Temperature	40^{o}c (max.)
Constituents	Air and Moisture Cl_2 : 9.5 mg/Nm3
Method of Disposal	Discharge into atmosphere

(2) Waste Gas from Hydrochloric Acid Synthesis (C)

Flow Rate	30 Nm3/hr
Temperature	35^{o}C
Constituents	H_2, CO_2 and Moisture HCl : 80 mg/Nm3
Method of Disposal	Discharge into atmosphere

4.1.4 EDC/VCM Unit

There will be two sources of waste gas from the EDC/VCM Unit (Figure R5.)

(1) Stack Gas from two EDC Cracking Furnaces (A)

Flow Rate	63,500 Nm^3/hr
Temperature	160^{o}C
Constituents	Air and Moisture SO_2 : 0.1 g/m^3 (max.) NOx : 0.35 g/m^3 (max.)
Method of Disposal	Discharge into atmosphere

(2) Incinerator Scrubber Vent

Flow Rate	42,500 Nm^3/hr
Temperature	63^{o}C

Constituents		
	HCl,	<20ppm
	Cl_2,	<5ppm
	NO_x,	140ppm
	CO,	40ppm
	Ethane, Ethylene & Fuel Hydrocarbons	60ppm
	(plus air and moisture)	

4.2 AIR POLLUTION CONTROL SYSTEMS

4.2.1 Ethylene Unit

The flue gas from the ethane crackers (furnaces) will be direct vented to the atmosphere. Similarly the waste gas (mostly air) from the spent caustic wash tower of the spent caustic pre-treatment unit will be direct vented to atmosphere.

4.2.2 Chlor-Alkali Unit

The chlorine discharge from the chlor-alkali plant is residual gas from the chlorine vent/emergency scrubbing system. This will consist of two absorption towers and related equipment designed to collect and neutralize any vented chlorine by reacting it with dilute caustic soda. The chlorine enters at the base of each absorption tower and flows upwards through the caustic soda solution which is fed in at the top of the tower and is recirculated from the bottom. The system generates hypochlorite waste.

4.2.3 EDC/VCM Unit

Waste gases from the EDC/VCM Unit derive from the two EDC cracking furnaces and the high temperature waste incinerator (See 3.1.4 above). The cracking furnace waste gas comprises residues of burnt fuel which are direct vented as no attenuation devices are considered to be necessary.

The high temperature waste incinerator is the most significant pollution control device in the complex and is designed specifically to virtually eliminate atmospheric discharge of hydrocarbons and especially VCM, chlorinated hydrocarbons, and photochemically reactive hydrocarbons. BF Goodrich and Badger have developed a complete incineration system that is in successful operation at the BFG Calvert City Kentucky and LaPorte Texas VCM plants, Norsk Hydro in Norway and Ibn Hayyan in Saudi Arabia. The basis for the design of the system is expected to comply with U.S. EPA/OSHA regulations and guidelines for vent gas incinerators; and with Korean air emission standards.

The system is designed to oxidize contaminants in all continuous process vents from the VCM Unit. A spare incinerator train is included. In addition, two liquid chlorinated byproduct streams produced in the VCM unit are fed to the system for destruction. A block diagram of the unit is shown on Figure R6.

Vent streams are fed to the thermal oxidizer by a system of collection headers, knockout drums and flame arresting devices. Liquid wastes are blended and filtered within the Incineration Unit prior to being fired. Within the thermal oxidizer hydrocarbons and carbon monoxide are oxidized to CO_2, H_2O and HCl and traces of Cl_2 are also formed. Exhaust gases are cooled in the waste heat recovery unit to produce steam. The cooled gases are then quenched with water and sent to the HCl Absorber where HCl and Cl_2 are removed by scrubbing with caustic.

An alternate mode of operation is the production of 10 percent aqueous HCl in the first absorber stage and tail gas cleanup with caustic in the second stage. To reduce free chlorine concentration of the blowdown streams, SO_2 is added.

Scrubber blowdown and product acid streams are cooled prior to leaving the unit. Each of these operations is discussed in more detail below.

Vent Collection/Liquid Knockout/Flame Arrestor System

The principal vent from the VCM unit is the OHCl vent which contains ethylene, CO and chlorinated hydrocarbons in a stream of other environmentally inert compounds (including oxygen). Since this stream may enter a flammable region due to swings in oxygen and ethylene concentrations, it enters the thermal oxidizer through a dedicated knock-out drum and flame arrestor.

VCM process vents that do not contain oxygen and water but may contain HCl are collected in the dry vent header. These vents include continuous (or potentially continuous) vents from the EDC Cracking Unit and the EDC Purification Unit (Hiboil Column). Also collected are "dry" decommissioning vents (mainly from EDC Cracking and VCM Recovery and Purification) and manual vents from the VCM storage area. A knockout drum and flame arrestors are provided.

Vents that may contain water and Oxygen are collected in the wet vent header. These include distillation column vents in the EDC Purification Unit (Heads Column, Dewatering Column, Vacuum Column), one vent from the VCM Purification Unit (Caustic Scrubbers), the vents from the Waste water Stripper and vents from the storage unit. Decommissioning vents containing water are also collected in this header. The combined stream is fed to the Thermal Oxidizer through a knock-out drum and flame arrestors.

Sources of vents having insufficient pressure to reach the incinerator are combined in the low pressure vent header which discharges into a knock-out drum. The Contaminated Water Tank and Process Sewer Tank are directed to this header. Pressurization is achieved by means of a steam ejector which also serves as a flame arresting device.

The vent from the Emergency HCl Neutralization Drum is fed separately to the incinerator through dedicated water-sealed flame arrestors.

Blowdown pumps are provided to pump liquid collected in the knock-out drums either to the process sewer or to the Wet Byproduct Tank in the storage unit.

Thermal Oxidizer (Incinerator)

The Thermal Oxidizer is designed to oxidize hydrocarbons and carbon monoxide to acceptable emissions standards. The unit is a horizontal refractory lined vessel with a hot shell designed to prevent corrosion. The individual vent streams enter the incinerator via separate nozzles. Some of the oxygen required for combustion is supplied by the OHCl vent. Additional oxygen is supplied by the combustion air blower to maintain 25 percent above stoichiometric requirements.

Under normal circumstances the vents and liquid wastes do not contain sufficient calorific value to maintain the 982°C temperature required for chlorinated hydrocarbon destruction and therefore fuel is burned. Fuel and air requirements are adjusted on the basis of temperature with oxygen trim control to maintain the proper excess air requirement.

Liquid Waste Feed Systems

Wet byproducts and dry byproducts are pumped to one of two day tanks (located in the Incineration Unit). Liquids are blended by a recirculation line from the Liquid Waste Feed Pump. Blended waste is filtered before being fed to the incinerator. The liquid waste feed system is designed to operate over the range of 50 to 200 percent of normal rates for turndown and inventory work down. Plant air is used for atomizing. The system is also interlocked with the Incineration System to compensate for fluctuations in load from vent streams.

Waste Heat Recovery Unit (WHRU)

Gases exiting the Thermal Oxidizer are fed to a fire tube boiler to cool the gases to a maximum of 288°C for heat recovery. The boiler uses natural recirculation with an external steam drum with demisting devices for vapor/liquid separation. High pressure boiler feed water is use to produce the high pressure steam which is sent to battery limits. The blowdown stream from the steam drum is sent to battery limits.

Quench/HCl Absorber

The first item in this system is the Quench Pot where gases from the WHRU are adiabatically quenched with water. Iron that enters the system via the firing of dry byproducts is knocked out in the Quench Pot to minimize contamination of recovered HCl (an alternate operation of the HCl Absorber). The blowdown from the Quench Pot (containing iron, solids and HCl) is combined with the Waste water Stripper bottoms stream for further treatment.

The HCl Absorber is designed for one of two operations: the base case of scrubbing the flue gases with caustic producing a NaCl brine blowdown for discharge, and an alternate operation of scrubbing with water producing a 10 percent HCl solution as a byproduct.

Normally, the quenched gases are scrubbed in the first stage of the Absorber with caustic to remove HCl and Chlorine. Sulphur Dioxide from cylinders is added to the recirculated liquid via reduction/oxidation potential control to reduce free chlorine.

A static mixer in the line aids in mixing the two streams. Blowdown from the first stage is set by controlling flow reset by density.

The blowdown is cooled in the HCl Cooler and sent to battery limits. Caustic makeup to the first stage is controlled by the pH of the circulating liquid. Water makeup is based on the bottoms liquid level.

The second stage of the HCl Absorber is normally used to scrub residual HCl and Cl_2 from the gases leaving the first stage. The blowdown from the second stage is sent to the first stage for Cl_2 reduction and cooling. The control system is the same as that of the first stage except that SO_2 is not added in the second stage.

In the alternate case where HCl is recovered in the first stage, the blowdown is controlled by HCl concentration (by density measurement) and water makeup is controlled by bottoms level. The acid is cooled in the HCl Cooler and sent to storage. The second stage of the HCl Absorber removes residual HCl and Cl_2 from the flue gases leaving the first stage by caustic scrubbing. In this case the SO_2 addition system is located in the second stage recirculation loop. The blowdown is sent to battery limits. Flue gases leaving the second stage are discharged to atmosphere via a stack with an integral demister to prevent carry out of any liquids condensed by cooling in the stack.

Relief System

What are probabilities of this

The relief systems are designed to handle emergency relief valve discharges from selected areas in the VCM Plant as well as normal vent streams to the Incinerator when the Incinerators are off line. There are three relief header systems:

- OVH - OHCl Vent Headers
- VF - Closed Vent Relief System
- ARH - Atmospheric Relief System

The three relief systems are collection headers which collect selected relief valve discharges and incinerator vent lines and dump them to atmosphere through high point vents. The VF and ARH relief systems include knockout pots for removal of entrained liquids during relief.

The OVH System is to collect primarily vents and relief valve discharges from equipment in the oxyhydrochlorination reactor effluent. These streams may be oxygen rich. In additions, the EDC absorber overhead is also dumped into this header during incinerator shutdown.

The VF System is to collect primarily vents and relief valve discharges from equipment in the dry VCM and EDC service. In addition, the incinerator Dry Vent Header is directed to the VF when the incinerators are off line.

The ARH System is designed to collect vents and relief valve discharges from equipment in wet EDC service. When the incinerators are off line, the following vents are sent to the ARH:

- Wet Vent Headers
- HCl Neutralization Tank Vent

Normally, HCl Neutralization Tank vent does not contain combustibles; therefore, this vent is diverted to the atmosphere.

Waste Streams

The liquid and solid waste stream to the high temperature incinerator will comprise a range of chlorinated hydrocarbons as listed below. Apart from the residual ethylene dichloride and vinyl chloride, all of these compounds are in relatively wide use in the community.

Wet Light	Weight kg/hr	OHS (1)	Uses
Chloroform	90	50 mg/m^3	Solvent, drugs, plastics, polishes
1,2 EDC	33	40 mg/m^3 (2)	plastics intermediate
Carbon tetrachloride	24	30 mg/m^3	dry cleaning, fire extinguishers etc.
1,1-dicloroethane	11.5	810 mg/m^3	cleaning and degreasing agent
Ethylchloride	9.7	2,600 mg/m^3	dyes, drugs, ethylcellulose

Trichloroethylene	3.8	270 mg/m^3	solvent, dry cleaning
Vinyl chloride	1.6	10 mg/m^3 (2)	plastic intermediate
Total	174 approx		

<u>Dry Heavies</u>

1,1,2-trichloroethane	415	45 mg/m^3	solvent
Tetrachloroethane	97	7 mg/m^3	drycleaning cement additive
Trichlorobutene	84	not listed	
Pentachloroethane	71	40 mg/m^3	solvent for cellulose (Germany)
Dichlorobutene	49	not listed	
1,2 EDC	45	40 mgm^3 (2)	plastic intermediate
Tetrachloroethylene	42	335 mg/m^3	dry cleaning agent
Monochlorobenzene	26	350 mg/m^3	dyes
Other	71		
	900 approx		

(1) These US Standards are given only as an index of relative toxicity of the compounds

(2) The levels of EDC and VCM are required to be kept as low as possible in occupational environments

The composition of the gas stream to the incinerator will be

	(Kg/Hr)
N_2	541.5
O_2	45
Hydrocarbons	18
CO_2	727.5
Chlorinated Hycrocarbons	160.5
Water	7.5
Total	1500

Destruction of Polychlorinated Hydrocarbons

The chlorinated hydrocarbon components of the waste streams to the incinerator are mostly compounds which are widely used in the community for industrial and other purposes.

Some other chlorinated hydrocarbons eg: (PCBs, HCB, dioxins and furans) have been strongly implicated as the cause of a variety of serious health disorders in people who have been exposed over long periods or to large quantities.

These polychlorinated hydrocarbons may be produced as liquid solid and gaseous waste streams during EDC/VCM processing in varying quantities depending on the actual process used. A primary reason for the choice of Goodrich technology for the PICL complex is the low levels of such polychlorinated hydrocarbons that this process generates and the effective waste destruction system which is incorporated in the unit.

HCB and PCB's (polychlorinated biphenyls) may be generated in the Goodrich VCM process in low ppm quantities and (as high-boiling compounds) find their way into the liquid chlorinated by-product stream. Normally less than one ppm of these materials is found in this stream.

In order to test the efficiency of the thermal incinerator and to obtain US/EPA permit for the destruction of PCB's, a formal test run has been made both at Calvert City and La Porte. At Calvert City the normal liquid by product was incinerated At La Porte, however, they at one time contemplated handling waste from a chlorinated solvents production unit from which the heavies contained about 3500 ppm of PCB's. Waste with this composition was used for the test at La Porte.

A formal test was conducted at La Porte with observers from the EPA present. Sampling and laboratory testing were done by an independent environmental testing organization. The trial burn exceeded the U.S. EPA requirement of 99.9999% destruction efficiency. The demonstrated efficiency in the run was 99.999996%. That is, no detectable quantity of PCB's, HCB or other chlorinated hydrocarbons could be found in either the incinerator stack gas or the scrubber water effluent.

4.2.4 Management of Fugitive Emissions

It is intended that a fugitive emissions management system will be developed for hydrocarbons, SO_2, VCM, NOx, HCl, CL_2, and acid gases, based on that specified for VCM by the US EPA (Bulletin 34904-15(1986) Section 61.65(b)). This management system is based on engineering design and maintenance procedures.

In addition, all recommendations made by Bureau Veritas and Technica with respect to fugitive emissions will be adopted.

The management system will be developed as part of the detailed design and will be submitted to the EPA for approval. This approval procedure is specified in the Victorian State Environment Protection Policy (The Air Environment)(1982) Section F-5.

4.3 TARGET ATMOSPHERIC EMISSION STANDARDS

4.3.1 Non Hydrocarbons

PICL has adopted the Environmental Quality Objectives defined by the Victorian EPA as the target standards for non-hydrocarbon atmospheric emissions from the proposed petrochemical complex at Kwinana. These objectives are expressed as design ground level concentrations rather than as emission criteria since the primary objective is to limit the potential exposure of people living or working nearby. A full explanation of the objectives is provided in the State Environment Protection Policy (The Air Environment) published in the Victorian Government Gazette No. 63 (1981) and No. 120 (1982).

Relevant design ground level concentrations are as follows:

Schedule B (Class 1 Indicators);

Carbon Monoxide	30 ppm	(1 hour average)
	10 ppm	(8 hour average)
Nitrogen dioxide	0.15 ppm	(1 hour average)
	0.06 ppm	(24 hour average)
Sulphur dioxide	0.17 ppm	(1 hour average)

Schedule C (Class 2 Indicators)

Chlorine	0.033 ppm	(0.1mg/m^3)	(3 minute average)
Hydrogen Chloride	0.2 ppm	(0.2 mg/m^3)	(3 minute average)

These represent ground level concentrations resulting from all industrial emissions in a local area (i.e. they are cumulative). These criteria are designed to protect the health of people, animals and vegetation, aesthetic enjoyment and local amenity, and the useful life and appearance of buildings, structures, property and materials.

Class 1 indicators should not exceed the target criteria on more than 3 days in any one year and if exceeded must remain below the levels listed below:

Carbon monoxide	60 ppm	(1 hour average)
	20 ppm	(8 hour average)

Nitrogen dioxide	0.25	ppm	(1 hour average)
	0.15	ppm	(24 hour average)
Sulphur dioxide	0.34	ppm	(1 hour average)
	0.11	ppm	(24 hour average)

These levels are classified as detrimental or concentrations at or above which a substantial proportion of any exposed population may be adversely affected.

The Victorian standards also require the calculation of target worse-case 3 minute average ground level concentrations for any local area based on the following emission levels.

Sulphur dioxide	1.8 kg/tonne of 100% acid
Sulphuric acid mist	0.1 g/m^3 expressed as SO_3
Nitrogen oxides	0.35 g/m^3
Carbon monoxide	2.5 g/m^3
Chlorine	0.2 g/m^3

4.3.2 Hydrocarbons

Three hydrocarbon target emission levels need to be considered, VCM, chlorinated hydrocarbons, and other non-chlorinated hydrocarbons.

VCM

Under the Victorian EPA policy VCM is classified in Schedule D as a Class 3 Indicator with a design ground level concentration of 0.033 ppm or 0.1 mg/m^3 (3 minute average).

However, the policy also states that Class 3 indicators shall be reduced to the maximum extent achievable by technology or may be prohibited if they are considered to constitute a significant threat to public health.

The US EPA standards relating to VCM have also been considered by PICL (US EPA Bulletin 34904-15(1986)). These stipulate that VCM emissions from EDC purification and VCM purification and formation should not exceed 10ppm as a 3 hour average and from oxychlorimation units 0.2 g/kg of the 100% of the EDC product. In addition, the standards require there to be no emissions from relief valves and that fugitive emissions be minimised or channeled to the plant VCM emission control system where the 10ppm 3 hour average applies.

While these standards admit the possibility of some low-level VCM emissions, PICL notes the provision that the levels should be reduced to the maximum extent possible and in accordance with this has decided to adopt target emission and ground level concentration standards at effectively zero i.e. not generally detectable in the incinerator stack gas.

Chlorinated Hydrocarbons

Victorian Air Quality Standards (design ground level criteria) for the chlorinated hydrocarbons in the liquid waste stream to the high temperature incinerator are as follows

	mg/m^3
Chloroform	4.0
1,2 EDC	6.7
Carbon Tetrachloride	2.2
1,1 dicloroethane	--
Ethylchloride	86.6
Tricloroethylene	17.8
1,1,2 tricloroethane	1.5
Tetracloroethane	--
Pentachloroethane	--
Tetrachloroethylene	6.3
Chlorobenzene	0.2

While these standards indicate that emissions of chlorinated hydrocarbons are generally admissable, the high temperature incinerator will effectively destory them and only trace levels of hydrocarbons will be emitted. Typically the levels will be so low as to be non-detectable.

Other Hydrocarbons

The US EPA applies ambient air quality standards for ozone to other hydrocarbons. These are

235 ug/m^3 (1 hour average)
100 ug/m^3 (annual average).

4.4 Atmospheric Emissions Modelling

See attached report by Dr. Ian Foster

5. LIQUID EMISSIONS

5.1 Waste Streams

5.1.1 Ethylene Unit

The ethylene unit has a number of liquid waste streams as indicated in Figure R4 which are described below

(1) Effluent Water from Water Quench (B)

	Oil Water Separator (a)	Water Stripper (B)	DIL STM Gen. (C)
Flow Rate (Normal)	0	0	1,500
(kg/hr) (max/min)	18,000	18,000	13,500
Temperature (°C)	40	40	40
Duration, Hrs	36 - 48	36 - 48	Continuous
Constituents			
pH	5.5 - 6.5	7.0 - 8.0	9.8 - 10.4
TDS, mg/l	30 - 100	30 - 100	200 - 1000
TSS, mg/l	5 - 15	0 - 10	0 - 5
BOD, mg O2/l	500 - 1500	100 - 600	150 - 500
COD, mg O2/l	1200 - 3500	400 - 700	300 - 500
TOC, mg/l (Total Organic Carbon)	400 - 1500	100 - 800	100 - 400
Phosphate, ppm	-	-	30 - 40
Chlorides, mg CL/l	10 - 20	10 - 20	7 - 12
Carbonate, mg/l	-	-	-
Phenol, mg/l	85 - 115	75 - 110	1 - 20
Sulfide, mg/l	-	-	-
Sulfite, mg/l	-	-	-
Oil, mg/l	300 - 600	5 - 30	0 - 20
Turbidity	200 - 400	0 - 50	0 - 50
Silica Content, ppm	-	-	-
Method of Disposal	Discharge into the waster water treatment system		

At any given time flow can come from only one source of the above three.

(2) Spent Caustic

Flow Rates: 2,000 kg/hr (normal) as continuous
4,000 kg/hr (max.)

Contituents:	Ph	13 - 14	
	TDS	69,000-84,000	mg/l
	TSS	5-100	mg/l
	BOD	2,000-6,000	mg O_2/l
	COD	4,000-9,700	mg O_2/l
	TDC	430-1,000	mg/l
Chlorides		20-600	mg CL/l
Carbonate		60,000-75,000	mg/l
Phenol		0.1-0.5	mg/l
Sulfide		2,800-4,500	mg/l
Sulfite		20-50	mg/l
Oil		80-200	mg/l

Method Disposal: Spent caustic treament unit

(3) Waste Water from Drain of Evaporator of Spent Caustic Treatment Unit (D)

Flow	1,000 kg/hr		
Temperature	40°C		
Constituents	COD	:	1,000 mg/l max.
	Phenol	:	Trace
	Oil	:	1 wt. ppm
	Sulphides	:	50 mg/l max.
Method of Disposal	Discharge into the waste water treatment system.		

(4) Waste Water from Spent Caustic Treatment Unit (E)

Flow	3,000 kg/hr		
Temperature	40°C		
Constituents	COD	:	1,000 mg/l max.
	Phenol	:	Trace
	Oil	:	1 wt. ppm
	Sulphides	:	50 mg/l max.

Method Of Disposal	Discharge into the waster water treatment system

(5) Waste Liquid from Caustic Tower (F)

Flow	200 kg/hr (1/2 hr; every 2 - 4 days)
Temperature	45°C
Constituents	Polymer (polyethylene, polypropylene)
Method of Disposal	Approved landfill in drums

(6) Waste Liquid from Tar Drum (G)

Flow	200 kg/hr (1/2 hr; every 2 - 4 days)
Temperature	80°C
Constituents	Water HC : Trace (polyethlene, polypropylene)
Method of Disposal	Approved landfill in drums

(7) Waste Liquid from Tar Drum (H)

Flow	300 kg/hr (Intermittent)
Temperature	80°C
Constituents	Polymer (polyethylene, Polypropylene)
Method of Disposal	Approved landfill in drums

(8) H.P. Steam blow Down (K)

Flow Rate	: 700 kg/hr (4 seconds per day)
Temperature	: 50°C
Constituents	: Ph 9.4 - 11.0 TDS 500 - 1,500 mg/l Phosphates 30 - 40 ppm (PO_4^{3-}) Silica content 50 ppm(max)
Method of Disposal	Discharge into cooling water effluent system without further treatment.

5.1.2 <u>Chlor-Alkali Unit</u>

There are no liquid wastes from the chlor-alkali unit.

5.1.3 <u>EDC/VCM Unit</u>

There will be two liquid waste streams from the EDC/VCM unit (as indicated in Figure R5):

(1) Waste Water Stripper Bottoms

Flow Rate	17,000 kg/hr
Temperature	Approx. 40°C
Constituents	Water
pH :	8.5 - 12.0
TDS :	1700 - 13,000 wt.ppm
TSS :	120 - 3500 wt.ppm
BOD_5 :	75 - 850 wt.ppm
COD :	340 - 1650 wt. ppm
EDC :	1 wt. ppm max
Method of Disposal	Send to the waste water treatment system.

(2) Incinerator Scrubber Bottoms

Flow Rate	11,500 kg/hr
Temperature	70°C approx.
Constituents	Water
NaCl :	12 wt.%
Na_2SO4:	Trace
Chlorine:	Trace
Method of Disposal	Discharge to cooling water effluent system without further treatment.

5.1.4 Rainwater Collection and Treatment

The complex will include a comprehensive site drainage system designed to enable the collection of the first 25mm of rainfall in any 24 hour period. This rainfall will be channeled to the process liquid effluent treatment unit. The logic of this design is that the first 25mm of rainfall will be sufficient to flush the drainage system and remove any pockets of contaminants. Rainfall in excess of 25mm from the EDC/VCM unit area and EDC storage tank area will also be collected and tested for EDC content. If this content is less than 100 ppb (parts per billion) it will be discharged, but if it exceeds 100 ppb it will be processed through a stripping column prior to discharge.

5.1.5 Salt Stockpile Area Run-off

The salt unloading and stockpile areas will have a comprehensive drainage system designed to collect all run-off and channel it to the brine recovery lagoon. The brine produced by the run-off will be pumped from the lagoon to the primary brine purification system, and thus into the process with the main flow of brine.

5.2 Liquid Effluent Treatment Systems

The liquid effluent treatment system consists of:

- The spent caustic treatment unit of the ethylene plant, and
- The main liquid effluent treatment system

5.2.1 Spent Caustic Treatment Unit

The Spent Caustic Treatment Unit will consist of

- an evaporation unit and
- a high temperature incinerator.

The evaporation unit concentrates effluents from the ethylene plant (see 4.1.1(2) above) prior to destruction in the incinerator. Waste heat from the incinerator is used in the evaporation unit with the temperature controlled by a vacuum pump. Gases from the evaporator (including waste gas returned from the incinerator pass through a stripping column (Venturi Scrubber) containing a NaOH solution spray to prevent formation of H_2S. The incinerator will be run at 900 - 950°C and with excess air of 1.2. The temperature in the furnace is controlled by the flow control of fuel gas.

The organic substances in the waste water supplied to the furnace are oxidized into CO_2, H_2O and N_2. The inorganic substances are oxidized into Na_2CO_3 and Na_2SO_4. The temperature in the furnace is higher than the melting points of the inorganic substances. Therefore, they melt and fall along the furnace walls into Smelt Dissolver at the bottom.

Hot waste gas is cooled to adiabetic solution temperature at the exit of the dissolver.

Inorganic substances which float in the waste gas become dust. They are cleaned by the No. 1 Venturi Scrubber and fed into the evaporator. The moisture in the waste gas is condensed and cooled by this evaporator. The gas is then led to the No. 2 venturi scrubber followed by the stack and discharged directly to the atmosphere.

A jacket structure will be adopted for the furnace to protect the refractories.

Liquid wastes form the spent caustic treatment unit are directed to the main liquid effluent treatment unit

5.2.2 Main Liquid Effluent Treatment Unit

The liquid effluent treatment unit will basically consist of primary treatment to reduce free oil and total suspended solids (oil separator, coagulation pit and air flotation tank), and secondary treatment to reduce phenol, BOD, and residual oil and TSS (aeration, clarifier, extended aeration and sand filter). Sanitary waste will be treated in a dedicated activated sludge unit comprising a grit chamber, aeration tank, sedimentation tank and chlorine contact chamber. The unit is illustrated in Figure R7.

5.3 Treated Liquid Effluent Discharge Criteria

Two potential discharge systems have been considered:

- by pipeline into Cockburn Sound, or
- combine with cooling water discharge into Point Peron ocean outfall pipeline.

The second of these alternative is favoured by PICL as Cockburn Sound is considered to be an environmentally sensitive locality. The possibility of using the Port Peron pipeline is being discussed with The Western Australian Water Authority. The EPA has advised PICL that discharge criteria for Cockburn Sound and ocean outfall are being developed.

5.4 Actual Liquid Effluent Discharge

The maximum daily average constituents in the treated liquid effluent discharge will be:

Temperature			Ambient
BOD_5	(PPM)	:	146
NH_3	(PPM)	:	7
Sulfide	(PPM)	:	1
TSS	(PPM)	:	353
Total Oil	(PPM)	:	10
Pathogenic Organism		:	Nil
Ethylene dichloride (PPM)		:	0.1
Vinyl Chloride (PPM)		:	0.05
Phenol (PPM)		:	0.05
pH		:	6 - 9
Quantity		=	150 ton/hr

6. SOLID WASTES

6.1 Waste Streams

Solid wastes generated by the complex will be

- brine sludge from the chlor-alkali plant,
- sludge from the cooling water treatment plant, and
- various wastes associated with cleaning of process equipment and storage including spent catalysts.

6.2 Brine Sludge

Details of the brine sludge are as follows:

Flow Rate 400 kg/hr

Constituents	Solid	:	50 Wt.% Inorganic salts such as $CaCO_3$, $BaSO_4$, $Mg(OH)_2$, which are formed as a result of treatment of impurities in raw salt.
	Moisture	:	50 wt.% as Brine (25 wt.% NaCl solution)

Method of Disposal   Return to origin of salt

6.3 Cooling Water Sludge

The quantity of sludge from the cooling water treatment plant is not known at this stage. This will either be disposed of on-site as occurs at the Water Authority Kwinana secondary treatment plant or off-site in an approved sanitary land fill site.

6.4 Cleaning Wastes/Catalysts

Wastes originating from the cleaning of process equipment will consist of:

- particulate coke from de-coking of the cracking furnaces.
- spent catalysts from the oxychlorination and acetylene hydrogenation units.
- heavy hydrocarbons absorbed in solid residues cleaned from the bottoms of storage tanks and in carbonaceous materials removed from column reboilers by hydraulic high pressure cleaning.

The volume of such wastes will vary annually depending on the need for cleaning operations and can be minimised by the adoption of appropriate process operation. Data from plants in the U.S.A indicate that the quantity may vary from 300 to 1000 tpa.

The wastes consists predominantly of inert carbon wet with heavy hydrocarbons and in particular tetrachloroethylene (TCE), and ferric chloride corrosion products.

TCE is a clear, colourless, non-flammable liquid which is widely used as a solvent especially for dry cleaning and degreasing. It is also a fumigant and is used medically for the treatment of hookworms and some trematodes.

However, repeated skin contact to TCE may cause dermatitis and high concentrations may produce eye and nose irritation. Acute exposure may cause depression of the central nervous system and death. TCE has also been found to be carcinogenic in animal experiments.

Appropriate work practices are therefore necessary to limit occupational exposure and appropriate disposal is required for TCE wastes.

The US occupational health standard (1985) is 670 mg/m^3 (8 hour average) with an acceptable ceiling concentration of 1,340 mg/m^3 and 5 minute peak concentrations of 2010 mg/m^3.

To protect public health, the Victorian State Environment Protection Policy (The Air Environment) 1981, stipulates a design ground level concentration of 17.8 mg/m^3 (3 minute average) for atmospheric emissions containing TCE. As the PICL wastes are contained in solid material this standard is not applicable to the proposed plant.

The recommended disposal method for TCE is by high temperature incineration or the liquid may be recovered from wastes and re-used as a solvent.

PICL is currently considering options for the appropriate disposal of or recovery of TCE from cleaning wastes and is seeking guidelines from the EPA and Health Department on this matter.

7. Noise

Predictions of noise emissions from the proposed plant are given in the appended specialist report by L.J. Storer and Associates.

8. MONITORING OF EMISSIONS

8.1 Atmospheric Emissions

PICL intends to implement a monitoring programme for VCM, HCl and chlorine atmospheric emissions. The VCM monitoring programme will be the same as that prescribed in the Victorian EPA State Environment Protection Policy (The Air Environment) 1982 (Section F-5). This will consist of a continuous ambient monitoring and recording programme with at least 4 transportable monitoring stations located at the plant boundary and if required a further station in a nearby residential area. The levels of VCM will initially be monitored semi-continuously by taking 12 two-hour samples per day at each station.

It is anticipated that this monitoring programme will indicate satisfactory performance of the plant in terms of target VCM ground level concentrations. In this case PICL may eventually apply to the EPA for the sampling requirement to be altered to one continuous sample in every 24 hours in accordance with the Victorian EPA policy.

Tests of all relevant items (seals, valves etc.) will also be made soon after start-up of the plant to check for fugitive emissions of VCM.

Procedures for the actual analysis of air samples and calibration of analytical equipment will be based on those specified by the US EPA in Bulletin 34904-15(1986) Sections 61.65(b)(8)(i) and 61.68.

It is recognised that the above policies may be superceded by the time that the petrochemical complex is commissioned. In this case, the most recent EPA approved monitoring policy will be adopted.

The HCl and chlorine atmospheric emissions monitoring programme will be based on the principles specified in the Victorian EPA Policy (1981) Clause 44. This requires routine monitoring with sampling stations located both on site and in surrounding areas. In this respect, PICL will seek advice from the EPA on the sampling design and location of the sampling stations during the construction phase of the complex and will adopt the EPAs recommendations.

8.2 Liquid Wastes

Routine monitoring of liquid wastes (cooling water discharge, process effluent treatment plant discharge, and tars) and of rain water drainage will be implemented. The sampling design will be based on frequent random sampling and broad spectrum analysis of all liquid wastes. A detailed sampling programme will be designed prior to commissioning of the plant and will be submitted to the EPA for approval.

8.3 Solids

No analysis of the brine slude wastes or monitoring at the disposal site is proposed at this stage.

9. WATER SUPPLY

9.1 REQUIREMENTS AND SOURCES

The petrochemical complex will require water for cooling, process and general purposes. The proposed sources and quantities of water are as follows:

- Process and General Purposes 200 m^3/hr. mains water
- Cooling water make up :500 m^3/hr. treated sewage water

9.2 PROCESS AND GENERAL PURPOSE WATER

9.2.1 Demineralization Unit

The demineralization unit will be a once through type Reverse Osmosis (R.O.) plant consisting of pre-treatment, pumping, filtration, RO module, chemical injection, degasifier, mixed bed demineralizer and ancillaries.

Demineralised water from the Demineralization Unit will be stored in the Demineralized Water Tank (capacity 500 m^3). From this tank the demineralized water will be pumped and distributed to users in process units and to the BFW and Condensate System.

The filtered water will be sent to Chlor-Alkali Unit from Reverse Osmosis.

9.2.2 Potable Water Treatment System

A Water Treatment unit will be provided to supply potable water to the Plant Complex.

Capacity

Potable Water : 25 m^3/h

Feed Water

Feed water to this system will be supplied from water mains.

The feed water will be treated as follows:

- Carbonation for pH adjustment
- Carbon filtered for organic removal
- Chlorination for disinfection

The treated water will be transferred to a reception water tank then pumped to an elevated storage tank (25m^3 in volume), from where it will be distributed to the Plant Complex by a gravity piping network.

9.2.3 Service water system

Service water will be supplied from water mains through the Demin water plant feed pumps. This water will be used for the cleaning of the plant. The maximum anticipated consumption will be approximately 10 m^3/hr.

9.2.4 Effluents from the Demineralization Unit

(a) Disposal from Reverse Osmosis (R.O.) unit

- Flow rate : 40.9 m^3/hr
- Analysis
  Conductivity : Approx. 2800 - 8000 micromhos/cm
- Disposal Method : Send to the final effluent basin in the waste liquid effluent treatment unit.

(b) Backwash water from filter for R.O. unit

- Flow rate : 290 m^3/day
- Analysis :
  SS : Approx. 100 wt. ppm
- Disposal Method : Send to the final effluent basin in the waste liquid effluent treatment unit.

(c) Disposal from mixed bed demineralizer

- Flow rate : 7.9 m^3/hr
- Analysis :
  pH : Approx 13
- Disposal Method : Send to the final effluent basin in the waste liquid effluent treatment unit.

9.3 COOLING WATER

9.3.1 Description

PICL has invested considerable effort in investigating the potential for use of treated sewage water for cooling purposes. The primary consideration in this assessment has been our opinion that use of such water would be preferable to

- intake and discharge of seawater from Cockburn Sound on environmental grounds, or
- use of groundwater (in association with air cooling) which would preclude other public and industrial use options for this resource.

Treated sewage water is available from the Western Australian Water Authority's sewage treatment plant at Woodman Point. That facility is described in detail in an Environmental Review and Management Programme (Western Australian Water Authority, 1982) and accordingly a summary only is provided below.

The Woodman Point Treatment Plant receives waste water (run-off, domestic, and some industrial discharge) from the southern and south-eastern suburbs of Perth. This water is screened to remove solids and passed through primary settling tanks before discharge to sea through a pipeline which runs on-shore to Point Peron at Rockingham and then 4 kilometres off-shore. The system was designed specifically to avoid the need for discharge to Cockburn Sound. The on-shore pipeline runs adjacent to Rockingham Road and at its nearest point is approximately 1 kilometre from the proposed petrochemical plant site.

The system has a capacity to handle 125 megalitres of waste water a day and surge flows of 250 megalitres per day. It is estimated that by the year 2001 it will be treating 122 megalitres per day. At present the average daily flow rate is approximately 62 megalitres per day although in dry periods the flow may average 50 megalitres. The estimated daily demand of PICL for cooling water is 20 megalitres per day. These figures are summarised below:

Woodman Point Supply	50 - 60 megalitres/day
PICL demand	20 megalitres/day
Woodman Point Capacity	125 megalitres/day
Estimated by 2001	122 megalitres/day

The design waste water quality criteria for the Woodman Point Plant are shown in Table 1.

Table 1

Woodman Point Treatment Plant
Waste water Quality

PARAMETERS (mg/1)		WOODMAN POINT WWTP EFFLUENT
TDS		580 - 760
Suspended Solids		100 - 150
BOD		170
Conductivity		750 ms/m
pH		7.3
Hardness (Calcium Carbonate)		100
Grease		40
Sodium		90 - 160
Potassium		9 - 20
Calcium		30
Magnesium		10
Nitrogen		45
Sulphides	up to	2
Phosphorous		10
Very high bacteria		
Considerable odour		
Temp		27° - 31° C
H_2S		Build up to 10 mg/l
Silica		-
Total Hydrocarbons		-

WWTP: Waste water treated primary.

The PICL proposal involves:

- drawing water from the main pipeline to the complex
- treatment of the waste water within the plant boundaries to make it suitable for use
- use for cooling purposes
- return of blowdown water from the cooling system to the main Water Authority pipeline for discharge to sea via Point Peron.

This 'loop' system is considered to have the additional advantage of avoiding any need for discharge to Cockburn Sound.

The treatment process would basically consist of:

- "secondary" biological treatment (e.g. activated sludge), probably incorporating biological nitrogen removal within the sludge process; and
- sand filter unit
- activated carbon filter unit
- chlorination for disinfection.

The treated effluent is expected to have the following quality:

TDS	580 - 760 mg/l
Suspended Solids	5 mg/l
BOD	10 mg/l
pH	7.2
Grease	1 mg/l
Calcium	30 mg/l
Magnesium	10 mg/l
Total nitrogen	10 mg/l
NH_3 - N	Negligible
NO_3 - N	5 mg/l
Phosphorous	10 mg/l
Bacteria	Negligible
Odours	None

The only other treatment prior to use as cooling water would be addition of desliming and algacide chemicals as follows:

Algacide: liquid or gaseous chlorine (5,200 kg gaseous chlorine/annum) - added to maintain 1 ppm available chlorine.

Corrosion and Scale Inhibitor: Zinc Organophosphate treatment to maintain 200 ppm as product in the water circuit has been suggested - amount required approximately 440 tonne/annum. However, PICL is investigating the use of non heavy metal inhibitors for technical rather than environmental advantages.

Sludge dispersant: Polyacrylate based dispersant slug dosed twice weekly at 50 ppm - amount required approximately 10 tonne/annum.

Biocide: Isothiazalone based biocide slug dosed once per week at 100 ppm as product for control of chlorine resistant microbes - annual requirement approximately 10 tonnes.

Zinc organophosphate has been chosen as the corrosion and scale inhibitor as it is considered to be more environmentally acceptable than alternatives such as chromates, phosphates, nitrates, nitrites, or silicates. Approximately 3 mg/L of zinc is likely to be added to the cooling water. Even if this amount of zinc were to be added to the total quantity of Woodman Point effluent the dilution factor at the ocean outlet is such that the water quality criteria for the outlet (0.02 mg/L of Zinc) would be achieved very rapidly after discharge.

The isothiazalone based biocide is biodegradable. It is considered that this biocide will have no significant environmental impact because of the relatively small quantities involved and the large dilution factors of both the total waste water and at the ocean outfall.

It is unlikely that scaling or phosphorous would present problems. However if more detailed investigations proved these parameters required treatment then soda-lime softening or an equivalent treatment would be required.

The temperature of the blow-down water from the cooling system would initially be about 40°C. However, it is expected that the temperature change at the ocean outfall compared to the present temperature would be minimal again as a result of dilution within the Woodman Point to Point Peron pipeline and the time required for transport.

9.3.2 Effluents

(a) Disposals from cooling tower make-up water treatment system.

Excess sludge from the activated sludge unit and backwash water from the sand filter and the activated carbon filter units will be directly disposed to the Point Peron pipeline outside the battery limit.

i) Sludge from activated sludge treatment.

- Flow rate : 9.0 m^3/h

- Analysis :

pH	: 7 - 7.3
TDS	: 760 mg/l
Solids (Excess Sludge)	: 1 wt%
BOD_5	: 5 - 20 mg/l
COD_{cr}	: 8 - 30 mg/l

- Disposal method : Send to the primary effluent water channel.

ii) Backwash water from sand filter

- Flow rate : 720 m^3/day (intermittent)
- Analysis :

pH	: 7 - 7.3
TDS	: 760 mg/l
Solids (SS)	: 560 mg/l
BOD_5	: 20 mg/l
COD_{cr}	: 30 mg/l

- Disposal method : Send to the primary effluent water channel

iii) Backwash water from activated carbon filter

- Flow rate : 610 m^3/2 weeks (intermittent)
- Analysis :

pH	: 7 - 7.3
TDS	: 760 mg/l
Solids (SS)	: 560 mg/l
BOD_5	: 20 mg/l
COD_{cr}	: 30 mg/l

- Disposal method : Send to the primary effluent water channel

(b) Disposal from steam generation unit

- Flow rate : 0.5 m^3/h
- Analysis :

pH	: 9.4 - 11.0
TDS	: 500 - 1500 mg/l
Cl	: -
$PO_4 3$	: 20 - 40 ppm
SiO_2	: 50 ppm (max.)

- Disposal method : Send to the final effluent basin in the waste effluent treatment unit.

(c) Cooling circuit water

- Flow rate of blowdown : 86 m^3/hr
- Analysis of blowdown :

pH	: 7 - 8
TDS	: 3,800 mg/l
Solids (SS)	: 20 mg/l
BOD_5	: 20 mg/l
COD_{cr}	: 30 mg/l
Total hardness ($CaCO_3$)	: 650 mg/l
Na^+	: 800 mg/l
K^+	: 85 mg/l
Cl^-	: 880 mg/l
Total Zn	: 5 mg/l (max.)
Cl_2 (free chlorine)	: 1 mgl/ (max.)
Corrosion/scale inhibitor	: 60 - 70 mg/l
Slime inhibitor	: 6 mg/l (min. 0.3 mg/l max 100 mg/l)

- Disposal method: Send to the final effluent basin in the waste liquid effluent treatment unit.

10. SALT SUPPLY

Negotiations over the supply of salt to the petrochemical complex are at any early stage. However, it is considered likely that the primary source will be derived from Lake Deborah at Koolyanobbing (WA Salt Supply) with possibly a lesser quantity from Dampier. A two source system would ensure continuity of supply should one source be disrupted for any reason.

The salt from Koolyanobbing will be delivered by rail to the complex at Kwinana where a stockpile equal to 2 weeks demand will be developed and maintained. Brine sludge wastes will be backloaded by train to Lake Deborah for disposal by thin spreading on the lake surface. Any salt from Dampier would probably be delivered by ship to the Fremantle Port area and road transported to site.

11. LOADING

Location and Specific Facilities

EDC, ethylene and VCM will be loaded in liquid state via mechanical loading arms located either on the most northerly berth of the BP Kwinana Refinery Jetty or on the disused BHP No. 1 Jetty. (A Study is currently being carried out to evaluate the more suitable of the two options.) A loading arm will be dedicated to each of the products. A vapor return line will be provided on the VCM and Ethylene loading arms to return the mixture of inert gas and boil-off vapor displaced from the tanker's cargo hold. The boil-off vapour will be re-compressed and returned to the appropriate storage (after removal of inerts and non-condensables.) It is anticipated that each arm will be equipped with range alarms to detect longitudinal drift along and transverse drift of tankers from the berth, which will ultimately effect shutdown of the loading pumps and valves, and if so desired will effect subsequent automatic disconnection of loading arms thus preventing damage to arms which would lead to rupture and spillage of product.

The proposed facilities are as follows:

Product Liquid Temp. (°C)	Loading Capacity (m^3/hr)	Total Shipping Duration (hr)	Loading Arm Diam. (ins)	Vapour Return line diameter (ins)
VCM -15	500	48	8	6
EDC Amb.	315	48	6	N/A
Ethylene -104	170	48	4	4"

Management of Spills

Any spillage of refrigerated ethylene or VCM from the loading facility, would evaporate very rapidly and thus would not cause marine pollution. Any spill of EDC would immediately fall to the seabed and would remain as a cohesive slug for some time. This would enable recovery by dredging or pumping.

12. CONTINGENCY PLANNING

PICL is committed to the development of a comprehensive contingency plan for the petrochemical complex. This will be modelled on that the proposed ammonia-area plant and will be developed as a component of the HAZOP study which will evaluate all safety aspects of the detailed plant design. PICL is also committed to full cooperation with the Department of Resources Development, Town of Kwinana, neighbouring industries, and emergency services in the development of a comprehensive contingency plan for the Kwinana Industrial Area in general. Development of such a plan has recently commenced.

13. Transport

At present all traffic entering or leaving the proposed plant site has no option but to use Mason Road. However, this situation may change as a result of the contingency planning study being coordinated by the Department of Resources Development. It is anticipated that this traffic will approach Mason Road either from Kwinana or from the north via Rockingham Road.

The traffic will consist almost entirely of vehicles of employees and some service vehicles although in the construction period there will also be trucks including some very large loads. Discussions will be held with the Main Road Department and the Town of Kwinana to plan for the coordination and management of this traffic.

The traffic volume is not expected to appreciably effect noise levels due to the existing traffic noise from Rockingham Road and should not be noticeable from Kwinana and other nearby urban areas.

When the plant is operational, there will be some road traffic carrying chemicals, process material or wastes to and from the complex .

All major products will be exported via pipeline and/or ship, whilst all major process intermediates, such as chlorine, and a number of chemicals, such as 33% hydrochloric acid, will be manufactured in situ. The significant road traffic related to liquid chemicals and waste transport will be as follows:

Chemical/Waste	Type of Container	Estimated Annual Tonnage by Road (metric tons per annum)
Zinc Organophosphate (Corrosion Inhibitor)	Drums	440
Methanol (99%)	Road Tanker	24 (max)
Sulphuric Acid (98% solution)	Road Tanker	2,500
Sulphuric Acid (70% solution)	Road Tanker	3,300
Sodium Hypochlorite (12% Solution)	Road Tanker	9,000

The sulphuric acid (70% solution) from the plant will be returned to the supplier or sold. The only wastes exported by road will be the waste liquids from the caustic tower and tar drum of the ethylene unit (see Section 4.1.1 above). This will constitute approximately 500 to 1000 kg per week of polymer and water with trace amounts of hydrocarbons in drums. No dedicated spill management system is considered to be necessary for road transport of these wastes.

14. Power Interruptability

The agreement between SECWA and PICL allows for interruption of power supply for:

- 40 x 40 minute periods each year and
- 5 x 5 hour periods each year.

The chlorine storage of 50 tonnes will allow the plant to maintain its process operations during power interruptions of up to 2 hours.

15. Maintenance Schedules

PICL will adopt maintenance schedules as recommended by equipment manufacturers/designers.

16. Flare System

The flare system will only operate during 'emergency' situations. It will be designed to receive and destroy any potential emissions from relief valves associated with all components of the plant except the EDC/VCM unit. The system will also be able to cope with emergency discharge associated with total shutdown of the ethylene unit (260 tph maximum design load).

Relief valve discharges from the EDC/VCM unit will be either collected or directed to the unit's incinerator for destruction.

17. Response to Other Matters Raised in Submissions

17.1 SUB 3/4 (a) - (C)

The proposed site for the petrochemical complex in Kwinana offers the only option for the plant to be cost effective because of its proximity to ethane/propane supply, existing jetties and Alcoa's alumina refinery.

The Kwinana industrial area is zoned for heavy industry and therefore it is appropriate for PICL to seek approval to establish the proposed complex in that area.

17.2 SUB 3/4(d)

The hydrology and hydrogeology of the plant site have not been considered in detail as the complex will not be using groundwater and will have a comprehensive drainage system designed to prevent any potential for groundwater contamination due to spillages.

17.3 SUB 3/12

On decommissioning, the plant site will presumably be sold for other industrial use.

17.4 SUB 3/13

PICL believes that there is no justification for establishing a medical database of local residents because of its proposal.

17.5 SUB 3/14

Matters relating to occupational noise during construction and operation of the petrochemical plant will be resolved through discussion and reporting to the Department of Occupational Health, Safety and Welfare, and the Department of Mines.

17.6 SUB 3/16

Advances in definition of the nature of the proposed plant and design and management decisions made since the publication of the ERMP and Preliminary Risks and Hazards Analysis have enabled more specific information and analysis of environmental effects to be presented in this response.

17.7 SUB 3/17

No requirement for an EIS has been made by the Commonwealth.

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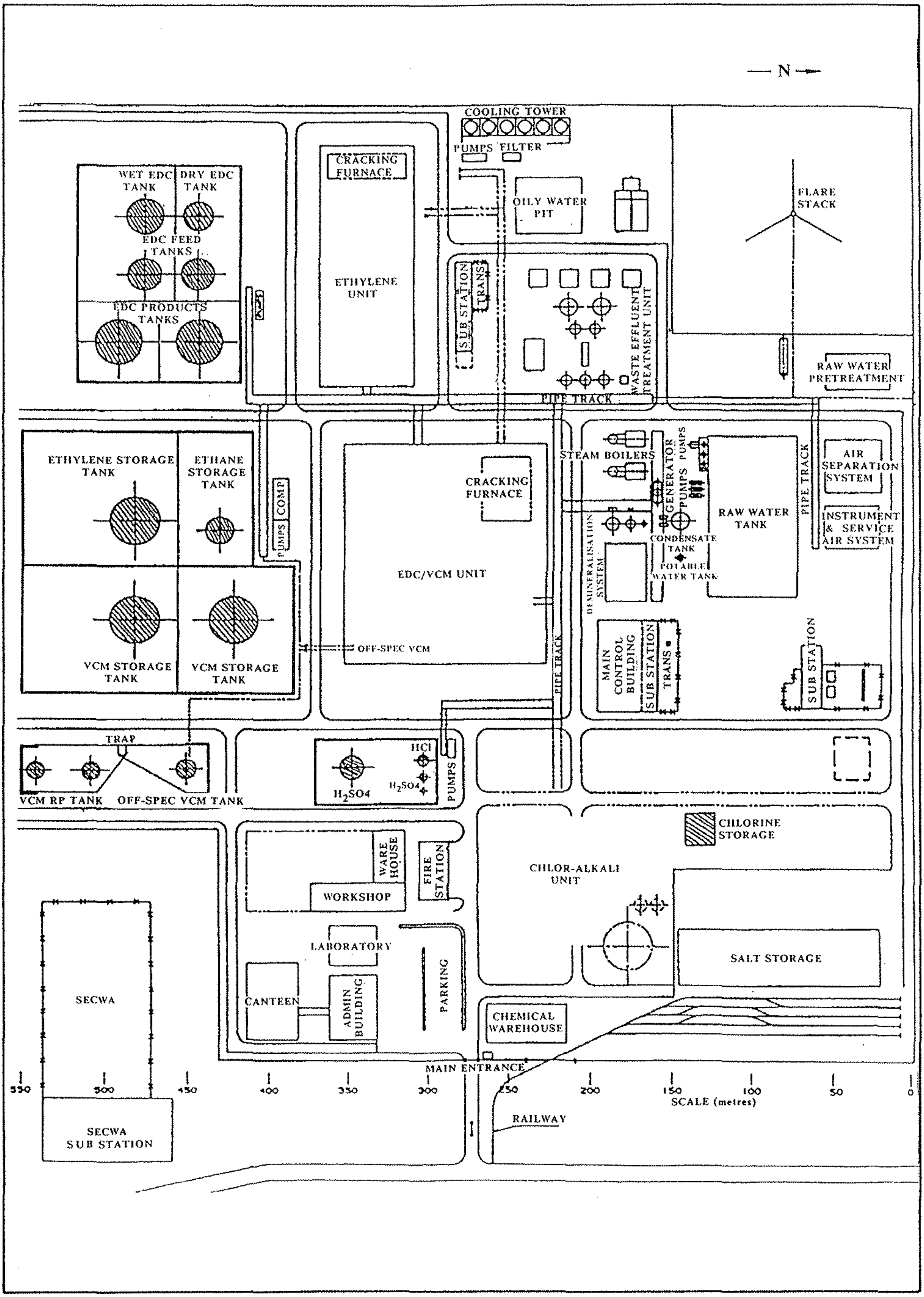
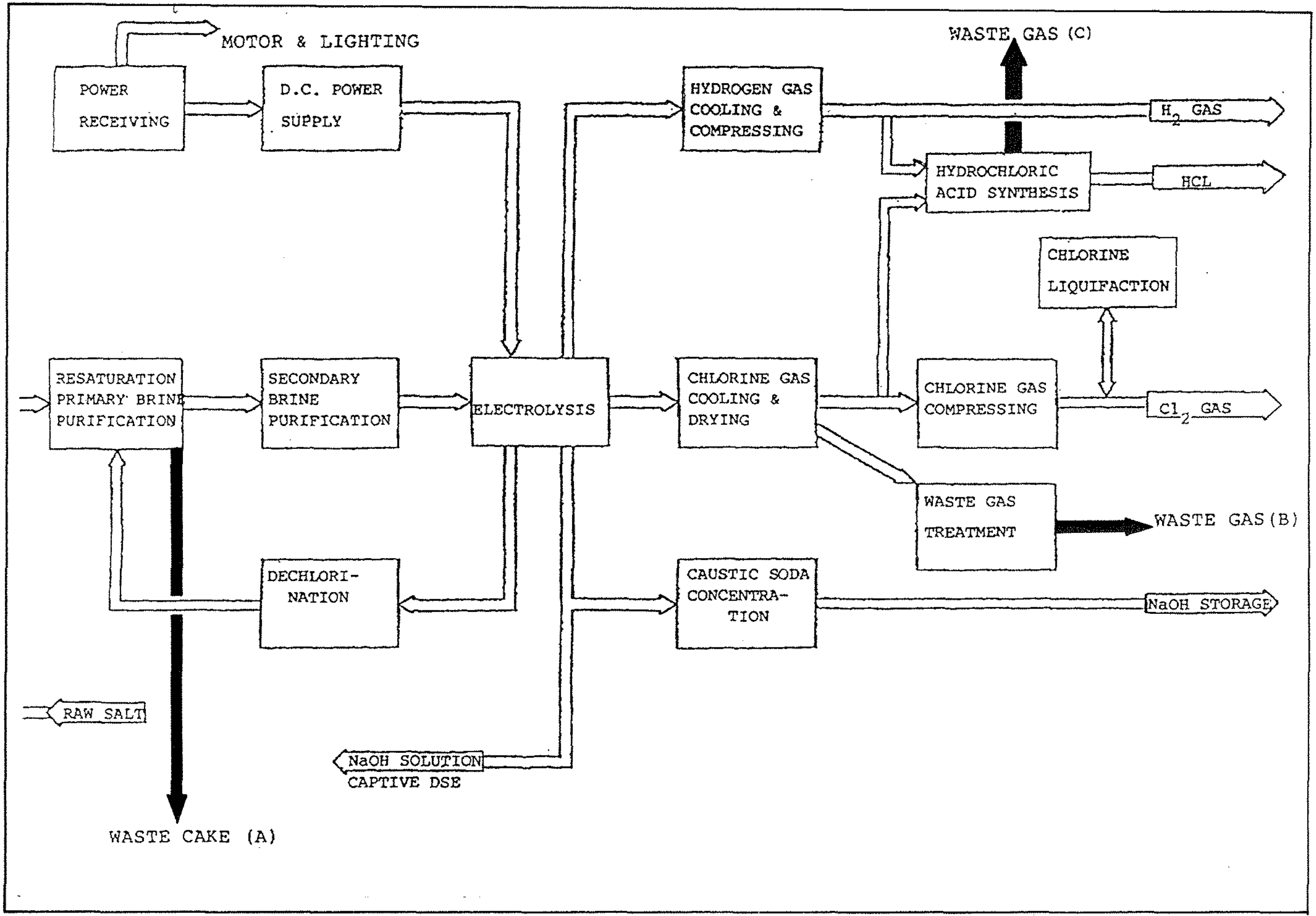
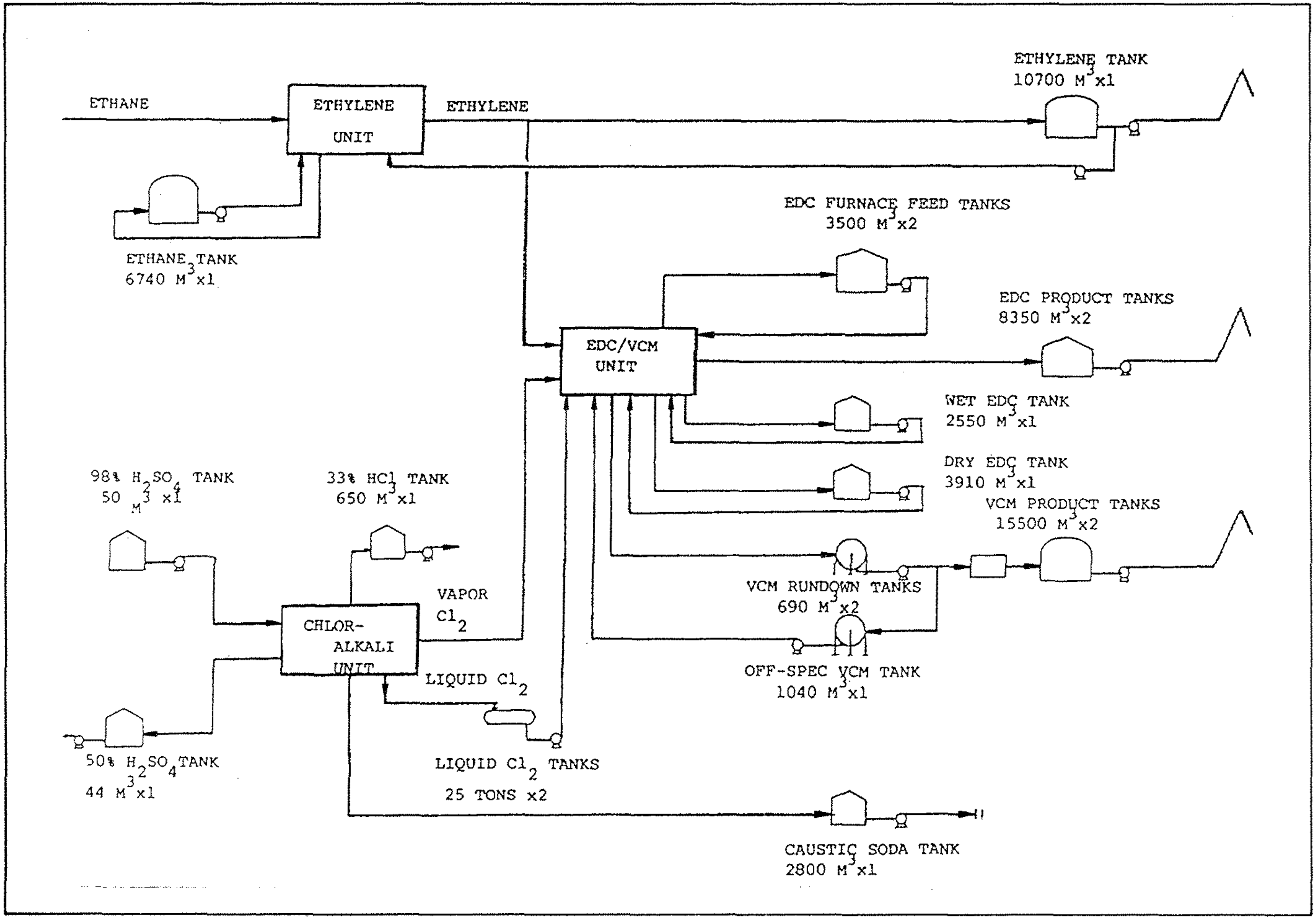


SITE LAYOUT FIGURE R1

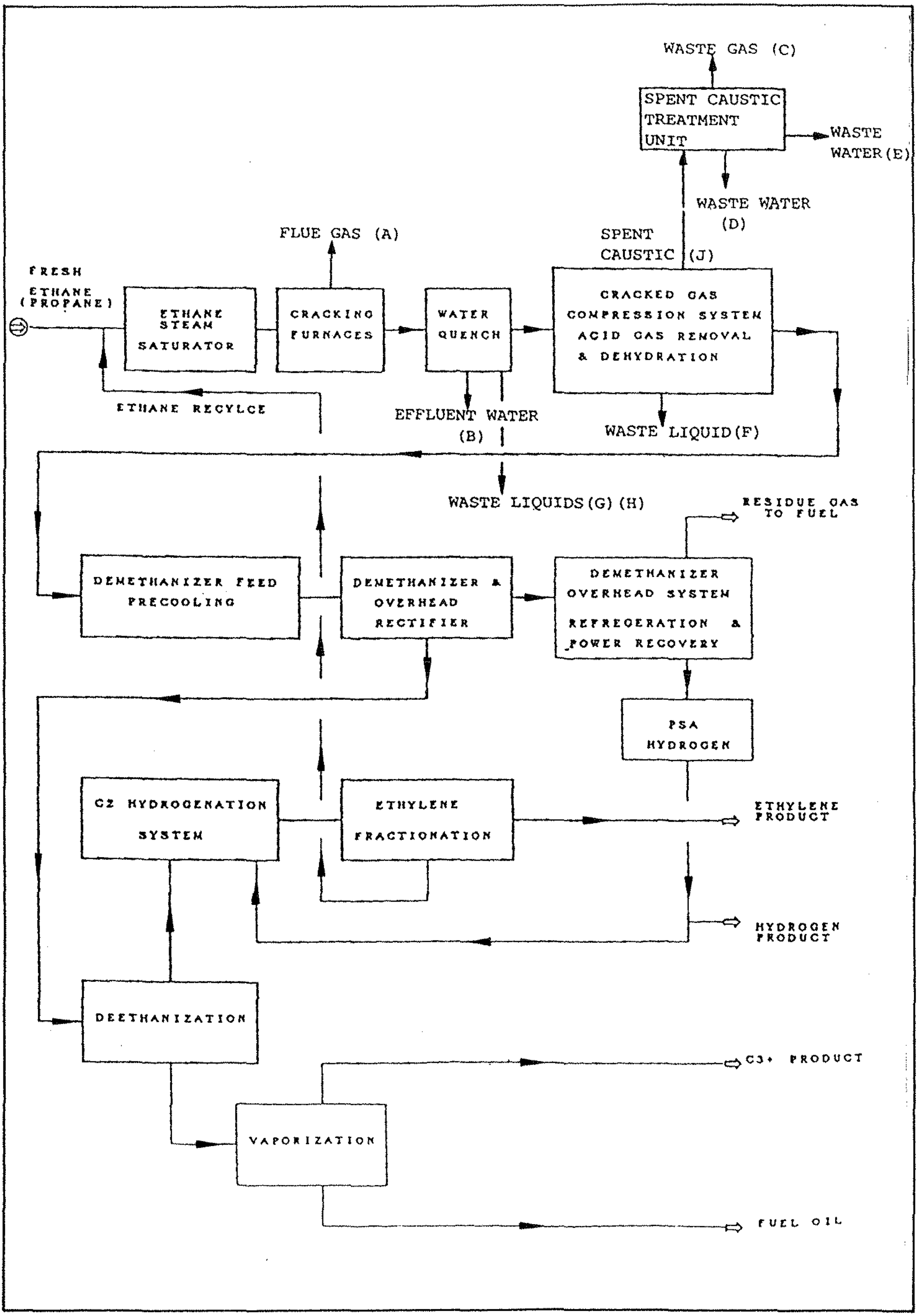


CHLOR-ALKALI UNIT BLOCK FLOW DIAGRAM

FIGURE R2



STORAGE DETAILS FIGURE R3



ETHYLENE UNIT BLOCK FLOW DIAGRAM FIGURE R4

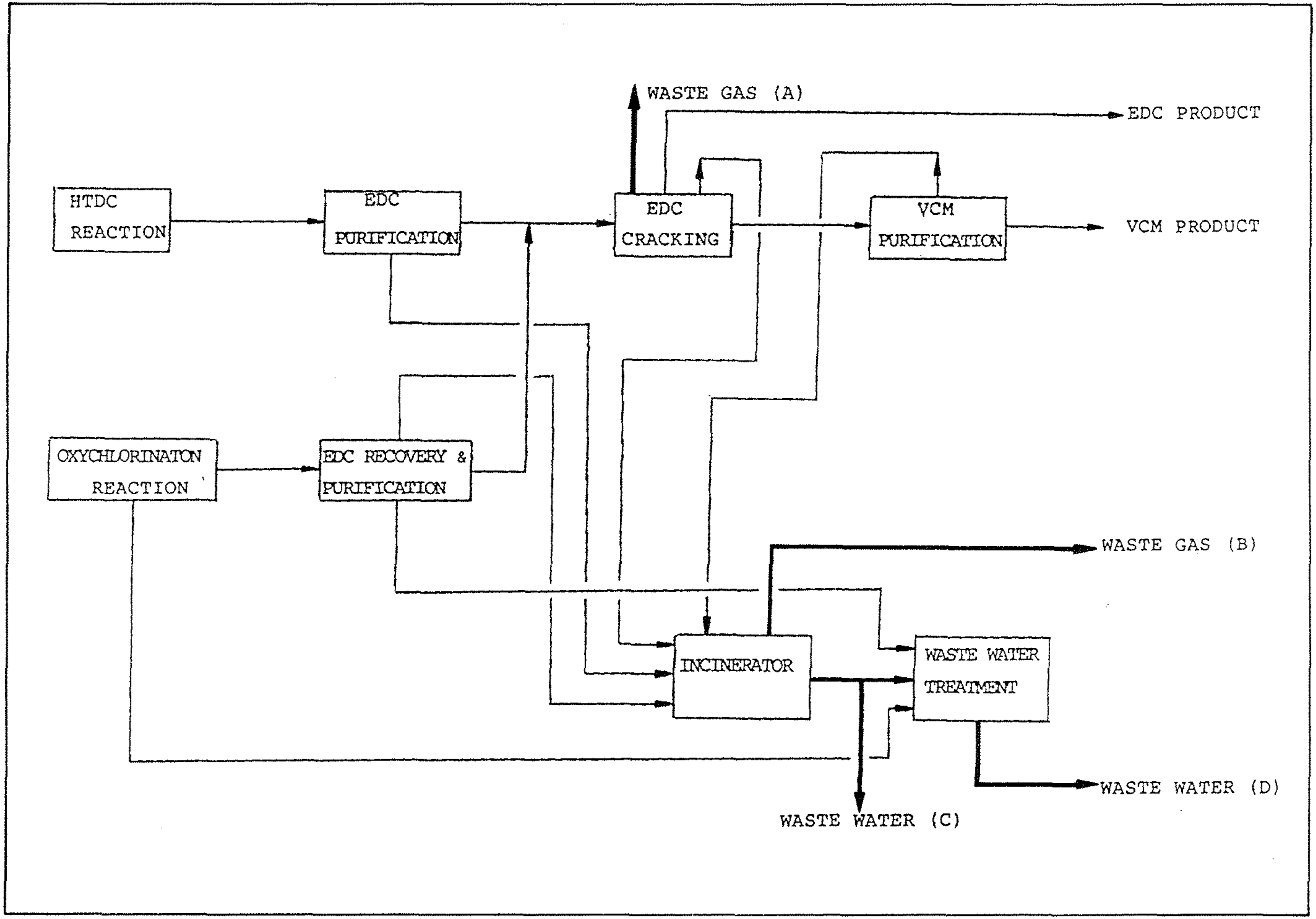
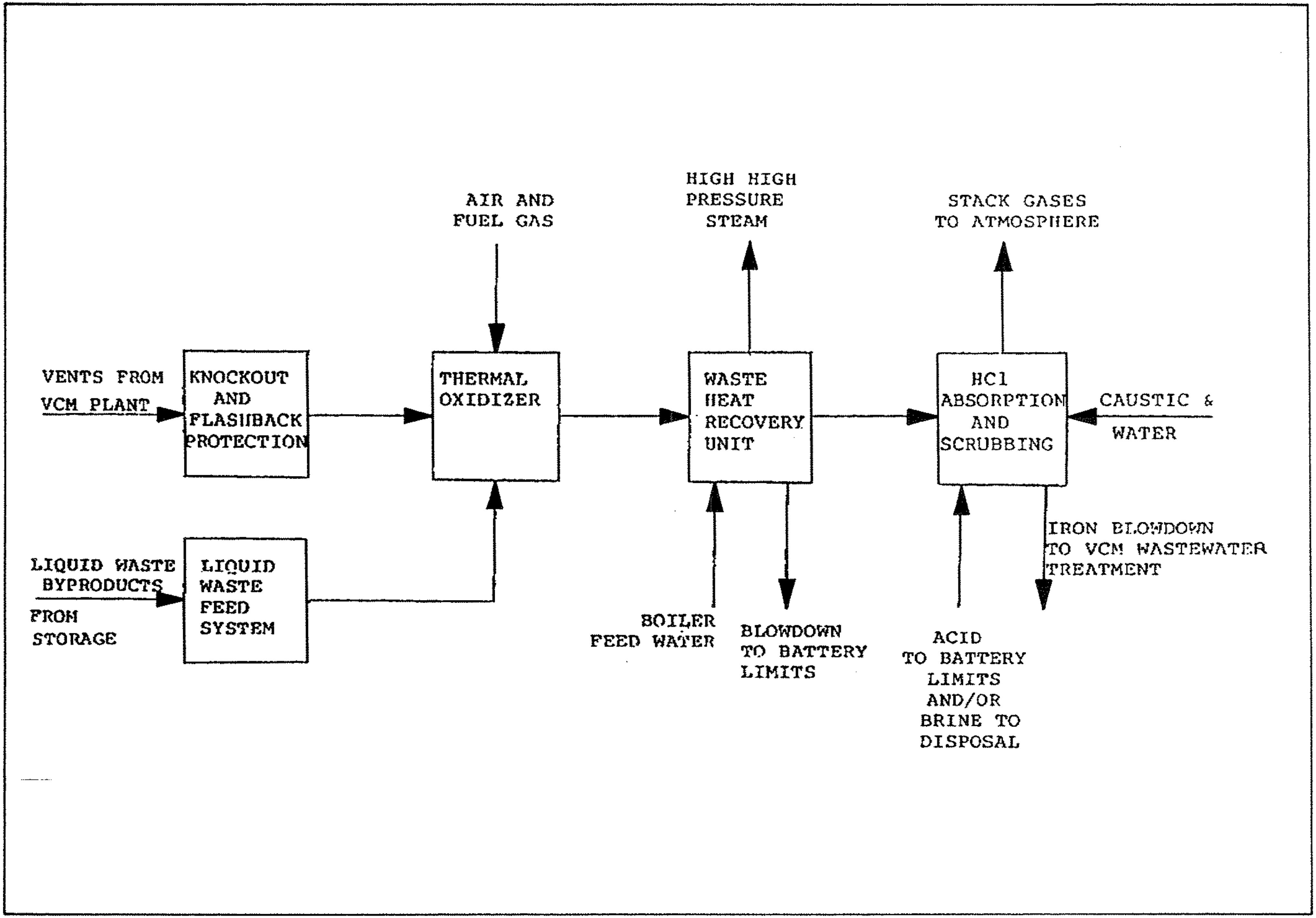


FIGURE R5 EDC/VCM UNIT WASTE STREAMS

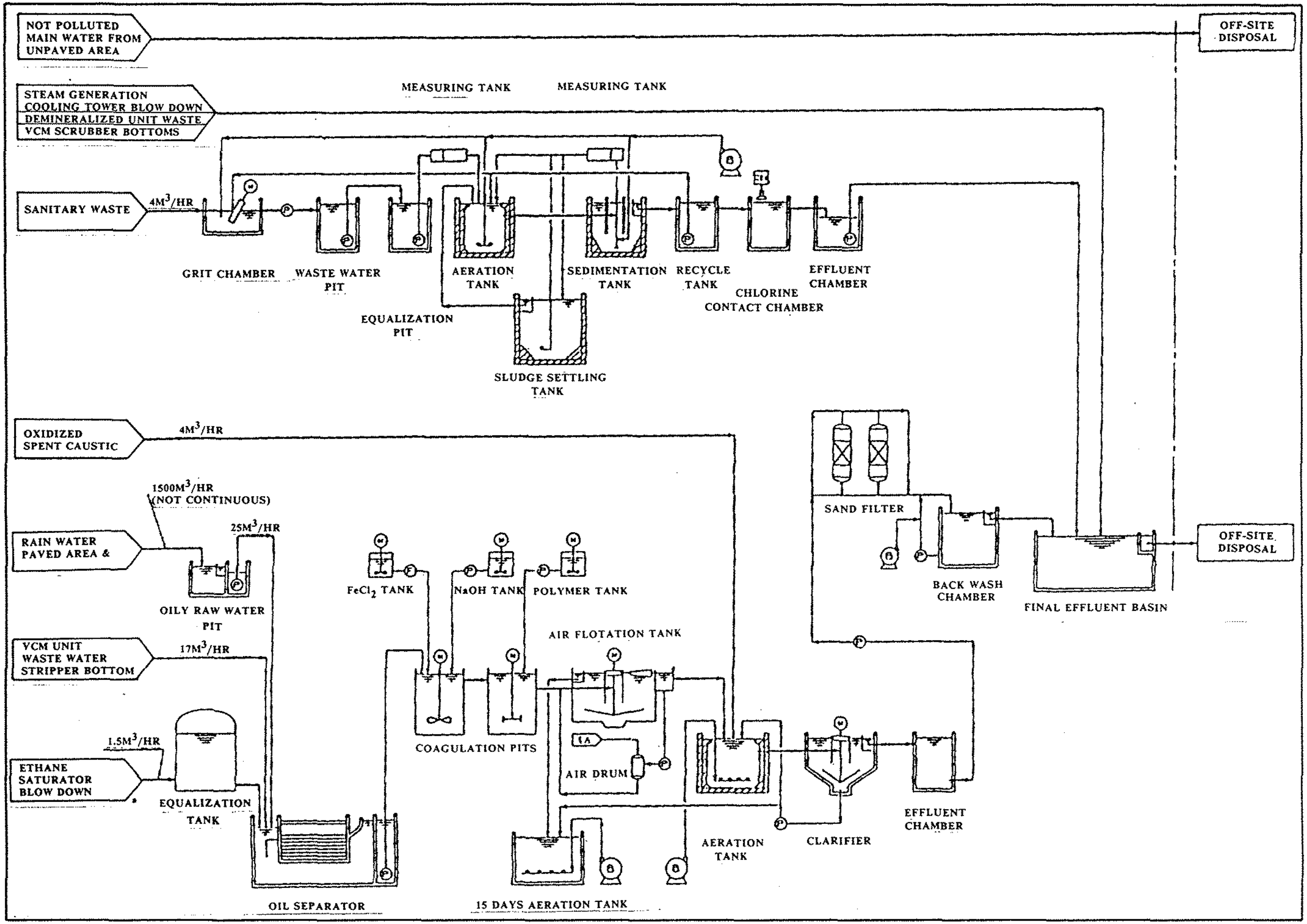


INCINERATION UNIT FLOW DIAGRAM

FIGURE R6

FIGURE R7

SEWER, RAINWATER & PROCESS EFFLUENT TREATMENT UNIT



NOISE EMISSION & IMPACT STUDY

OF

Proposed Petrochemical Complex

AT

KWINANA

FOR

Petrochemical Industries Co. Ltd.

BY

L.J.STORER & ASSOCIATES

April 1988

I N D E X

1. INTRODUCTION & OBJECTIVE

To undertake a study of the likely noise emissions from the proposed Petrochemical Complex in the Kwinana Beach area of Perth, Western Australia. To determine likely noise emission levels and characteristics and assess the impact on surrounding residential areas.

2. CONCLUSIONS

It is the findings of this report that:

A) Due to topography, distance and prevailing winds, the most critical area for receival of plant noise emission will be the Southern boundary of the Hope Valley residential area (Location A).

B) An acceptable noise level in this area, based on the Environmental Protection Authority's background level survey, is likely to be 44 dB(A) between 0700 and 2200 hours and 37 dB(A) between 2200 and 0700 hours and weekends.

C) Under maximum propagation conditions, the down wind noise level at 'A' would be 38 dB(A). Under more normal conditions of down wind propagation, the level would be 30 dB(A) and 23 dB(A) for calm conditions. Due to likely tonal components, an adjustment of plus 5 dB(A) is made to this level, resulting in a maximum of 43 dB(A). The level of 43 dB(A) may not be acceptable to residents in the period 2200 to 0700 hours and could give rise to complaints.

D) Attenuation of plant, in particular treatment of tonal noises, may be required to achieve acceptable levels during the 2200 to 0700 hours when down wind propagation and temperature inversion exists. (Less than 5% of time).

3. METHODS

3.1 Determination of Acceptable Noise Levels

To determine potentially acceptable noise levels in the residential areas, an assessment was made of background noise level measurements carried out by the E.P.A. at Honor Ave., Hope Valley.

3.2 Determination of Plant Emissions

Sound power levels of various items of plant were sourced from two areas:

1. Major Equipment:-
   Overall sound power levels in dB(A) supplied by J.G.C. Corporation.
2. Sundry Equipment (Pumps, Electric Motors, etc):-
   Theoretical calculations based on empirical data.

The plant has been treated as an open plan complex with no allowance for building attenuation. Allowance has been made for screening within the plant.

Plant equipment has been grouped into a number of areas. Equipment sound levels in each of those areas have been logarithmically added and considered as a ground level point source at the centre of each of these areas.

The exceptions to this are, the Flame Tower, Cooling Tower and Cracker combustion noises which are calculated as point sources at the height appropriate in each case.

3.3 Determination of Resultant Noise Levels In Residential Areas

The propagation of plant noise levels to the residential areas is based on the following formula.

$$Lp = Lw - K_1 - K_2 - K_3 - K_4 + K_5$$

where Lp = Sound Pressure level at receiving point

Lw = Sound Power level of source

K_1 = Geometric Spreading either by:
$10 \log (4\pi R^2) - 3$ for Hemispherical Radiation
or by $10 \log (4\pi R^2)$ for Spherical Radiation
where R is the distance from source to receiver (m)

K_2 = Atmospheric Attenuation - After Sharland

K_3 = Barrier Effect - After Maekewa

K_4 = Ground Attenuation - After O.C.M.A.

K_5 = Down Wind Propagation - After Concawe - Catagory 5

4. RESULTS

4.1 Background & Acceptable Noise Levels

From field observation, studies of contour mapping and prevailing wind conditions, the Hope Valley area to the North East of the proposed plant was determined as the most critical area.

Specifically the area targeted as the most likely to receive maximum noise propagation is the corner of Armstrong and Honor Avenue (Refer Figure 1, Location A).

This location is the nearest of an elevated area that has direct line of sight to the proposed plant. Other areas are closer (by approx. 300 m), however reduced ground levels create a barrier which will provide extra attenuation.

The background noise level studies undertaken by the E.P.A. were carried out in Honor Avenue and therefore are appropriate to use in this assessment. The E.P.A. study was carried out for the period 29th January to 12th February 1988.

For the purpose of this report, noise levels are categorised into two times, daytime 0700 to 2200 hours and nightime 2200 to 0700 hours.

The data of interest in the E.P.A. study is the L90 percentile levels (i.e. noise levels exceeded for 90% of the time).

To arrive at single overall figures for day and nightime background noise levels, it is considered appropriate to use an arithmetic average of all the individual L90 figures for the period required.

This average is:

Daytime 0700 to 2200 hours	41 dB(A)
Nightime 2200 to 0700 hours	34 dB(A)

It is therefore the consideration of this report, on the basis that levels of up to 5 dB(A) above background are generally acceptable, that the following levels be considered as acceptable levels for plant noise emission to the Hope Valley area. These levels are based on a 3 dB(A) increase over the above background levels:

Daytime 0700 to 2200 hours	44 dB(A)
Nightime 2200 to 0700 hours	37 dB(A)

This acceptability is dependant on no noise characteristics in the emissions. If for instance tonal components exist, the above levels should be reduced by 5 dB(A) to assess their acceptability.

/..4

4.2 **Plant Noise Emission**
A summary of all relevant equipment and corresponding sound power levels are contained in Table 1. From this data, the total sound power level for each area has been calculated and is also shown in Table 1.

4.3 **Determination of Noise Propagation**
Based on the total plant emissions in Table 1 the propagation under a worst case scenario at the critical area A, is estimated to be 38 dB(A).

The worst case scenario is formulated on the basis of down wind propagation, which results in a negative 7 dB attenuation and a temperature inversion which results in no ground effect attenuation. Other scenarios would be calm with temperature inversion 36, wind propagation only 30 and calm 23.

It has not been possible to carry out noise propagation calculations for various frequencies, as equipment spectral information is not available at this stage.

The available information is in overall sound power levels - A weighted.

Factors K_1 to K_5 therefore have been based on the octave band of centre frequency 1000 Hz.

Using theoretical formula to construct a typical frequency spectra for typical equipment, validity of this method was checked. The results show that this is a reasonably valid method. A typical calculation showing the comparison is as follows, based on an electrically drive reciprocating compressor - distance 2800 m, hemispherical radiation:-

	SOUND POWER LEVELS OCTAVE BAND CENTRE FREQUENCY Hz								OVERALL dB(A)
	63	125	250	500	1K	2K	4K	8K	
	112	110	106	105	107	108	106	101	113
A weighting correct	26	16	9	3	0	+1	+1	1	
K_1	77	77	77	77	77	77	77	77	77
K_2			2	4	12	24	43	60	12
K_3	5	5	5	5	5	5	5	5	5
K_4	4	5	9	9	7	7	5	3	7
Addition	-	7	4	7	6	-	-	-	
		9		9.5					
Resultant Level	12.5 dB(A)								12 dB(A)

The results of propagation calculations are contained in Table 2, showing calm and maximum propagation conditions.

5. SUMMARY & DISCUSSION

From the overall calculations (Table 2), it can be seen for the worst case conditions under normal plant operations, the resultant level at the critical area in Hope Valley would be 38 dB(A).

When compared to the previously determined likely acceptable levels of 44 dB(A) daytime and 37 dB(A) nightime, the calculated maximum level exceeds this level by 1 dB(A) at nightime only.

The excess of 1 dB(A) at nightime is unlikely to give rise to complaints.

It is probable that tonal components will exist in the transmitted noise which would incur a penalty of 5 dB(A) to reflect the annoyance characteristics.

The tonal noises would effectively render the transmitted noise up to 6 dB(A) in excess of the acceptable nightime levels.

At this stage of planning, it is not possible to determine which, if any, plant would produce strong tonal components. Typically though it is fans and blowers that generally exhibit these qualities. It is likely that attenuation will be required to blowers and compressors to reduce the tonal component level and also likely that acoustic lagging will be required to compressor piping.

It is possible that the flare tower under full burn conditions and worst case propagation conditions, could produce noise levels of up to 51 dB(A) (41 under no wind conditions) at Hope Valley. As this flare is only an emergency operation, it is unlikely to cause any significant effect on the rare occasion of a full burn.

Through all calculations, no allowance has been made for steam release noises. The plant has no design for permanent dumping or venting of steam and relief ports are to be fitted with silencers.

The predictions for noise emission to Hope Valley are based on the worst case propagation scenario of light South Westerly winds and conditions of temperature inversion. These conditions occur less than 5% of the time - see wind rose Figure 3. The balance of the time noise emission will be reduced to as low as 23 dB(A).

In summary, under relatively normal conditions noise emission from the plant will result in levels of 23 to 30 dB(A) at Hope Valley and under the most adverse conditions, 38 dB(A). The maximum conditions exist for relatively short periods of time. i.e. Less than 5%. Down wind propagation resulting in levels of up to 30 dB(A) could arise for up to 28% of the time and it should be noted background noise levels would increase due to wind for at least half of this time.

The balance of the time levels would be less than 30 dB(A) due to up wind attenuation.

If attenuation of plant is instigated to reduce any tonal component noise levels, then this should be considered acceptable and complaints should not arise.

L.J.STORER

TABLE 1

EQUIPMENT SOUND POWER LEVELS & PROPAGATION CRITERIA

AREA & EQUIPMENT	DISTANCE TO A SCREENING DETAILS	SOUND POWER LEVEL Lw dB(A	
		INDIVIDUAL	SUB TOTAL
1. CHLOR ALKALI/STORAGE	2500 metres - Min Screen		
Hydrogen Compressor		108	
Pumps 43 off		115	
Crane		105	
Pay Loader 2 off		114	
Conveyors		108	118
2. ETHYLENE CRACKING	3000 metres - Med Screen		
Crackers - 3 off			
Combustion	10 m High	116	116
Blowers	30 m High	107	107
Refrig Comp/Turbine		113	
Charge Gas Comp/ Turbine		113	
Popylene Comp.		113	
Pumps 15 off		112	119
3. E.D.C/V.C.M	2700 metres - Med Screen		
Crackers - 2 off			
Combustion	10 m High	114	
Recycle Comp.		114	114
Pumps 36 off		115	
Storage Refrig. Comp.		107	117
4. UTILITIES AREA	2500 metres - Med Screen		
Boiler 1 off		103	
Feed Pumps		104	
Instr. Air Comp.		108	111
5. COOLING TOWER	2900 metres - Med Screen		
Fans 6 off	15 m High	117	
Water Fall		112	
Pumps		110	119
6. WATER TREATMENT	2700 metres - Min Screen		
Pumps 6 off		105	
Regen. Air Blower		110	111
7. Flare Tower	2700 metres - 40 m High	100 (140)*	100 (140)

* Flare Tower during max. burn.

TABLE 2

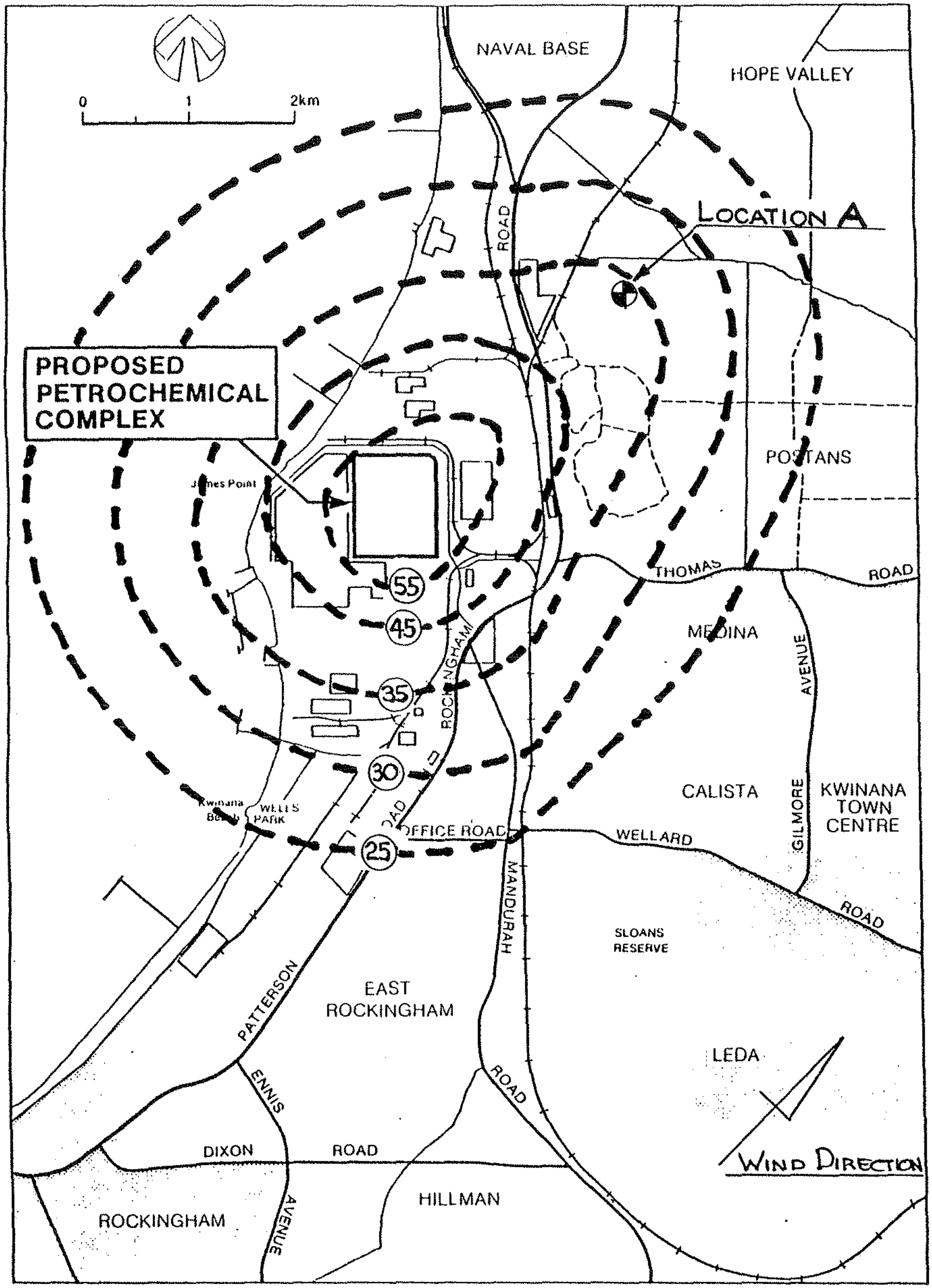
PROPAGATION CALCULATIONS

AREA No	Lw dB(A)	$-K_1$	$-K_2$	$-K_3$	$-K_4$	NO WIND Lp dB(A)	DOWN WIND COND. ATTENUATION CORRECT $+ K_5 + K_4$	DOWN WIND Lp dB(A)
1	118	76	12	5	7	18	7 + 7	32
2	116	79	12	5	7	13	7 + 7	27
	107	81	12	5	5	4	7 + 5	16
	119	78	12	5	11	13	7 + 11	31
3	114	78	12	5	7	12	7 + 7	26
	117	77	12	5	11	12	7 + 11	30
4	111	76	12	5	11	7	7 + 11	25
5+	119	79	12	5	5	18	7 + 5	30
6	111	77	12	5	7	10	7 + 7	24
7*	100 (140)	80	12	4	3	1 (41)	7 + 3	11 (51)
						23(41) dB(A)		38 (51) dB(A)

* Flare during maximum burn.

\+ Possible low frequency beat characteristics - masked by overall level.

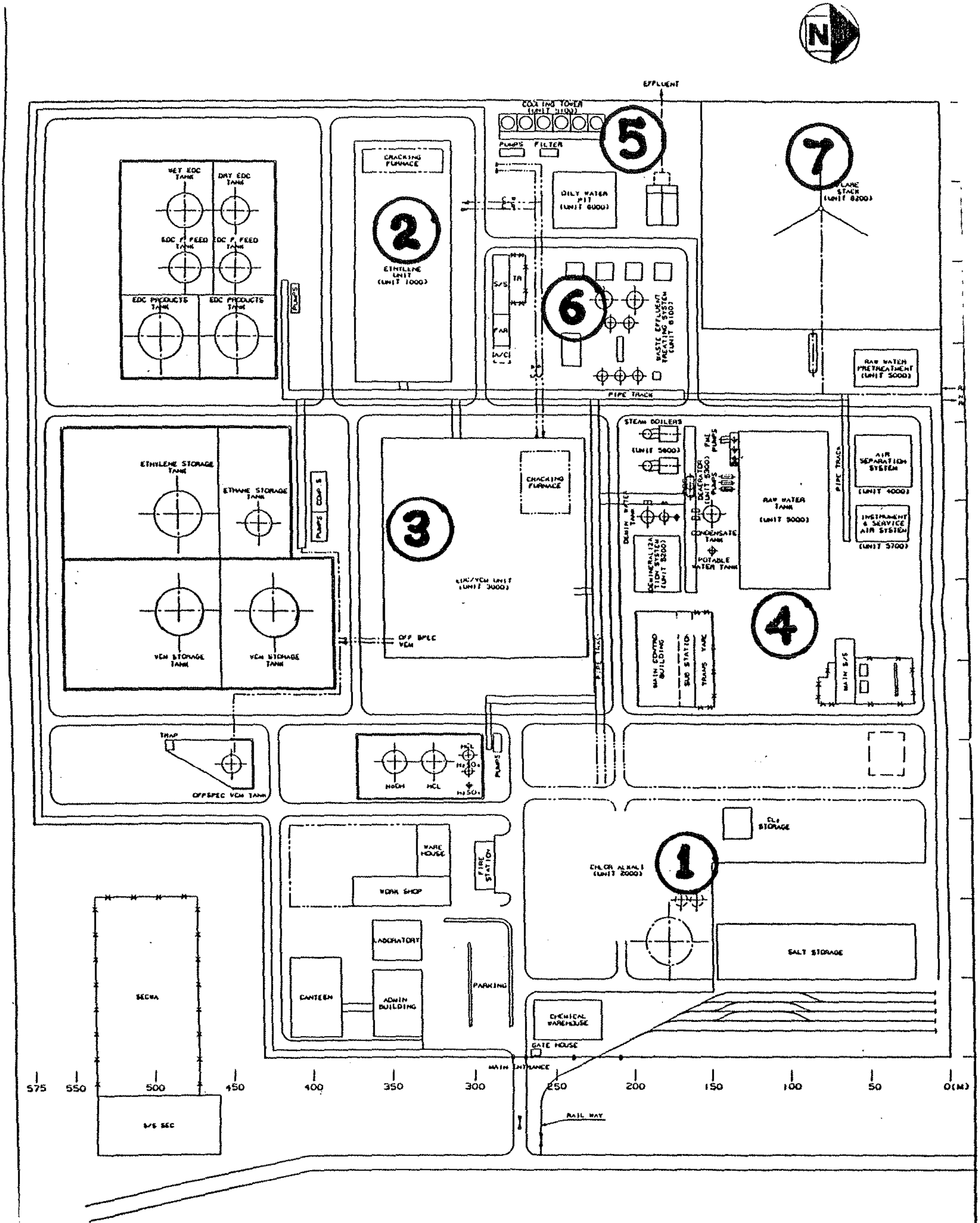
Probable tonal components in overall noise level leading to a + 5 dB(A) adjustment for assessment.



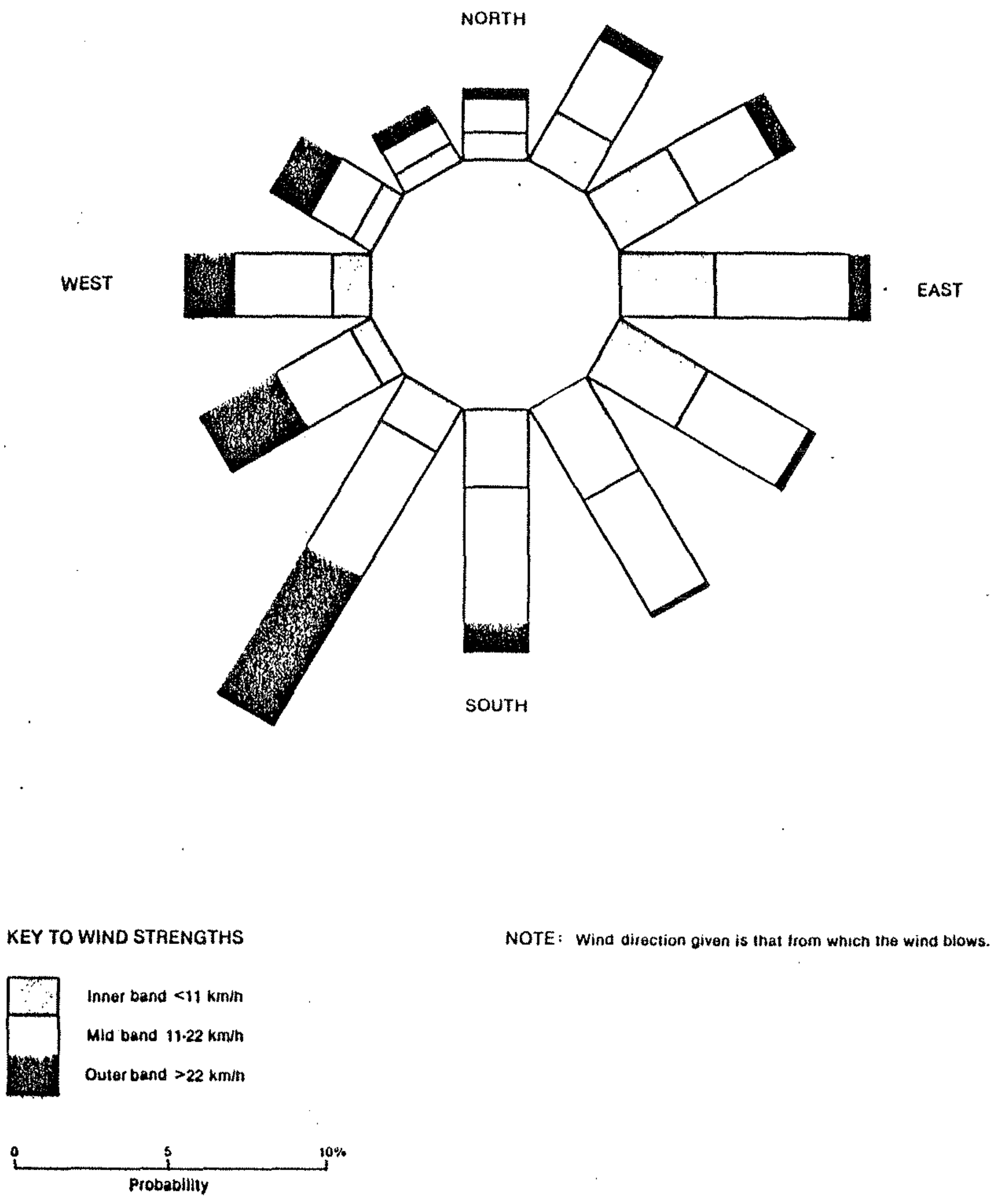
KWINANA SITE PLAN SHOWING EXISTING INDUSTRIAL DEVELOPMENT AND LAND USE

NOISE LEVEL [dB(A)] CONTOURS - DOWN WIND PROPAGATION

FIGURE 1



Noise Source Area Locations Figure 2



NOTE: Wind direction given is that from which the wind blows.

Source: Hope Valley Base Station, 1 January 1980 to 31 December 1980

Figure 3
WATTLEUP BASE STATION WIND DIRECTION FREQUENCY

ATMOSPHERIC EMISSIONS FROM THE PROPOSED PETROCHEMICAL COMPLEX AT KWINANA

ANALYSES PREPARED FOR PETROCHEMICAL INDUSTRIES COMPANY LIMITED

by

Dr. Ian Foster, Meteorologist

PICL Air Pollution Study

1. Introduction

This report describes the results of preliminary calculations of air emissions from the proposed PICL petrochemical complex at Kwinana. Inputs such as pollutant concentration, flow rates, stack heights, emission temperatures and building dimensions are those supplied by PICL or its agents and are current for March 1988. The purpose of this study is to calculate ground level concentrations of pollutants using standards are exceeded. Any changes to design parameters will require further air pollution calculations.

2. Inputs and calculations

Emissions data required as input for air despersion modelling are contained in Table 1. The possibility exists that some of this data may be updated. Source strength is in units of grams per second (g/s) and is easily converted to kilograms per hour for comparison with values given in other reports. Volume flux is given in cubic metres per second and is expressed at emission temperature. This can be converted to 0 degrees C (STP) by calculating air density or molar volume at emission and STP. Other units are consistent with industrial usage. See the Appendix for details of these calculations.

Air dispersion calculations were performed with MAXMOD, a computer model used by the Environmental Protection Authority. This model is based on Gaussian plume assumptions (Turner, 1970; Hanna et al., 1982). Horizontal and vertical plume spread are determined using modified Briggs equations. Building effects and plume rise are calculated using equations of Briggs (1975) and utilizes virtual sources to account for building-induced plume spread. Line source emissions are accounted for using the procedure described by the United States Environmental Protection Agency (USEPA, 1980) for their Buoyant Line and Point source (BLP) model. Limited vertical mixing, such as caused by low level temperature inversions, is also included. MAXMOD was run to find maximum ground level concentrations for a range of wind speeds and all stability classes. Results presented here represent worst case conditions as the three ethylene furnaces and the two EDC furnaces were treated as two single sources and as two solid buildings rather than separate columns. These assumptions lead to an over estimate of ground level concentrations.

Ground level pollutant standards, as adopted by the Victorian EPA, are listed in Table 2. For NO_2, SO_2 and CO the standards are 1 hour averages and are quoted at acceptable and detrimental air quality levels. Standards for the other pollutants are 3 minute averages and represent design concentrations that are to be applied when determining stack heights. As such, they are concentrations that must not be exceeded.

3. Results

Results of the analyses are shown on Tables 3 to 7 and on the appended graphs. These indicate that design ground level concentrations will be below the required standards beyond the eastern boundary of the plant when the positions of the stacks are taken into account. This is the direction of urban areas and of most other industries.

Emissions are likely to exceed the nominated design ground level concentrations within the plant boundaries during certain conditions. These predictions are linked to the cracking furnaces (Figures 1 to 4) and result from entrainment of the plumes into the wake of the buildings. However, in this context occupational standards apply rather than design ground level concentrations. The relevant occupational standards of the American Conference of Government and Industrial Hygienists 1985 - 1986 are

NO_2	6 mg/m^3
SO_2	5 mg/m^3 (8 hour average)

It is clear from the analysis that these occupational levels will not be exceeded.

Table 1 also lists emission of ethane and ethylene from the EDC/VCM incinerator. These are generally classified as asphyxiants for which occupational standards are not published. The ground level concentrations are plotted in Figure 5.

TABLE 1. Input variables to computer model.

Unit	Stack ht (m)	Source strength (g/s)	Vol flux at exit temp (C) (m^3/s)	Exit temp (C)	Exit velocity (m/s)
Ethylene cracker :					
NOx	58	9.63	43.57	160	14.2
SOx	"	2.76	"	"	"
Chlor-Alkali :					
Cl_2	55	6.33 10-3	0.76	40	7
HCl	"	6.67 10-4	9.38 10-3	35	7
EDC/VCM Cracker :					
NOx	40	6.17	27.89	160	14.2
SOx	"	1.76	"	"	"
Incinerator:					
HCl	55	3.05 10-1	14.50	63	7
CO	"	6.08 10-1	"	"	"
HC	"	9.14 10-1	"	"	"
Cl_2	"	7.50 10-2	"	"	"
NOx	"	2.13	"	"	"
VCM		0.0			

TABLE 2. Ground level pollutant standards.

Pollutant	Average	Standard (ug/m^3)
NO_2	1 hr	Acceptable : 307, Detrimental : 512
SO_2	"	" : 485, " : 970
CO	"	" : 37416
HCl	3 min	Design : 200
Cl_2	"	" : 100
VCM	"	" : 100

TABLE 3. Maximum concentrations of NOx AND SOx for ethylene cracker. 1 hr averages.

Stability class	Conc (ug/m^3)		Distance (m)	Wind speed (m/s)
	NOx	SOx		
A	810.1	232.2	50	1.6
B	1009.6	289.3	"	1.9
C	1399.0	401.0	"	2.0
D	1855.5	531.8	"	2.0
E	3011.2	863.0	"	1.5
F	3715.2	1064.8	"	1.7
Standards:				
Acceptable	307	485		
Detrimental	512	970		

TABLE 4. Maximum concentrations of Cl_2 for Chlor-Alkali plant. 3 min averages.

Stability class	Conc (ug/m^3)	Distance (m)	Wind speed (m/s)
A	0.6	225	0.5
B	0.2	298	1.5
C	0.2	477	1.5
D	0.2	838	1.5
E	0.1	1619	1.5
F	0.1	5000	0.5
Standard :	100		

TABLE 5. Maximum concentrations of HCl for Chlor-Alkali plant. 3 min averages.

Stability class	Conc (ug/m^3)	Distance (m)	Wind speed (m/s)
A	0.1	170	0.5
B	<0.1	271	1.5
C	<0.1	395	1.5
D	<0.1	695	1.5
E	<0.1	1474	1.5
F	<0.1	3433	0.5
Standard :	200		

TABLE 6. Maximum concentrations for NOx and SOx for the EDC/VCM plant, 1 hr averages

Stability class	Conc (ug/m^3) NOx	SOx	Distance (m)	Wind speed (m/s)
A	641.9	183.1	50	1.8
B	803.2	229.1	"	1.8
C	1103.2	314.7	"	2.3
D	1501.4	428.3	"	2.3
E	2041.7	582.4	"	2.1
F	2631.4	750.6	"	2.2
Standards :				
Acceptable	307	485		
Detrimental	512	970		

TABLE 7 Maximum concentrations of HCl, CO, HC, Cl_2, and NOx for the EDC/VCM incinerator scrubber. NOx concentration is a 1 hr average, all others are 3 minute averages.

Stability class	Conc (ug/m^3) HCl	CO	HC	Cl_2	NOx	Dist (m)	Wind speed (m/s)
A	52.4	104.5	157.1	12.9	201.4	50	1.5
B	51.4	102.7	184.7	12.7	197.8	"	1.9
C	61.6	122.9	184.7	15.2	236.8	"	2.1
D	82.9	165.6	248.8	20.4	319.0	"	2.1
E	87.6	174.9	262.7	21.6	336.8	"	1.8
F	79.2	158.0	237.4	19.5	304.4	"	2.0
Standards :	200	37416	---	100	307,512		

4. References.

Briggs, G.A., 1975
Plume rise predictions. in Haugen, D.A. (ed), Lectures on air pollution and environmental impact analyses.
American Meteorological Society, Boston, 296 pp.

Hanna, S.R, Briggs, G.A. and Hosker, R.P., 1982
Handbook on atmospheric diffusion
Technical Information Centre, US Dept of Energy, DE82002045 (DOE/TIC-11223),
102 pp.

Turner, D.B., 1970
Workbook on atmospheric dispersion estimates.
Environmental Protection Agency. Office of Air Programs, pub. no. AP-26, Research Triangle Park, North Carolina.

USEPA 1980
Buoyant line and point source (BLP) dispersion model user's guide.
Report No. EPA/DF-81/001d. US Environmental Protection Agency, Research Triangle Park, North Carolina.

APPENDIX. Calculation of source strengths and volume fluxes.

1. Ethylene cracker.

At STP, mass flow = 128000 kg/hr, NOx conc = 0.35 g/m^3, density = 1.29 kg/m^3.

Source strength (Q) = 128000 * 0.35/1.29 * 3600 s/hr
= 9.63 g/s or 34.67 kg/hr

Conc SOx = 0.1 g/m^3, Q = 2.76 g/s or 9.92 kg/hr.

Q at STP = Q at emission temperature.

Volume flux at 160 C : 128000 kg/hr / 0.816 kg/m^3* 3600 s/hr

= 43.57 m^3/s.

2. Chlor-Alkali plant.

Cl_2 : Q(STP) = 2400 m^3/hr * 9.5 10-3 g/m^3/ 3600 s/hr
= 6.33 10-3 g/s or 2.28 10-2 kg/hr

Volume flux at 40 C : (2400/3600) * (1.29/1.13)
= 0.76 m^3/s

HCl : Q(STP) = 30 m^3/hr * 80 10-3 g/m^3 / 3600 s/hr
= 6.67 10-4 g/s or 2.40 10-3 kg/hr

Volume flux at 35 C : (30/3600) * (1.29/1.13)
= 9.38 10-3 m^3/s

3. EDC/VCM plant.

NOx and SOx : Calculate Q as for ethylene cracker using flow rate of 63500 m^3/hr and NOx and SOx concs of 0.35 and 0.1 g/m^3 respectively. Thus ,

Q, NOx = 6.17 g/s or 22.2 kg/hr
Q, SOx = 1.76 g/s or 6.34 kg/hr.

Volume flux at 160 C : (63500/3600) * (1.29/0.816)
= 27.89 m^3/s

Incinerator scrubber.

Q (STP) for HCl : 1.29 kg/m^3 * 42500 m^3/hr * 20 ppm(wt) * 10-6

= 3.05 10-1 g/s or 1.10 kg/hr

Q (STP) for CO : $1.29 * 42500 * 40 * 10^{-6}$
$= 6.08\ 10^{-1}$ g/s or 2.19 kg/hr

Q (STP) for HC : $1.29 * 42500 * 60 * 10^{-6}$
$= 9.14\ 10^{-1}$ g/s or 3.29 kg/hr

Q (STP) for Cl_2 : $1.29 * 42500 * 5 * 10^{-6}$
$= 7.5\ 10^{-2}$ g/s or 0.27 kg/hr

Q (STP) for NOx : $1.29 * 42500 * 140 * 10^{-6}$
= 2.13 g/s or 7.67 kg/hr

Volume flux at 63 C : (42500/3600) * (1.29/1.05)
= 14.5 m^3/s

FIGURE 1

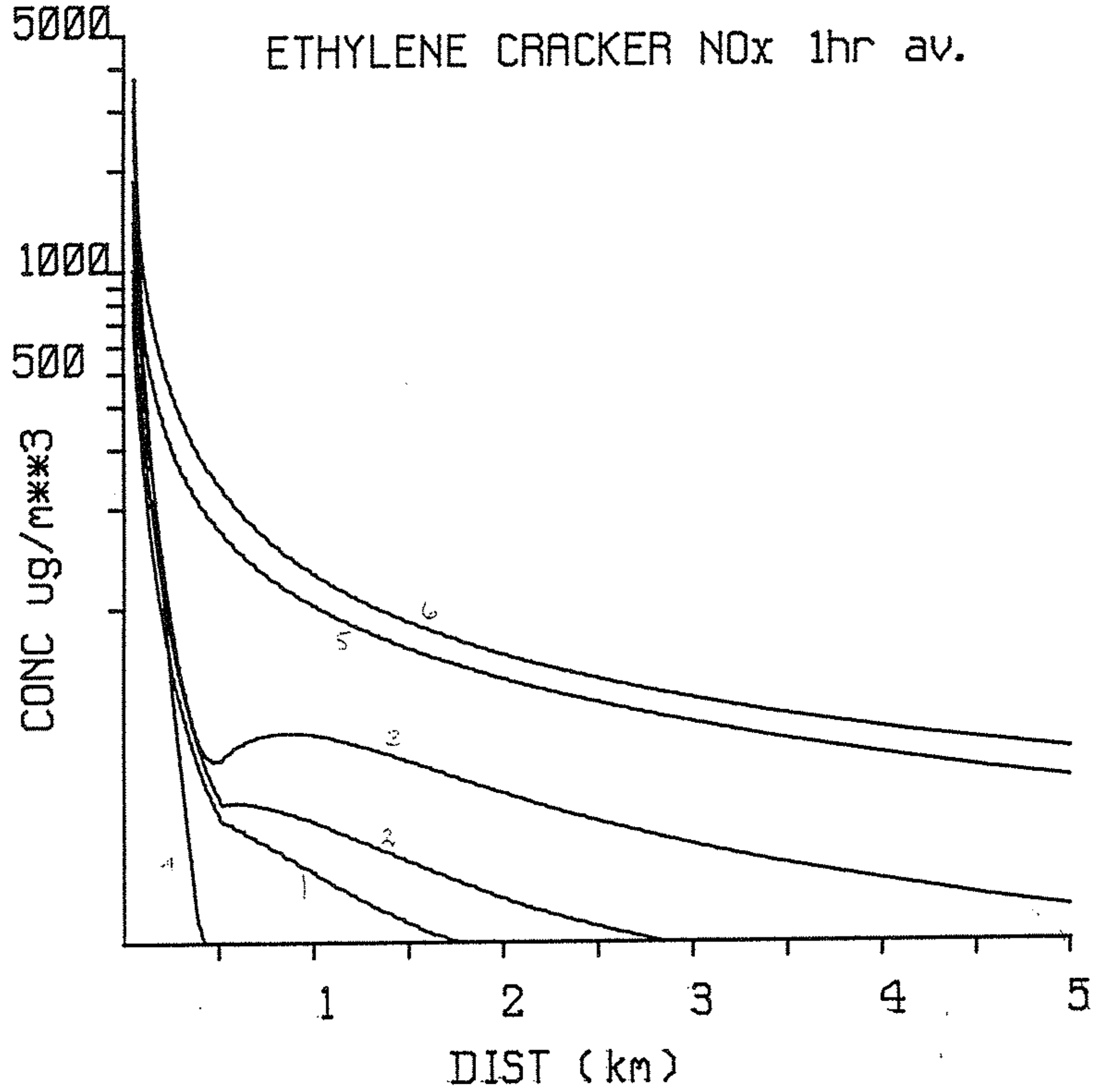
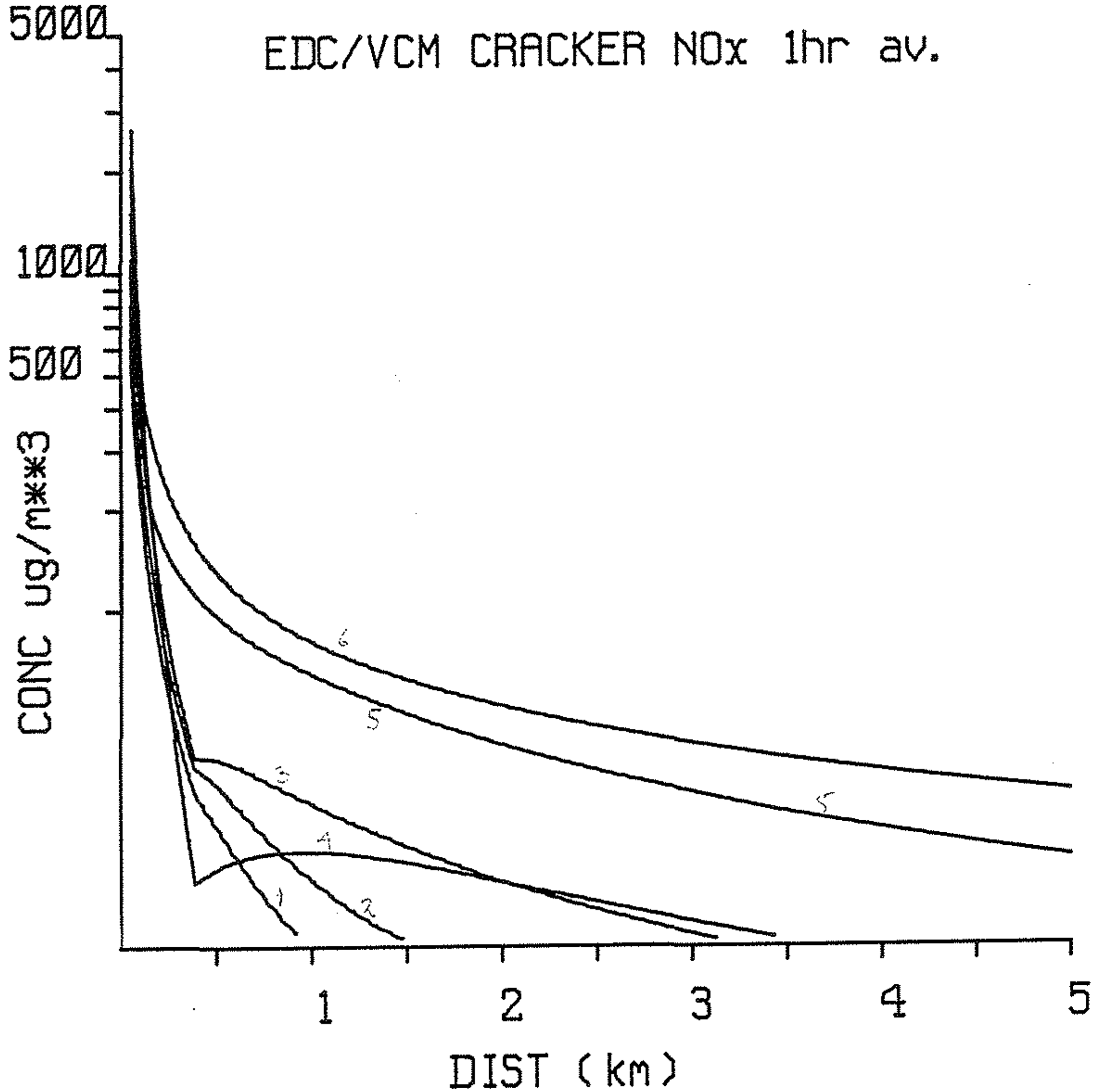
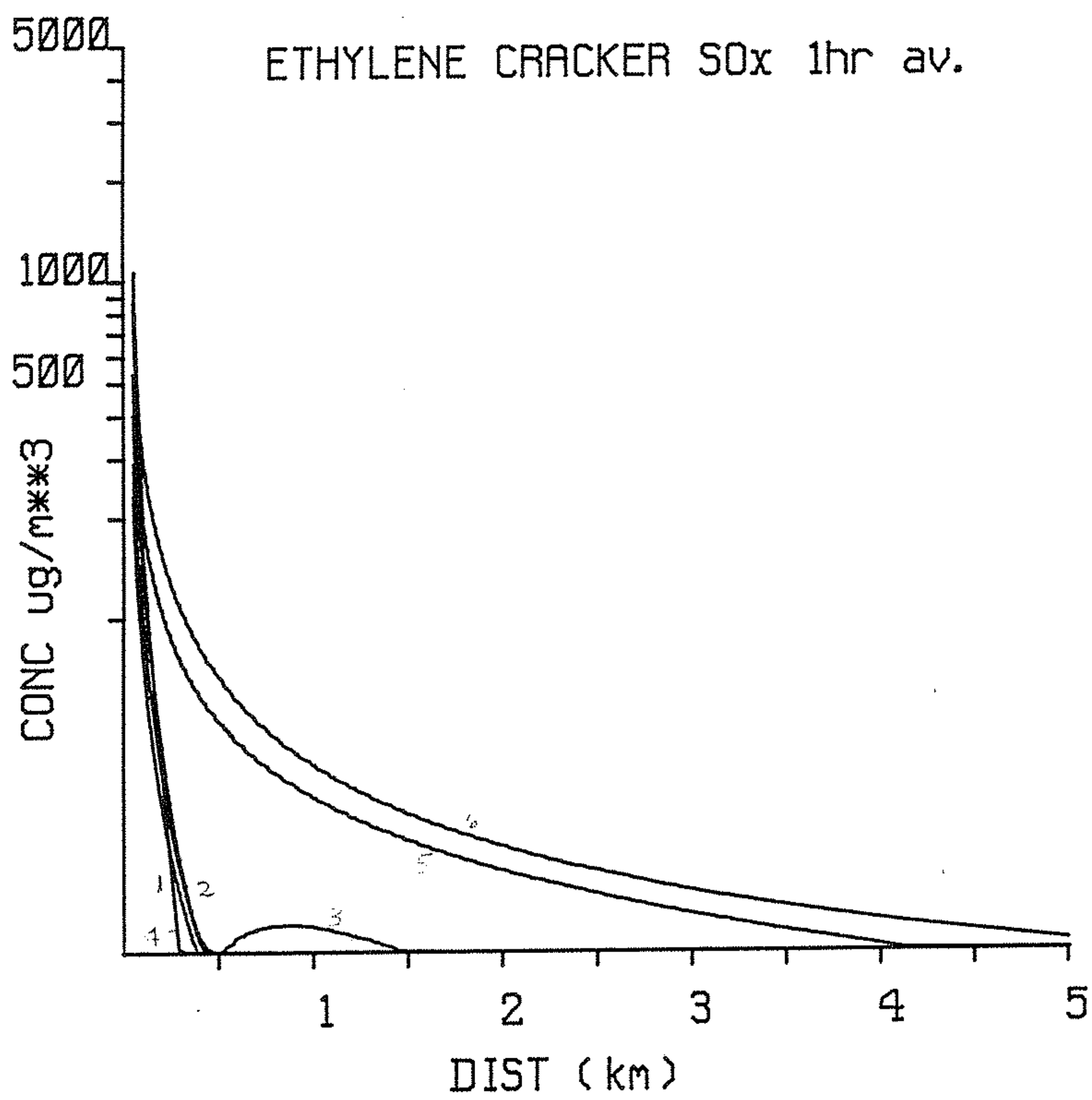

ETHYLENE CRACKER NOx 1hr av.
5000
1000
500
CONC ug/m**3
1
2
3
4
5
6
1
2
3
4
5
DIST (km)

FIGURE 5

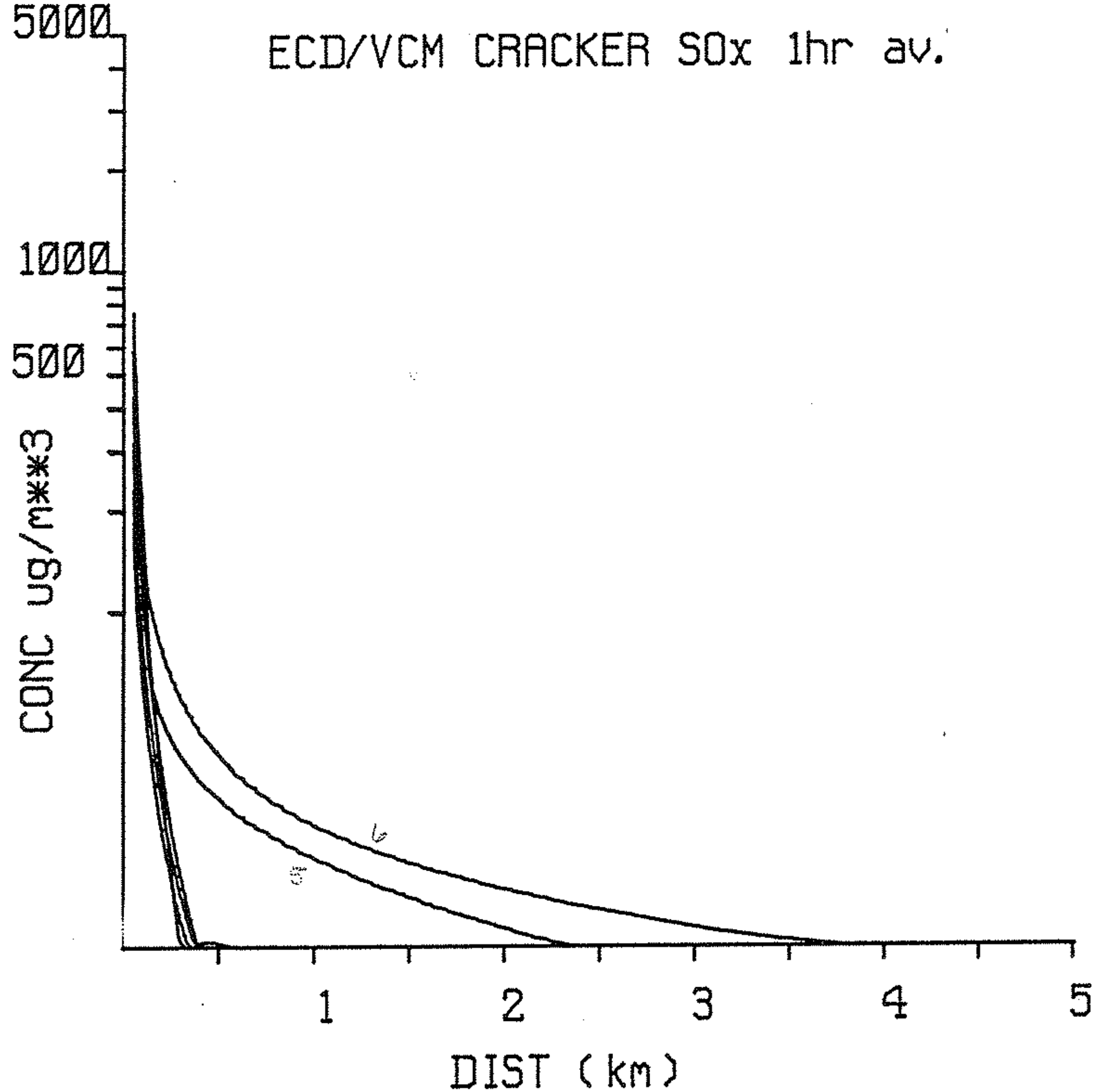


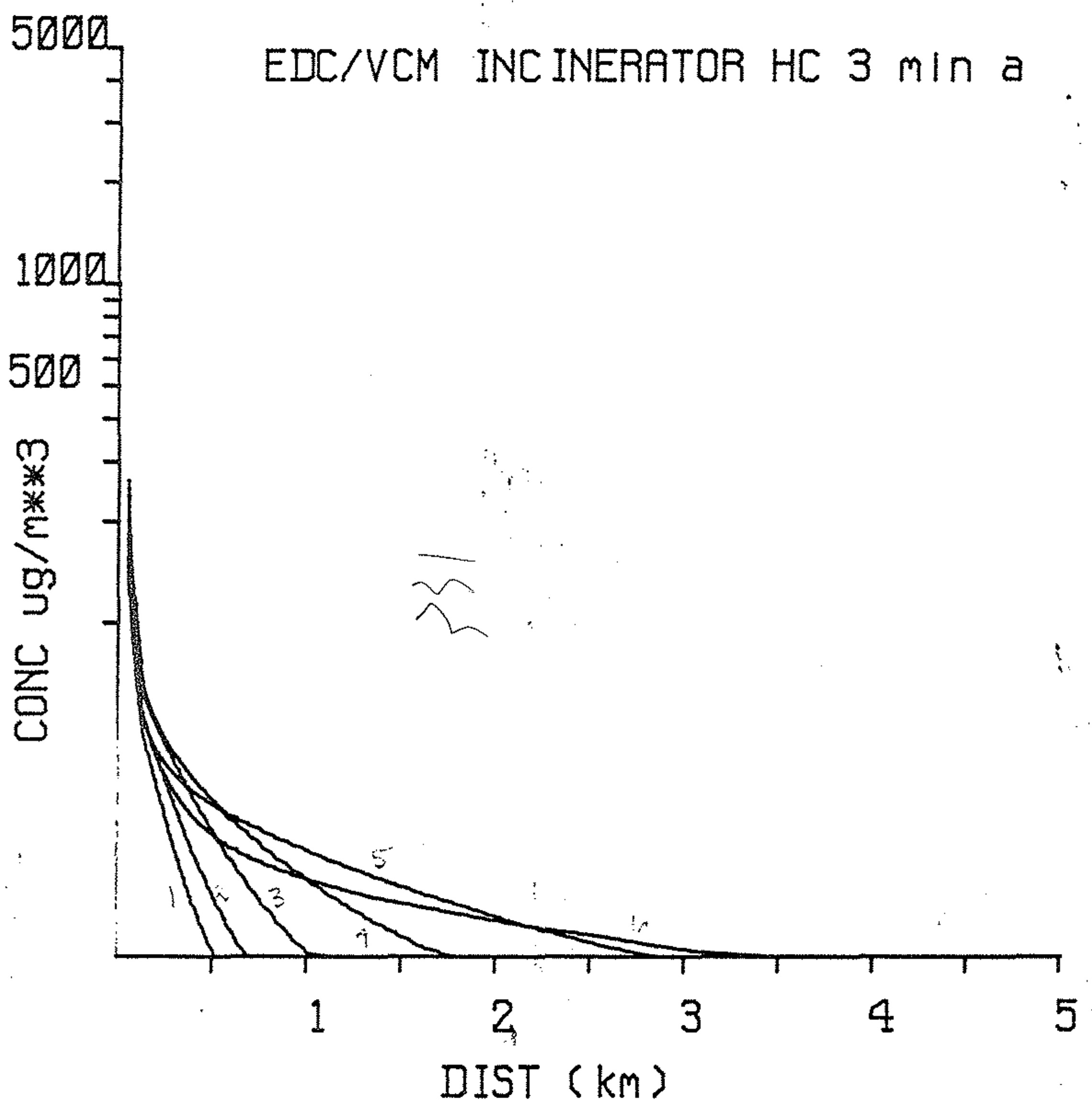
EDC/VCM CRACKER NOx 1hr av.
CONC ug/m**3
5000
1000
500
1
2
3
4
5
6
DIST (km)



ETHYLENE CRACKER SOx 1hr av.
5000
1000
500
CONC ug/m**3
1
2
3
4
5
DIST (km)

FIGURE 4


ECD/VCM CRACKER SOx 1hr av.
CONC ug/m**3
5000
1000
500
DIST (km)
1
2
3
4
5
6
5


EDC/VCM INCINERATOR HC 3 min a
5000
1000
500
CONC ug/m**3
1
2
3
4
5
DIST (km)
331