BOTANY EXPANSION STAGE II

ENVIRONMENTAL IMPACT STATEMENT

ICI Australia Limited

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16-20 Beauchamp Road Matraville NSW 2036

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BOTANY EXPANSION STAGE II. EIS / INDUSTRIAL PLANTS
- POLYETHYLENE

~~Desmond Navaratnam~~ 22 SEP 199 951980

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Chapter 1 SUMMARY

1.1 INTRODUCTION

ICI Australia Limited (ICI) commenced operations on its site at Botany, New South Wales, in 1942. Over the ensuing 37 years there have been a series of expansions to supply the growing Australian demand for a variety of chemicals. The site now contains an integrated petrochemicals manufacturing complex.

In 1977 ICI published a long term redevelopment and expansion plan[1] for its Botany site. Stage I of this plan involved the construction of a polypropylene plastic resin plant, for which approval was obtained in January 1978. This plant is due to commence commercial production later in 1979. The 1977 expansion plan gave details of future stages of development on the Botany site, including expansion of the company's ethylene, ethylene oxide and polythene manufacture (Stage II).

In approving ICI's proposal for construction of the polypropylene plant, the New South Wales Planning and Environment Commission (PEC) also noted that, were ICI to proceed with Stage II then a further Environmental Impact Statement (EIS) would be required. In February 1979 ICI announced its intention to proceed with Stage II, subject to securing the necessary planning and environmental approvals. This EIS has been prepared to accompany ICI's Development Application to the PEC and the Botany Municipal Council for approval of Stage II.

The Stage II ethylene plant will be implemented on a 'design and construct' basis. The tenderer selected by ICI will be required to first design the plant to meet operational, safety and environmental performance specifications set by ICI, and then to construct the plant after ICI's acceptance of the design.

However, the 'design and construct' contract cannot be let until after development approval has been obtained. This means that, while final details of plant layout are not available when a Development Application is made, any conditions of approval will be incorporated into the final plant specification. Thus preparation of a Development Application and accompanying EIS represents only the first of a series of approvals that must be obtained for any new plant. Separate approvals must be obtained from the State Pollution Control Commission (SPCC) in relation to noise or any discharges to air or water, from the Department of Industrial Relations and Technology in relation to vessels containing liquids or gases at pressure, from the Botany Municipal Council for permission to build, and from a number of other authorities.

1.2 COMPANY PROPOSALS

ICI's basic proposal is to expand production of polythene and the range of ethylene oxide chemicals. This in turn requires a substantial increase in ICI's production of ethylene, the basic raw material used in the manufacture of polythene, polyvinylchloride (PVC), ethylene oxide and its derivative chemicals.[2] Chapter 2 provides a detailed explanation of ICI's need to expand its operations at Botany.

1 ICI Australia Limited. *Polypropylene Plant Environment Impact Statement*, August 1977. Pages 22-24 of the 1977 report describe the overall expansion plan and are reproduced in full in Appendix 1 to this EIS.

2 Appendix 6 is a Glossary of Terms

Major elements of the proposed expansion are:

1 Construction of an ethylene plant to produce high purity ethylene and propylene. The capacity of this ethylene plant will be 250,000 tonnes per annum (tpa). The existing ethylene plant will be placed on standby after the new plant has been commissioned.
2 Expansion of the existing ethylene oxide plant and construction of new facilities for production of ethylene oxide derivatives.
3 Construction of a new low density polythene plant.

These works will be accompanied by a proportionate extension of existing boiler plant and other site services. Landscaping, already commenced, will be further extended.

All of the proposed plants will use established technology and will incorporate the design and operational experience of comparable plants recently constructed elsewhere throughout the world. Detailed descriptions of the proposed plants are given in Chapter 3.

Subject to obtaining planning and environmental approvals, ICI is planning to bring the ethylene and ethylene oxide plants and the polythene plant into production in 1983.

1.3 SAFETY CONSIDERATIONS

The siting, layout, detailed design and day-to-day operations of the proposed plants will incorporate a systematic consideration of all aspects of safety in order to minimize any risk of injury to the public or employees. In the unlikely event of a hazardous incident occurring, the risk of injury to the public or employees and the likelihood of an incident at one plant triggering incidents at nearby plants or properties will be minimized.

Chapter 4 contains a detailed explanation of the safety design and operating procedures adopted by ICI and proposed for the new plants.

1.4 SUMMARY OF ENVIRONMENTAL EFFECTS

Atmospheric Emissions (Chapter 5)

Stage II will involve substantial increases in the production of ethylene and ethylene derivatives. However, losses of hydrocarbons to the atmosphere will remain at their 1977 levels. This containment of hydrocarbon emissions to 1977 levels is being achieved by improvements in existing plants, and by the use of more efficient technology in the proposed plants. There will be some increase in emissions of nitrogen oxides and sulphur dioxide.

Noise (Chapter 6)

The acoustic assessment of Stage II has indicated that its noise contribution in adjacent residential properties will not exceed 40dB(A). The overall level of noise emission from the site is predicted to be 50dB(A) in adjacent residential properties.

Liquid and Solid Waste (Chapter 7)

The plants will generate relatively small quantities of process waste. This will include chemical effluent, cooling tower blow down and process drainage. It will be treated on site to standards established by the Metropolitan Water Sewerage and Drainage Board (MWS&DB) prior to discharge into the Board's sewerage system. Contaminated stormwater runoff will be treated in a manner acceptable to the relevant authorities. Very small quantities of solid waste will be created and this will be disposed of in an approved manner.

Transport (Chapter 8)

At present, on-site car parking is provided for all employees. Additional car parking will be provided for the Stage II construction workforce and for the additional permanent on-site workforce required on commissioning of the Stage II plants. In the context of existing traffic levels on roads bounding the Botany site, the volume of traffic generated by the additional permanent workforce will be small.

When the Stage II plants are fully operational, the volume of raw materials and products transported in and out of the site by road will have increased by about 26%. ICI is investigating the possible use of direct rail transport to and from the site. However, as with private vehicle movements, the impact of the additional commercial traffic will be minor in comparison to existing levels of traffic on the main roads serving the Botany site.

Visual Effects (Chapter 9)

The proposed plants are generally located in the interior of the site and their visual impact will be minimal. The landscape improvement programme commenced in 1978 will be continued for the Stage II plants.

Economic Impact (Chapter 10)

The Stage II expansion will create substantial new employment opportunities within the New South Wales construction industry over the period from 1980 to 1984. When operating, these plants will provide a significant number of new direct and indirect jobs in the Sydney region and will make a major contribution to the national balance of trade. The expansion programme at Botany will secure supplies of essential raw materials for other industries including the Australian plastics processing industry.

Approximately $400 million will be spent over a three and a half year period on construction of the Stage II plants. During this period an average of $91 million per annum will be injected into the Australian economy, most of it in N.S.W. The on-site construction workforce will average 750 workers over the construction period. This direct on-site employment will be supplemented by an average of 3200 persons employed directly and indirectly on design and equipment fabrication over the construction period.

On commissioning of the Stage II plants about 200 on site jobs will be created. More than 60% of these will be for unskilled workers, who will be trained by ICI. The multiplier effect of the operation of the Stage II plants will be high because of the considerable interdependence between firms in the chemical industry. Permanent indirect and induced jobs elsewhere in the Australian economy will be of the order of 350-400 new jobs.

Chapter 2 THE NEED TO EXPAND OPERATIONS

2.1 INTRODUCTION

ICI products are connected with almost every aspect of human activity — food, clothing, health and housing, business and leisure — and include industrial, agricultural and gardening chemicals, plastics, synthetic fibres, pigments, paints, pharmaceuticals, fertilisers and commercial explosives. Many ICI products have become household names: 'Terylene' fibres and yarns, 'Dulux' paints and 'Savlon' antiseptics. More generally a wide range of ICI products are basic raw materials for many manufacturing processes in Australian industry. The names of some of the more important chemicals at ICI's Botany site and their end uses include:

Typical ICI Products	**Typical End Uses**
Chlorine	Paper, water purification
Sodium Silicates	Soap and detergents
Caustic Soda	Alumina, soaps, detergents
Soda Ash	Glass
'Perclean'	Dry cleaning
Carbon Tetrachloride	Aerosols and refrigerants
'Alkathene' polythene	Plastic bags, cable insulation
'Corvic' PVC polymers	Water pipe, electric wiring insulation
Polypropylene	Packaging, carpets, furniture
Brake Fluids	Automotive
'Teric' Surfactants	Detergents, wool scouring

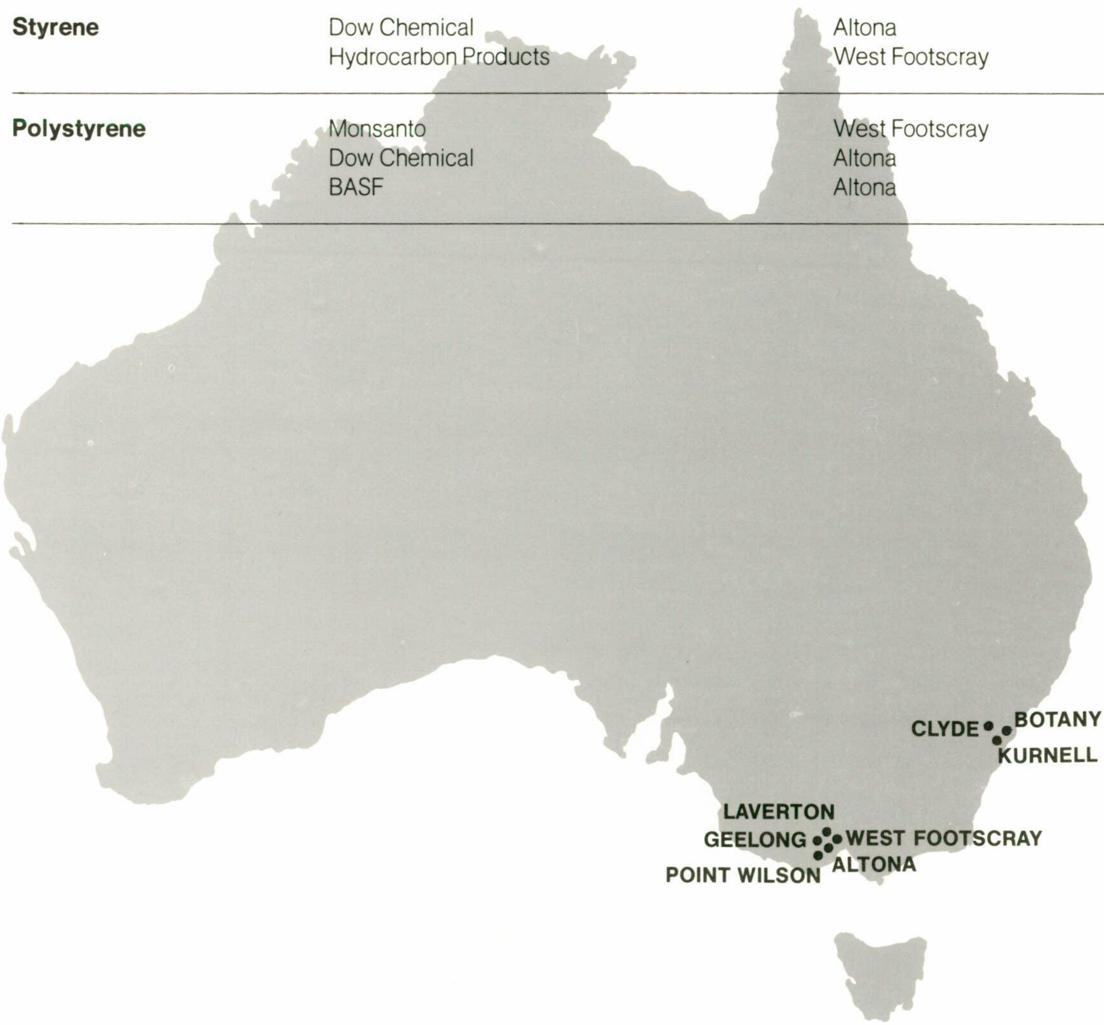
Petrochemical products meet fundamental needs in a modern industrial society and the demand for these products in Australia has been growing faster than the economy as a whole. In the period 1970 to 1978 average gross domestic production grew at about 3.6% per annum while the production of plastics grew at an average of 12% per annum. This demand arises not only from increases in population and income, but also from the substitution of petrochemical based products for many traditional materials. For example, plastics continue to replace traditional products in many domestic uses and are finding new uses as lightweight materials in the manufacture of automobiles and other consumer durables.

Per capita Australian consumption of low density polythene, polypropylene and ethylene oxide products is currently below levels in the United States and many European countries, and the Australian demand for ethylene, low density polythene and ethylene oxide products is already nearing the available Australian production capacity. By 1983 the demand for these products will be sufficient to justify new, economically sound production units. In both 1973/74 and again in 1979, as a direct result of global oil supply fluctuations, supplies of petrochemicals from overseas either increased greatly in price or were not readily available.

The total energy content of plastics is lower than alternative materials such as steel and aluminium, and increasing energy costs will support the trend to increased use of plastics.

The presence of local petrochemical production based on local raw materials ensures stability for important sectors of Australian industry, including plastics fabrication, automotive, paint, textiles and household goods; all significant employers of labour.

PRODUCT	MAJOR PRODUCERS	PLANT LOCATION
Ethylene	ICI Shell Chemical Altona Petrochemical Company	Botany Clyde Altona
Polythene	ICI Union Carbide Hoechst	Botany Altona Altona
Ethylene Oxide	ICI	Botany
Polypropylene	ICI Shell Chemical Hoechst	Botany { Clyde, Geelong } Altona
Vinyl Chloride	ICI B F Goodrich	Botany Altona
PVC	ICI B F Goodrich	{ Botany, Laverton } Altona
Styrene	Dow Chemical Hydrocarbon Products	Altona West Footscray
Polystyrene	Monsanto Dow Chemical BASF	West Footscray Altona Altona



1 MAJOR AUSTRALIAN PETROCHEMICAL PRODUCERS AND PLANT LOCATIONS

2.2 REGIONAL MARKETS

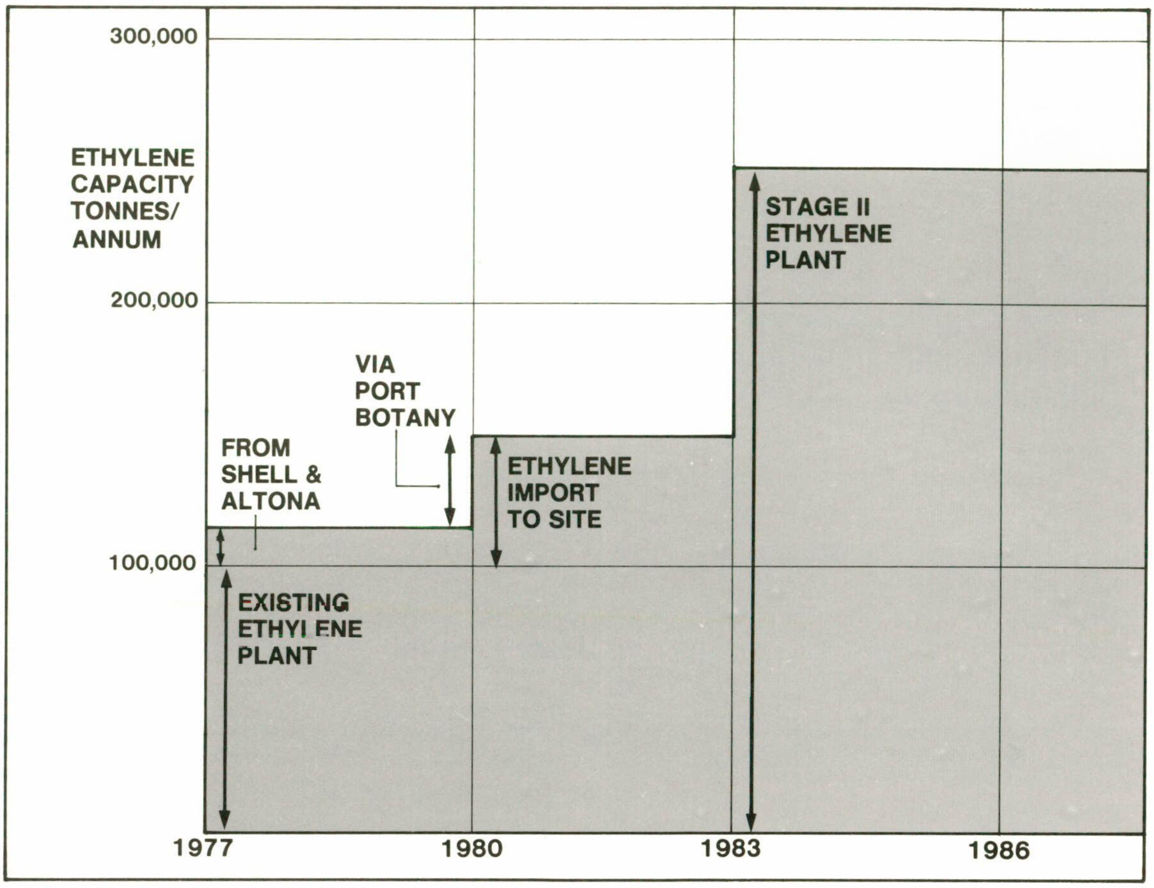
New South Wales and Victoria provide most of the Australian market for petrochemical products and it is in these two States that the major petrochemical complexes are located — at Botany-Kurnell-Clyde in New South Wales and Altona-Laverton-Geelong in Victoria. As Figure 1 illustrates, most Australian petrochemical manufacture is undertaken by companies whose plants and production capacity is split between the Botany-Kurnell-Clyde petrochemical complexes in New South Wales and the Altona-Laverton-Geelong complexes in Victoria. While there is some flow of materials between these two complexes, they basically serve local markets in Victoria and New South Wales.

2.3 INDUSTRY GROWTH

The Australian petrochemical industry is made complex by the national spread of markets. As a major Australian petrochemical manufacturer ICI recognises that its plans for expansion must be developed within the context of a national distribution of markets and the capacity and options of ICI's competitors. These plans involve the expansion of ethylene, polythene and ethylene oxide production at Botany with development of chlor alkali, ethylene dichloride and vinyl chloride monomer production at its Point Wilson site and polyvinyl chloride at its Laverton site, both in Victoria.

ICI's plan has the advantage of meeting the growing shortfall in ethylene, polythene and ethylene oxide manufacturing capacity in New South Wales. Were ICI not to proceed with construction of additional manufacturing capacity at Botany, growth in demand for ethylene in New South Wales in the next 10 years could lead to substantial shortfall. It would not be economical to build a new ethylene plant elsewhere in New South Wales and the high cost of interstate ethylene transport would make supply to Sydney from interstate economically impracticable. The alternative would be substantial imports from abroad.

As a transitional step, ICI intends to import ethylene by ship to cater for demand on Botany site above the present installed capacity so that a greater proportion of the larger plant's capacity will be utilized when it comes into production in 1983, as illustrated in Figure 2.



2 ETHYLENE AVAILABILITY

While importing of ethylene is a practical and economical arrangement for limited periods and quantities it does not offer a basis for long term expansion. There are uncertainties in the availability and cost of overseas supplies in the time period which must be considered for major expansion of ethylene consuming plants.

As will be evident from the discussion in Chapter 3, the operation of a modern petrochemical complex is highly integrated. It is not practicable to develop single purpose plants in geographic isolation from other plants. Most plants require interconnection by pipeline to other related plants providing feedstock or manufacturing downstream products. Major petrochemical complexes are therefore developed on a single site or, where several manufacturers are involved, on separate but closely linked sites.

2.4 MAIN ELEMENTS OF EXPANSION AT BOTANY

ICI's overall plan for expansion comprises:

EXPANSION PRIOR TO STAGE II

- A polypropylene plastic resin plant.
- An ethylene import terminal at Port Botany.
- A minor expansion of the existing low density polythene and ethylene oxide plants to meet market demand before further ethylene derivatives capacity can be constructed.

STAGE II EXPANSION

- An ethylene plant of 250,000 tonnes per annum capacity to replace the present plant, which will be placed on standby.

- Further expansion and upgrading of the low density polythene, ethylene oxide and derivatives capacity.
- Provision of Number 4 boiler and extension of other services.
- Installation of an LPG receiving and storage facility at Port Botany.

STAGE III EXPANSION

- Extension to the first stage of the polypropylene plant.

Approval for the Stage I polypropylene plant was granted in January 1978, subject to a number of conditions (see Appendix 2). The plant will commence commercial production in 1979.

The ethylene import terminal at Botany was approved in 1978, is presently under construction and is expected to be completed in 1980.

The Development Application for the minor expansion of the existing low density polythene and ethylene oxide plants was lodged in March 1979 and approval was granted in July 1979 (see Appendix 3).

Chapter 3 describes the Stage II proposals which are the subject of this E I S.

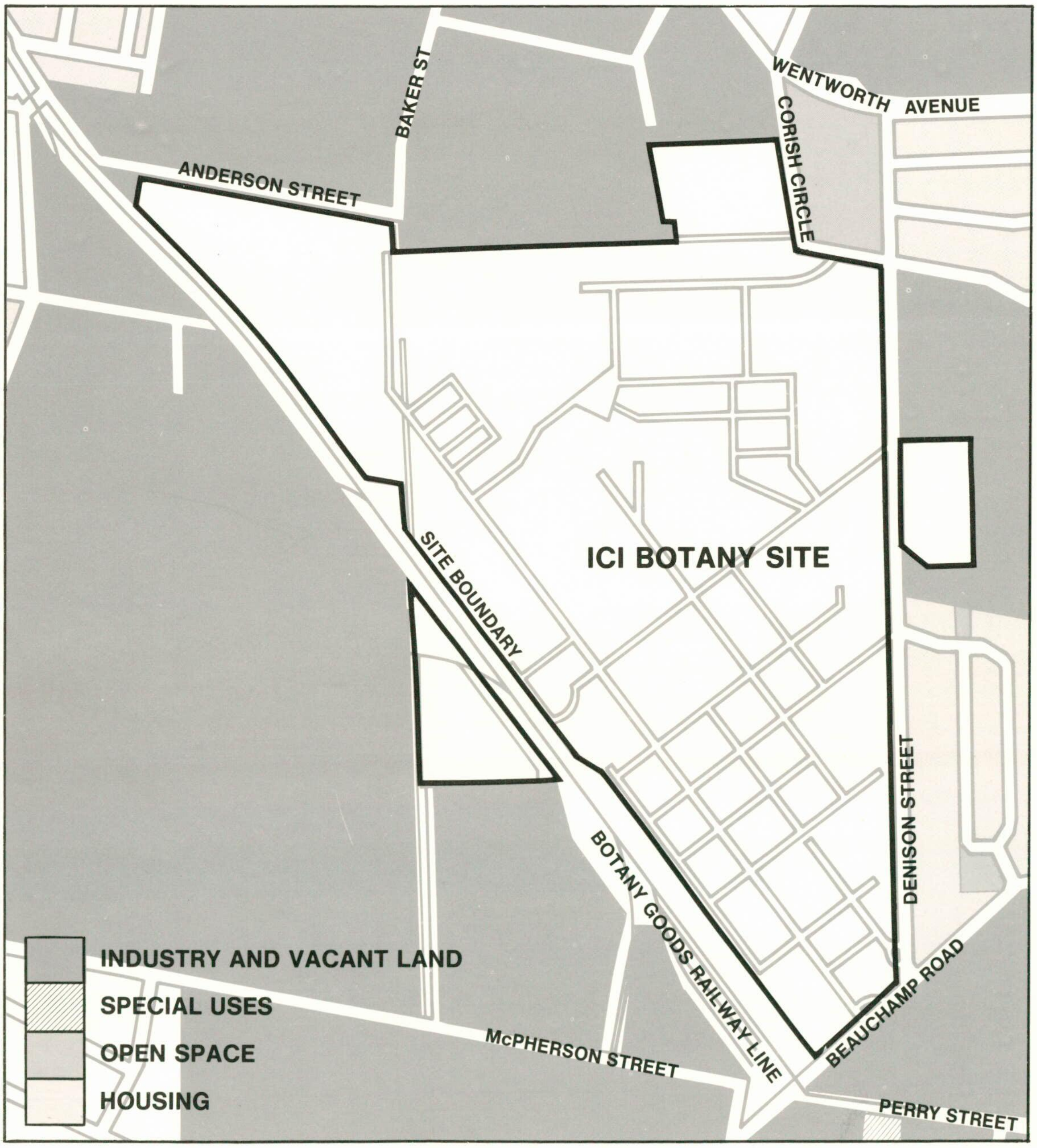
PROPOSALS

Chapter 3 THE PROPOSAL

3.1 INTRODUCTION

ICI's 73 hectare site at Botany is an integrated chemical complex. The site itself contains a number of functionally related petrochemical manufacturing processes and is linked to other plants at Clyde, Rhodes, Matraville and Kurnell. Feedstocks and products flow between these plants. The site is served by existing major roads, a rail line, feedstock and product pipelines, power and water supply. It also has direct road and pipeline access to the new port now being developed in Botany Bay.

ICI's site is located at almost the centre of the Botany central industrial area. Heavy and light industrial development or vacant land zoned industrial surround the greater part of the site (Figure 3) and adjacent or near neighbouring industries include Esso, Amoco, Caltex, Golden



3 ICI BOTANY SITE AND ADJACENT LAND USES

Fleece, BP, Kelloggs and Johnson and Johnson. Light industrial uses near or adjacent to ICI's site include engineering, auto repair, electrical and printing works and warehousing. In addition to this industrial development there are considerable areas of vacant land.

ICI's site has a perimeter of approximately five kilometres. At the southern end of Denison Street residential development abuts the site for 500 metres. As Figure 3 illustrates there are other residential areas at varying distances from the site.

Development of Botany site began in 1942 with construction of a plant to produce carbon bisulphide for defence purposes. The site was selected for chemical manufacture, principally because the area was at that time sparsely settled. Other important factors were a slightly better labour situation, given the manpower shortage during the war, than in the south to south eastern or industrialised western suburbs and a reliable subsidiary water supply (the Botany bore water basin). Other key dates in the development of the Botany site are:

1944 Commencement of chlorine and caustic soda production, followed by chlorinated solvents, rubber chemicals, rural products and formaldehyde.

1950 Commencement of manufacture of polyvinyl chloride (PVC) in Australia's first PVC plant.

1957 Commencement of production of polythene in Australia's first polythene plant.

1963 Commencement of the production of carbon tetrachloride and perchlorethylene.

1964 Commencement of production of ammonia, ammonium nitrate, nitric acid, urea and ethylene oxide and derivative products.

1966 Commencement of production of vinyl chloride monomer from ethylene and commissioning of a new boiler station.

1967 Commissioning of the existing ethylene plant.

1970 Commencement of production of soda ash.

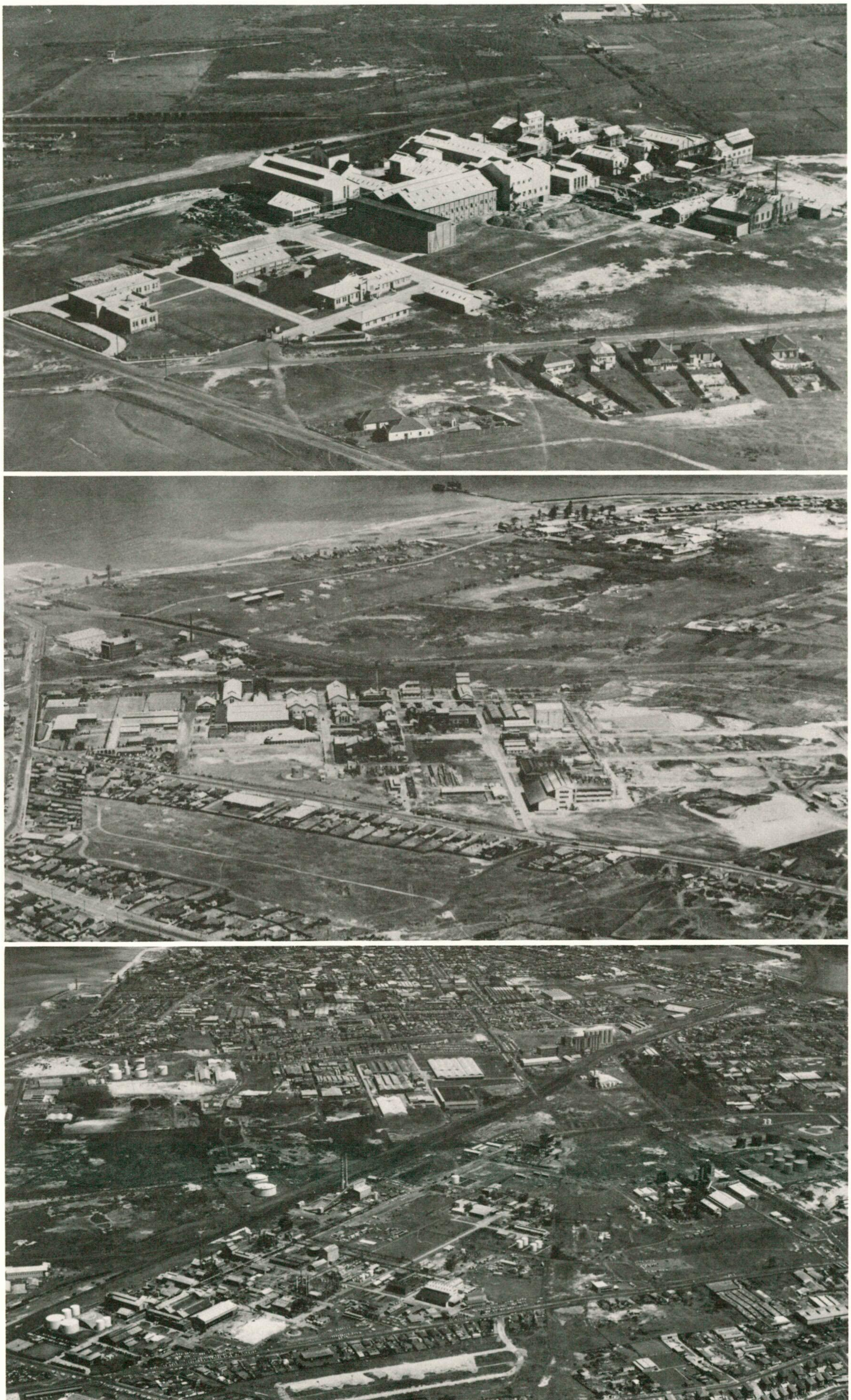
1971 Capacity of ethylene oxide plant increased.

1976 Commissioning of a multi-purpose plant to produce speciality chemicals for the detergent, food processing and pharmaceutical industries based on ethylene oxide derivatives.

1977 Commissioning of a new silicates plant.

1979 Completion of construction of the polypropylene plant, Number 3 boiler and a ground flare for the existing ethylene plant.

Figure 4 shows the Botany site at various stages of development: 1945, 1955 and 1966.

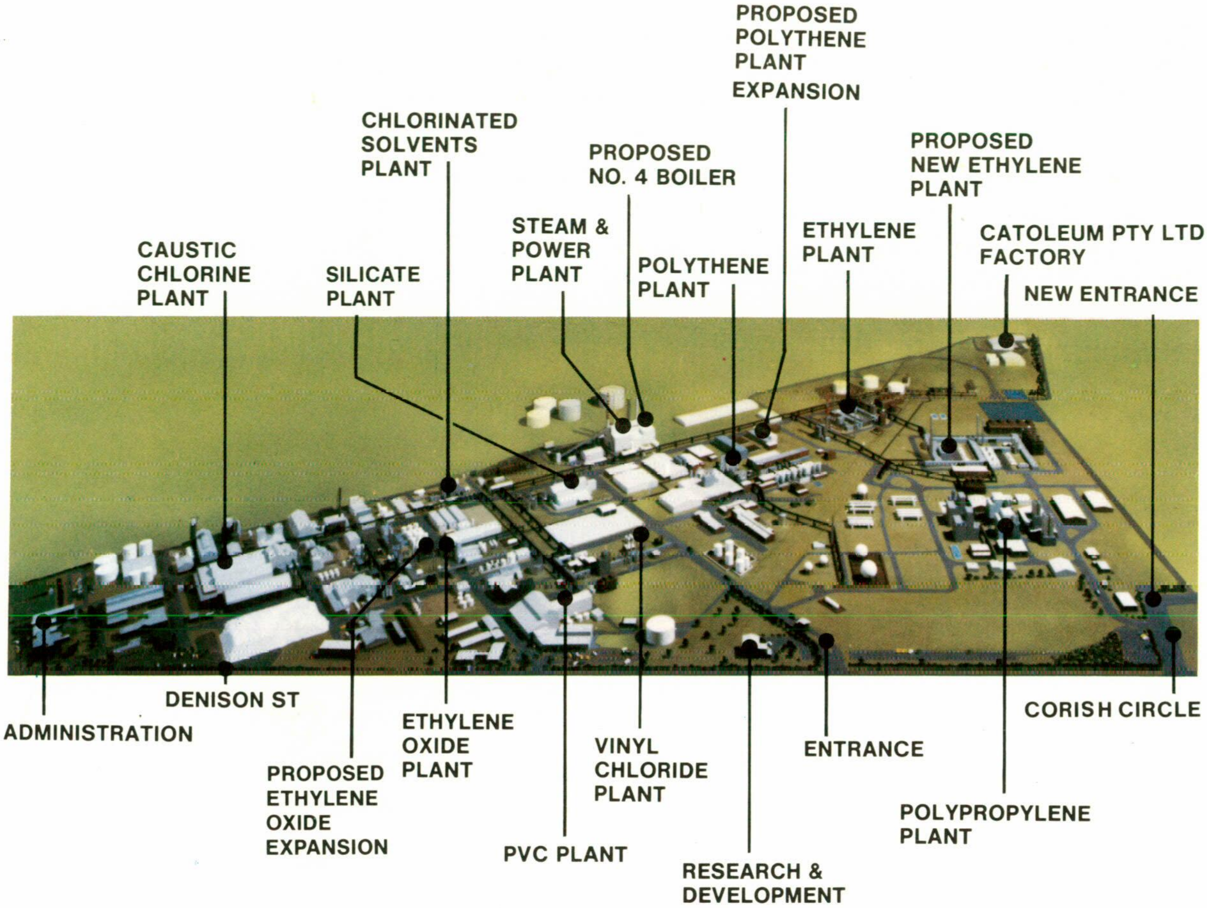


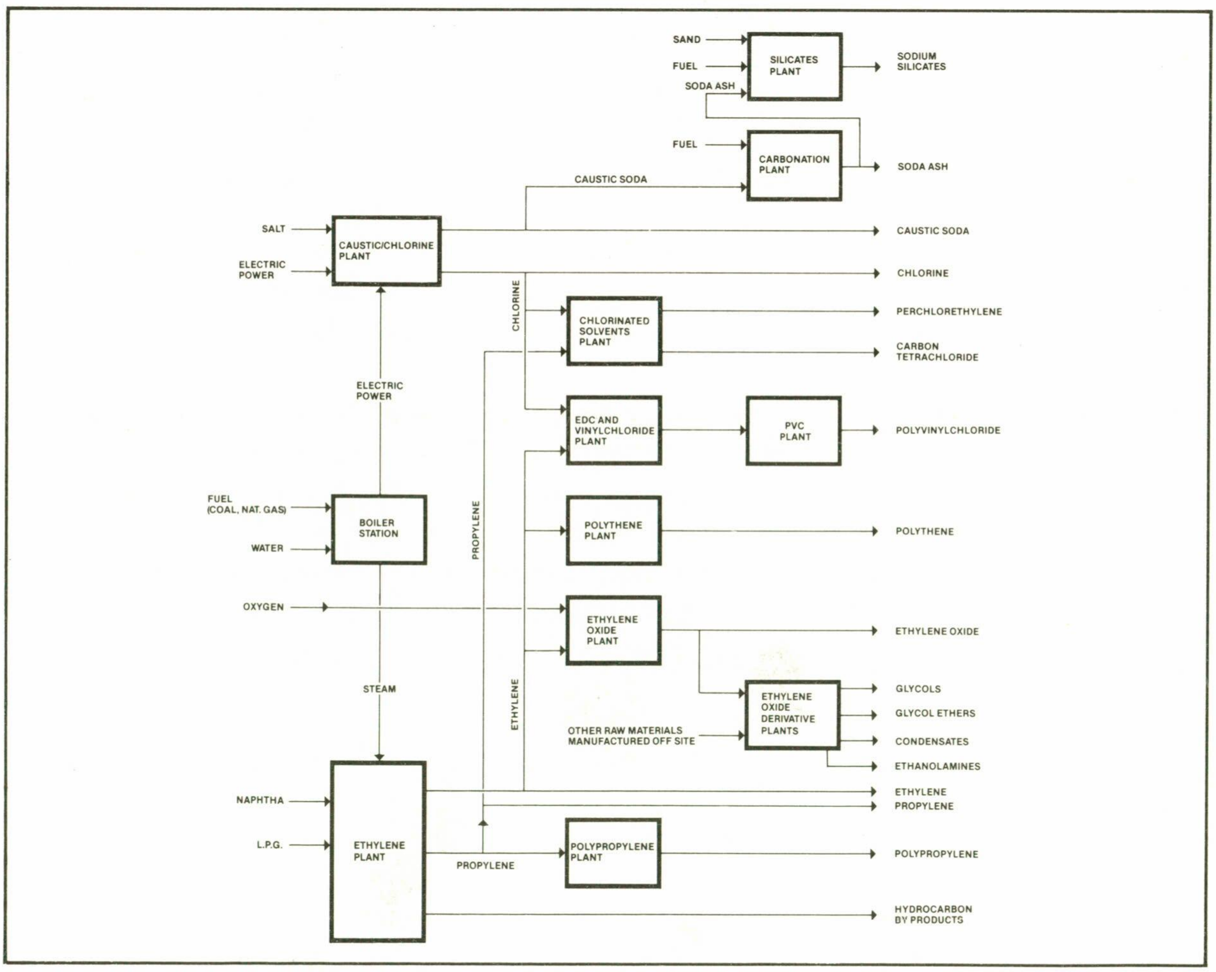
1945

1955

1966

4 STAGES OF DEVELOPMENT AT BOTANY: 1945, 1955, 1966





5 BOTANY SITE AND BASIC PRODUCTION PROCESSES

Some 50 basic chemicals are manufactured on the site. Figure 5 illustrates the highly integrated nature of the production processes on the site and the relatively few raw materials used in the manufacture of a wide range of chemical products.

From salt and electricity come the inorganic chemicals caustic soda and chlorine. Some of the chlorine production is combined with propylene and ethylene and other hydrocarbons to yield chemicals such as PVC, perchlorethylene and carbon tetrachloride. Some of the remaining chlorine is used to purify Sydney's water supply.

A proportion of the caustic soda is converted into various grades of sodium silicate and into soda ash and the rest is supplied to industrial users in solution or solid form.

Ethylene and propylene, along with other hydrocarbon byproducts, are made in the ethylene plant from naphtha. These chemicals are the raw materials for the production of polythene, ethylene oxide, polypropylene and a wide range of specialised products.

3.2 ELEMENTS OF THE EXPANSION

The main elements of Stage II are:

- An ethylene plant with a design capacity of 250,000 tonnes of ethylene per annum. This plant will produce high purity ethylene and propylene from hydrocarbon feedstocks by using the conventional process of steam cracking, followed by separation and purification of the products of cracking. The process will be similar to that used in the existing ethylene plant.
- Expansion of the existing ethylene oxide plant reaction section, together with the replacement of existing product separation and purification processes with more modern equipment of larger capacity. This will result in a capacity increase of approximately 70 per cent. The existing capacity of the ethylene oxide derivatives plants will be increased by the installation of additional units, similar to those already operating.
- A new low density polythene plant to operate in parallel with the existing polythene facilities.
- Elevated flaring and ground furnace facilities to handle waste gases from the new ethylene plant.
- Addition of a fourth boiler and demineralised water plant to the existing steam and power plant.
- Extension of services essential for the additions: power, steam, town and cooling water, fire water reticulation, instrument air, nitrogen and effluent treatment facilities.
- Construction of additional control rooms, laboratories, workshops, stores, office blocks, canteens, on-site car parks and other amenities as required.
- Modernisation of existing plant and equipment within the polythene and ethylene oxide plants to reduce hydrocarbon losses to the atmosphere.
- Extension of landscaping along the Denison Street, Corish Circle and Anderson Street frontages and in selected areas within the site.

Figure 6 is a photograph of a model of the site, showing the location and general form of the extensions described above.

3.3 FEEDSTOCKS AND PRODUCTS

The quantities of raw materials entering the Botany site annually and their mode of delivery are as shown on Table 1, together with the expected increases due to Stage II.

TABLE 1 **Feedstock**

Raw Material	Quantity per Annum (1979)	Present Method of Transport	Increase in Raw Materials Required for Stage II	Proposed Method of Transport for Additional Feedstocks for Stage II
Naphtha/LPG	300 000 tonnes	Pipeline	400 000 tonnes	Pipeline
Salt	130 000 tonnes	Road	N.A.	N.A.
Coal	92 000 tonnes	Road	50 000 tonnes	Road or Rail[1]
Power	53 megawatts	Underground Cable	18 megawatts	Underground Cable
Towns Water	3 600 megalitres	Pipeline	3 400 megalitres	Pipeline

1 For comment on the possible use of rail transport see Section 8.4

Other raw materials are used on the site in relatively small quantities, including a range of organic chemicals used in the ethylene oxide derivatives plants, chemical additives and water treatment chemicals. These are brought into the site by truck. Oxygen, used in the manufacture of ethylene oxide, is delivered by pipeline from an on-site oxygen plant owned and operated by Liquid Air Australia. If expansion of the storage facility for naphtha feedstock is required, the new tank would be located adjacent to the existing tanks on the west boundary of the Botany site.

A receival and storage facility will be required for LPG feedstock. This facility would be located at Port Botany in the area set aside by the Maritime Services Board for bulk liquids. The maximum quantity stored would be about 20,000 tonnes, probably in two tanks. A separate Development Application and Review of Environmental Factors for the LPG storage facility will be submitted to the appropriate authorities.

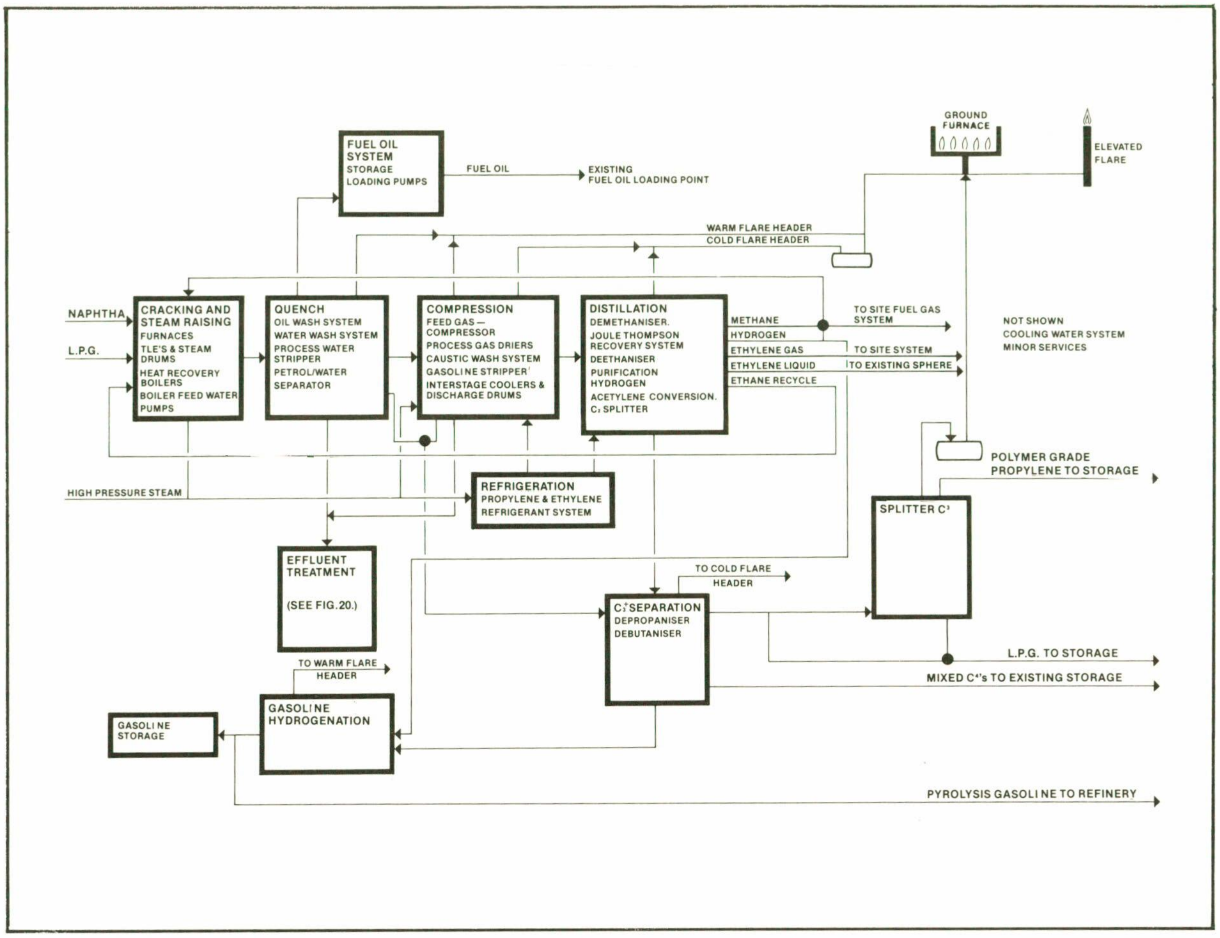
The major products exported from the Botany site are polythene, ethylene oxide derivatives, polypropylene, PVC, caustic soda, chlorine and chlorinated solvents. As a result of the Stage II expansion there will be increases in the quantities of polythene and ethylene oxide derivatives distributed from the site. These products will be transported by road, although the feasibility of rail transport is under investigation (Section 8.4).

3.4 ETHYLENE MANUFACTURING PROCESS

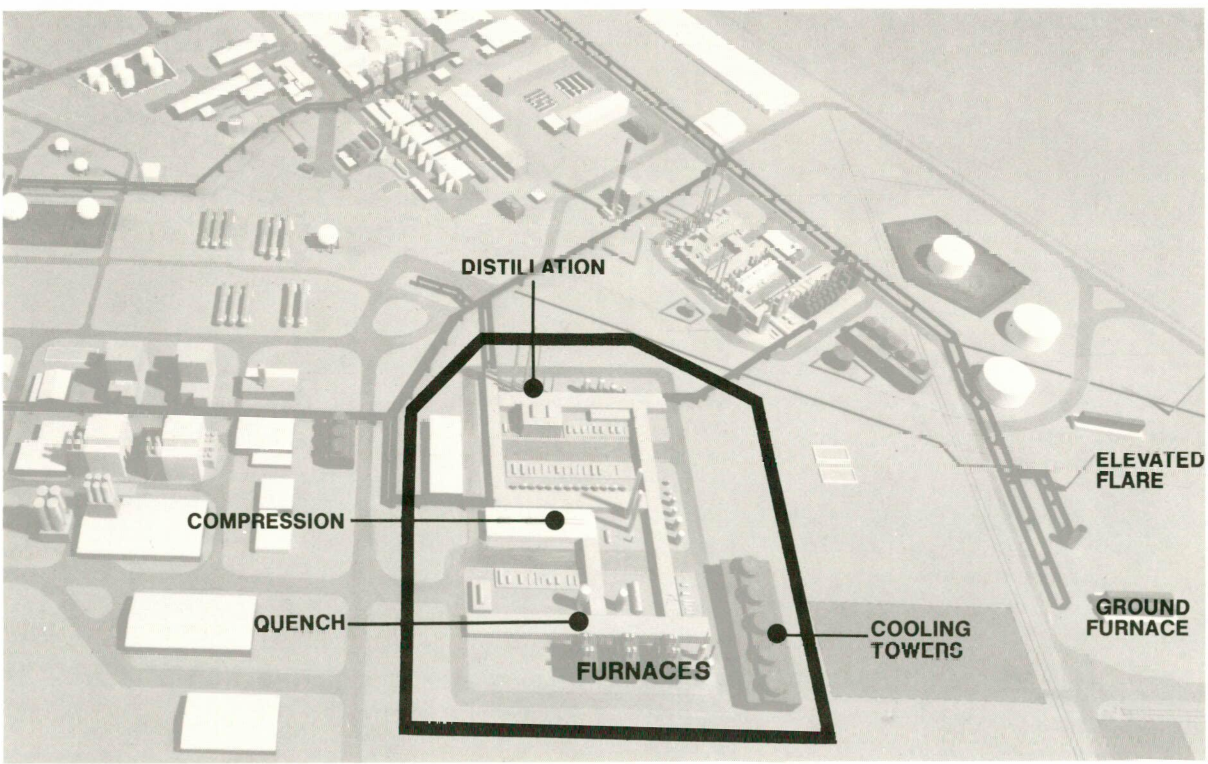
In the ethylene manufacturing process hydrocarbon feedstocks are cracked in the presence of steam in tubular pyrolysis furnaces to yield a mixture of ethylene, propylene, butadiene and petrol rich in aromatic components, together with fuel gas and fuel oil. The gases leaving the furnaces are rapidly cooled and quenched with circulating oil to remove fuel oil fractions. The final quench with water condenses gasoline range materials along with the dilution steam.

The condensed water is vaporised and recycled as dilution steam to the cracking furnaces. Uncondensed gases are caustic washed to remove acid gases and then compressed prior to cryogenic distillation to separate the various components of the cracked gas. Ethylene is recovered at 99.9+% purity and is suitable for use in the polythene and other ethylene derivatives plants. Propylene is recovered for later use in the polypropylene plant and the

6 PROPOSED STAGE II DEVELOPMENT



7 ETHYLENE PRODUCTION PROCESS AND MODEL OF PROPOSED ETHYLENE PLANT



remaining C3 and C4 hydrocarbons are supplied to customers. Crude gasoline will also be produced.

The new ethylene plant will be self-contained on the Botany site and will consist of four physically separate areas, all of which will be closely integrated in operation. These are:

- The cracking furnaces (consisting of a row of furnaces with sufficient spare capacity so that any one can be off line).
- Gas compressors.
- Gas separation areas (consisting of a series of distillation columns).
- Emergency waste gas disposal (consisting of an elevated flare, and a ground furnace).

In addition to the processing plant, there will be raw material and product storage areas, an office block, workshops, laboratory, central control room, a general amenities area and adjacent on-site car parking. Figure 7 is the general process diagram for ethylene manufacture, and a photograph illustrating the main elements of the proposed plant.

The ethylene produced by the plant is supplied direct to ethylene oxide, polythene, ethylene dichloride and vinyl chloride monomer (VCM) plants, with provision of a storage tank to accommodate fluctuations in supply and demand. No additional storage of ethylene on-site is proposed. The high purity propylene recovered in the process will be stored in horizontal pressure vessels both for supply to external users and for use in the manufacture of polypropylene. The fuel oil and pyrolysis gasoline byproducts will be stored in tanks on the site and distributed off-site either by road tanker or pipeline.

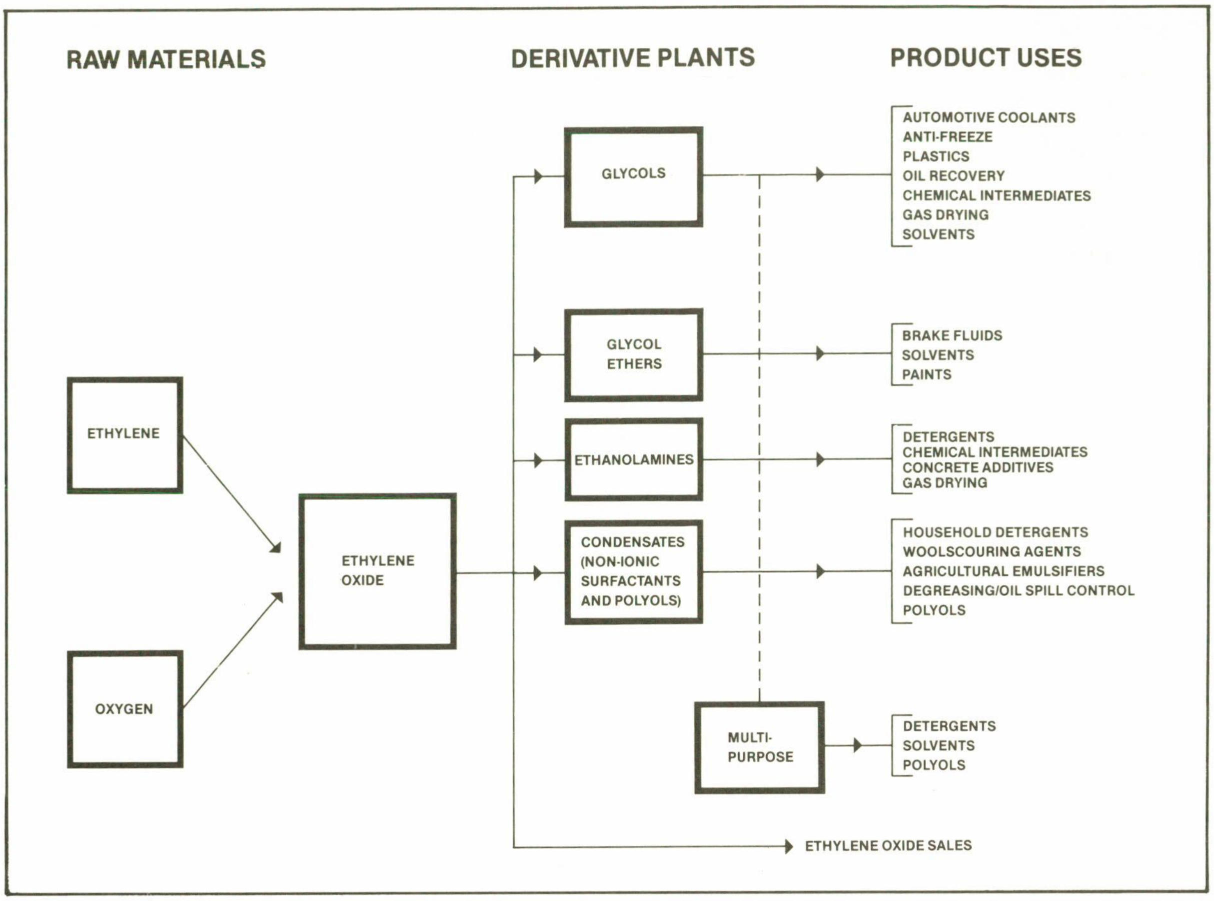
The ethylene manufacturing process proposed for the expansion utilises established technology currently in use in ethylene plants around the world. The ethylene plant proposed for Botany will include the most advanced design to ensure safety and environmental protection. This is discussed further in Chapters 4, 5, 6 and 7.

Elements of the existing ethylene plant, in particular the furnaces, may be used in the new plant. The remaining sections of the existing ethylene plant would be purged of residual products, decontaminated and placed on standby.

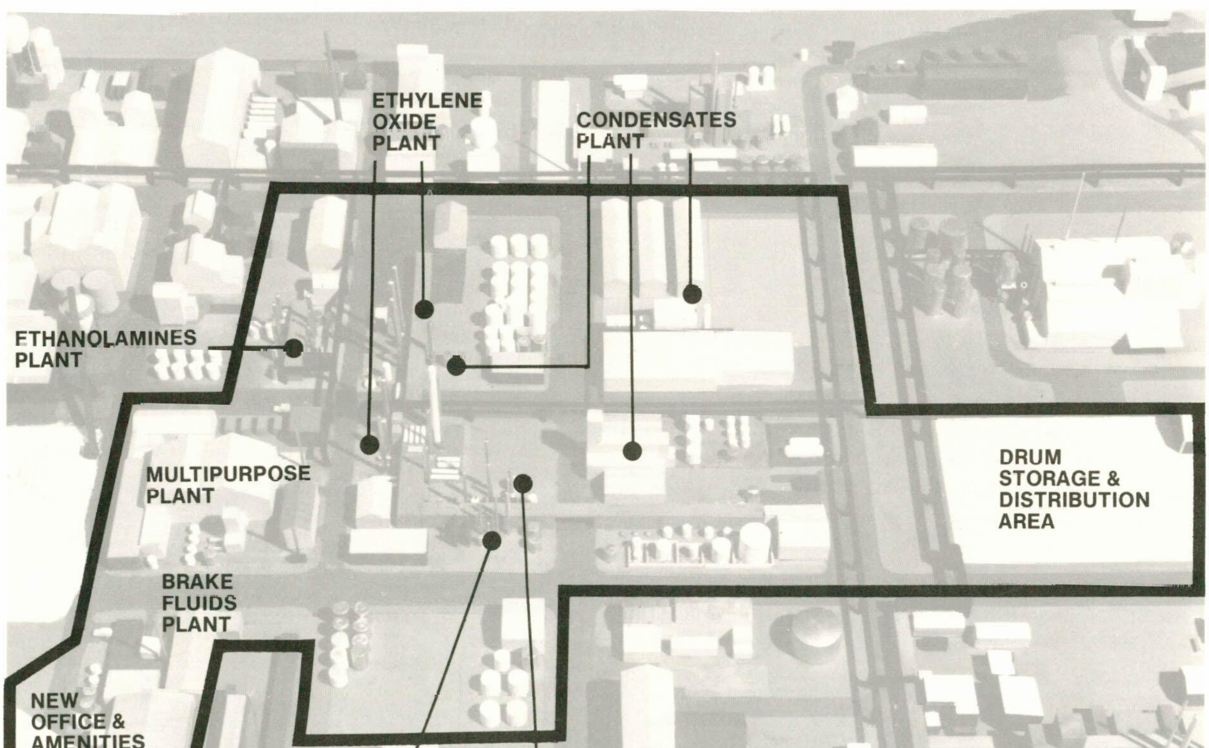
3.5 ETHYLENE OXIDE AND DERIVATIVES MANUFACTURING PROCESSES

Ethylene oxide is an easily liquefiable gas produced by the reaction of ethylene with oxygen. Ethylene oxide is stored in liquid form in refrigerated, pressurised, nitrogen blanketed storage tanks and is used as an intermediate in the manufacture of a wide variety of other chemicals on the Botany site or is supplied to external customers.

In the ethylene oxide manufacturing process, ethylene and oxygen are recycled at a pressure in the range 1500-2500kPa over a fixed catalyst in a tubular reactor. Ethylene oxide is formed in this process, together with carbon dioxide, which is recovered and then supplied to external customers. The reaction process also generates heat which is used to produce steam for production processes. Ethylene oxide and minor impurities are removed from the reactor outlet gases in water scrubbers. The remaining gas is then compressed and recycled to the reactor together with fresh ethylene and oxygen. The solution from the scrubbers is passed to a series of columns which successively remove water and other impurities to produce purified ethylene oxide which is pumped to storage tanks. From these storage tanks ethylene oxide is then pumped as a liquid to the various derivatives plants. These plants include:



8 ETHYLENE OXIDE AND DERIVATIVES PROCESSES



9 MODEL OF ETHYLENE OXIDE AND DERIVATIVES EXPANSION AREA

Glycol, Glycol Ethers and Ethanolamines Plants
In these plants ethylene oxide is reacted continuously with water, alcohol (methanol, ethanol or butanol) or ammonia, in tubular reactors to produce crude product mixtures. These mixtures are then separated into pure products in a series of distillation columns and are transferred to storage tanks. Glycols, glycol ethers and ethanolamines are used on-site in the manufacture of brake fluids and antifreeze and are used by other customers in the manufacture of paints, plastics and detergents.

Non-Ionic Surfactants Plant
Non-ionic surfactants (NIS) are produced in batch reactors from ethylene oxide and other raw materials including alkyl phenols, long-chain alcohols, fatty acids and amines and propylene oxide. Following reaction there is a series of finishing steps involving neutralisation, filtration and flaking. Non-ionic surfactants are then used in the manufacture of detergents, wool scouring agents, agricultural emulsifiers, degreasing agents and other products.

Multi-Purpose Plant
In this plant, glycol and glycol ether acetates are manufactured from glycols or glycol ethers and acetic acid and then purified by distillation. Polyols are manufactured by blending products made in the NIS plants with other raw materials. In addition, certain products are made by blending materials from the glycol, glycol ether and non-ionic surfactants plants. The products from this plant are used in solvents, plastics and detergents.

These processes are shown diagramatically in Figure 8.

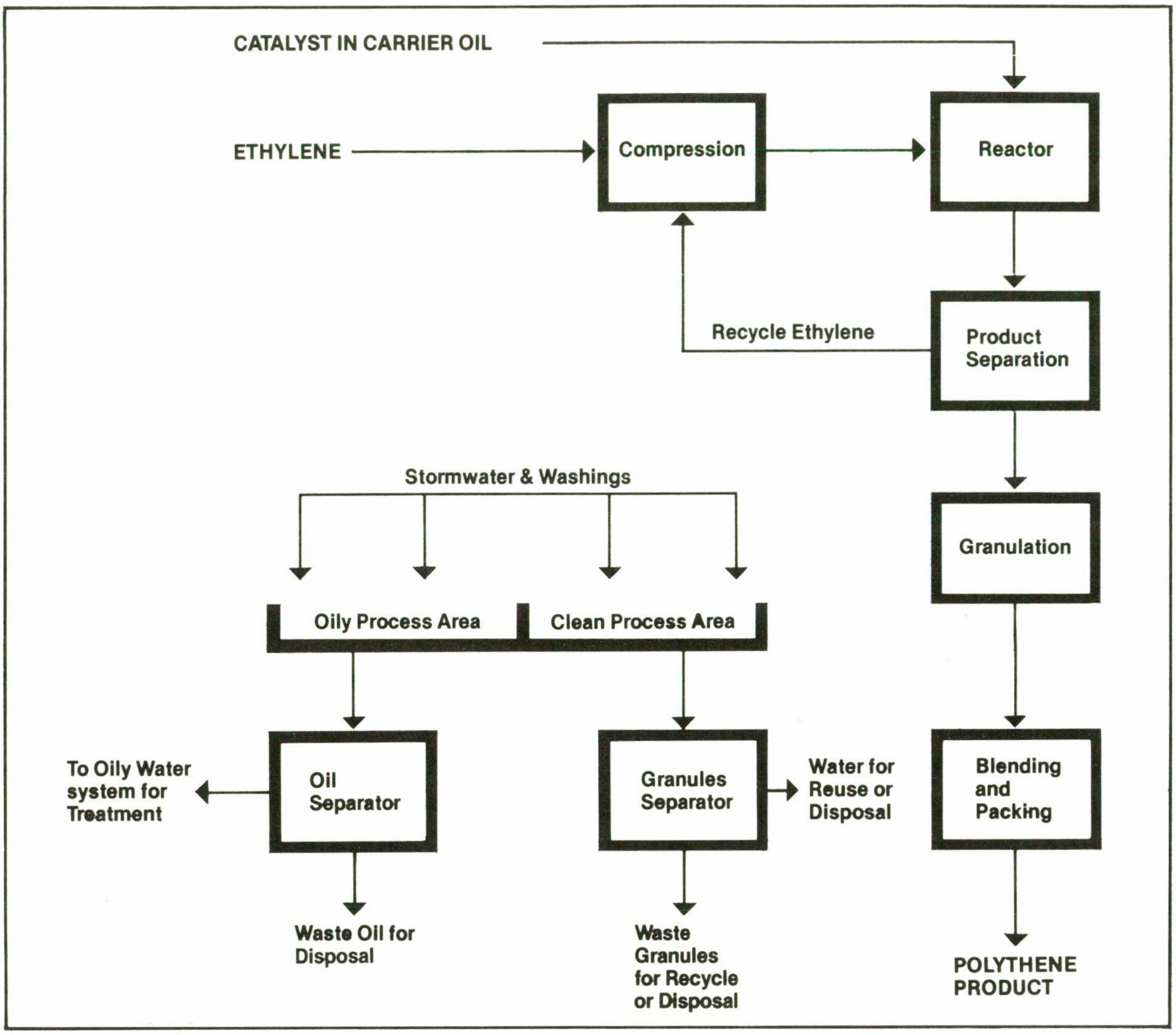
The ethylene oxide and derivatives processing plants comprise an assembly of columns and pressure vessels to a height of about 40 metres, linked by pumps and pipelines. There will be a control room containing instrumentation and micro-processor equipment, as well as workshops, a new office building, amenities block and associated landscaping. Figure 9 shows the location of the elements of the ethylene oxide and derivatives plants.

3.6 POLYTHENE MANUFACTURING PROCESS

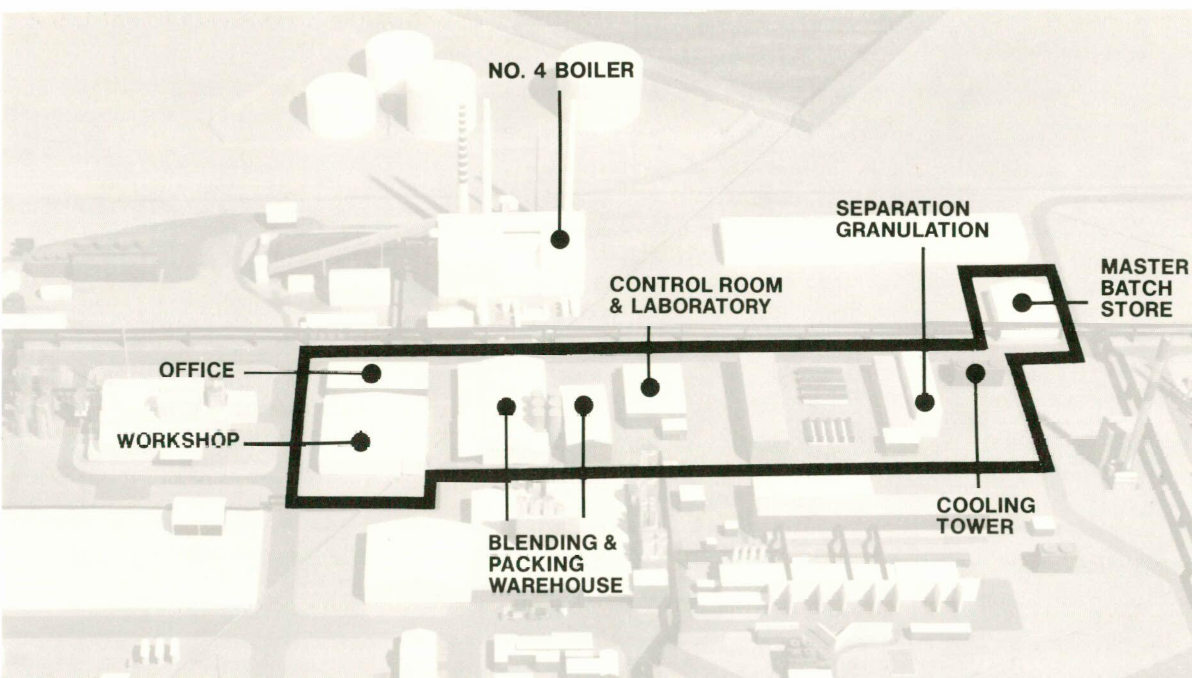
In the manufacture of polythene, ethylene is first compressed, then combined with recycled ethylene from the product separator (which is downstream in the process) and then further compressed. After cooling in a feed gas cooler, the gas enters a reactor located in a special protection bay. In this reactor temperature is controlled by the rate of injection of organic peroxide catalysts. A mixture of polymer melt and unreacted ethylene leaves the reactor through a pressure control valve and is cooled with water in a jacketed product cooler. The mixture then enters a separator in which polythene melt is separated from unreacted ethylene. The unreacted ethylene is cooled and recycled.

Polythene melt, containing some dissolved ethylene, flows from the separator into a hopper in which some further separation of ethylene from the melt occurs. This ethylene is recycled. Master batch containing various additives is injected by an extruder into the base of the hopper. The melt containing master batch is pumped by an extruder from the hopper into a pelletiser and granulated. An additive injection system also connected to the base of the hopper, allows for the addition of organic additives. Granulated polythene is hydraulically conveyed to a finishing area.

Gas from the hopper passes into a stock tank and separates from low molecular weight polymer and dissolved oil. The gas is then compressed by a booster compressor and joins the incoming fresh ethylene.



10 POLYTHENE PRODUCTION PROCESS



11 MODEL OF PROPOSED POLYTHENE PLANT AND NUMBER 4 BOILER

Following hydraulic conveying the granules are dried and stored in hoppers whose contents are periodically transferred to intermediate storage silos. The product is then conveyed into a pre-packing silo and fed by gravity to a packing line where it is automatically bagged in 25 kilogram sacks, palletised, shrink-wrapped and transported to the warehouse. Some polythene is also distributed from the site in bulk.

The polythene process uses well developed technology in which both safety design and environmental factors are major considerations. The reactor bay is shielded, while the reactor itself is protected against over pressure by bursting discs with water drenching apparatus to prevent aerial decompositions. Blow-offs, vents and outlets for relief devices throughout the polythene plant are connected to an atmospheric pressure gas holder to reduce emissions to the atmosphere. The details of waste treatment procedures are described in Chapters 5 and 7.

The polythene manufacturing process is illustrated in Figure 10 while Figure 11 shows the generalised layout for the polythene plant including the location of the main compressors, the reactor bay, granulation building and finishing area. In addition there will be an office block, canteen and amenities block, workshop and stores, warehouse, covered loading bay, control rooms and laboratory.

3.7 SERVICES

The services required to support the Botany site expansion include an extension to the steam generation facility. Steam is used basically for chemical processing and a pass-out type turbo alternator generates some electric power. It is envisaged that a fourth boiler will be required complete with its feedwater treatment plant. The boiler will be capable of generating approximately 90 tonnes of steam per hour.

If the boiler is coal fired, the existing coal handling facility will be extended to accommodate this. The existing surface coal storage of around 4000 tonnes would not need to be extended unless it were decided to receive coal by rail. A coal fired boiler stack would be similar to those on the existing coal fired boilers and would be of the same height, 66 metres.

The demineralised water plant would be an extension to that installed as part of the Number 3 Boiler project commissioned in June 1979.

SAFETY

Chapter 4 SAFETY

4.1 INTRODUCTION

Some of the processes described in Chapter 3 involve the use of liquids and gases which if not handled correctly can be dangerous. For this reason the safe design of these plants and the development of detailed safety management procedures are important factors. The record of ICI on Botany site over nearly 40 years has demonstrated that plant and equipment can be designed and maintained to minimise hazards and that employees can be trained and encouraged to work more and more safely, to recognise hazards and to remove or reduce them. ICI has been in the forefront of development of safety procedures in petrochemical plants and will continue to maintain a healthy and safe working environment and to define and teach safe working practices.

ICI has adopted a systematic approach to development of appropriate safety design and hazard management procedures. The objectives are to take all proper precautions so that in the unlikely event of a hazardous incident occurring the risk of injury to the public or employees is minimised, the likelihood of an incident at one plant triggering incidents at nearby plants or properties is eliminated and that there is negligible risk from events originating outside the site, such as fires or explosions in neighbouring factories.

To achieve these objectives careful attention is given to the following activities:

- Definition of potential hazards and specification of safe design limits for plant equipment and the subsequent supervision of construction and commissioning of equipment to minimise the likelihood and size of any incident.
- Protection of the public by locating plants at safe distances from residential or other public areas.
- Layout of production sites to ensure that adequate safety buffers are maintained between all major plant elements.
- Protection of employees by providing work areas which are either remote from potentially hazardous operations or are specially protected.
- Provision of equipment on-site to handle actual or potential incidents (permanent fire fighting facilities, gas barriers, fire proofing).
- Development of safety management procedures, training of staff in their use, and coordination of the procedures with those of civil authorities responsible for community safety and response to emergencies.

The following sections describe how ICI minimises risk to the public, employees, plant and equipment, by means of hazard analyses of new plant, specific design measures, staff training and provision of site emergency facilities.

4.2 LEVELS OF RISK

While few human activities are entirely risk free, the level of risk associated with ICI's activities is exceedingly small. Table 2 shows typical risks to members of the public from a variety of causes, involving both voluntary and involuntary activities.

TABLE 2 **Public risks — risk of death per person per year**

Cause	Risk per year (Chances per million)
Smoking 20 cigarettes per day[1]	5000
Drinking 1 bottle of wine per day[1]	77
Taking contraceptive pill[1]	20
Car driving (NSW) — licensed drivers[2]	161
Run over by road vehicle (NSW)[2]	52
Australians aged 15-65 — All causes[3]	5000
Earthquake (California)	2
Floods (USA)	2
Flooding of dykes (Holland)	0.1

Sources:

1 T A Kletz *The Application of Hazard Analysis to Risks to the Public at Large* Paper delivered to World Congress in Chemical Engineering, *Chemical Engineering in a Changing World* 1 July 1976.

2 Calculated from data from NSW Traffic Accident Research Unit

3 Calculated from data in Australian Year Book

For comparison it is estimated, using the history of incidents at chemical plants world-wide over a number of years, that the risk to residents close to the Botany site due to the new plants would be less than one chance per million per year. In the 37 years since operations commenced on the site, no member of the public living adjacent to or passing the site has been subjected to injury as a result of the plant's operations.

The risks to ICI employees are also small compared with those faced in a range of other kinds of employment. While reliable figures for Australian industries are not generally available, the figure for ICI Australia over the past 30 years is comparable with the UK chemical industry (see Table 3). Coupled with this low frequency of fatal accidents is a low frequency of injuries, in contrast to some of the industries listed below. The chemical industry in general and ICI in particular, pose minimal risks to both the public and employees.

TABLE 3 **Employee Risks — Number of Deaths per 1000 people in 40 years (at 2500 hours exposed per year)**

ICI Australia	4
Agriculture (UK)	10
Chemical Industry (UK)	4
Clothing & Footwear (UK)	0.15
Coal Mining (UK)	40
Metal Manufacture, Shipbuilding (UK)	8
Railway Shunters (UK)	45
Timber, Furniture (UK)	3
Vehicle Manufacture (UK)	1.3

Source of UK figures:

T A Kletz; *The Application of Hazard Analysis to Risk to the Public at Large;* Paper presented at the World Congress of Chemical Engineering; *Chemical Engineering in a Changing World;* Amsterdam, 1 July 1976

ICI's safety record is the result of a systematic approach to the layout of plants, restrictions on flammables stored in plants and the design and operation of plant equipment. ICI follows internationally accepted good practice to ensure that the possibility of any incident occurring is very small and that, even if one did occur, it would not damage the structure of any building or seriously injure any person beyond the boundary of the site.

Serious incidents are rare. For example, if there were a leak of flammable gas or liquid, a fire could not occur without a source of ignition. Plant design and management controls minimise the likelihood of either a leak or an ignition source. Prompt recognition of a leak or a fire enables the leak to be shut off and action taken to prevent the fire becoming significant. Of those few leaks that do ignite, most result in a local fire with very limited effects and no inconvenience or danger to the public. For example in the past three years there have been eight minor incidents and two false alarms which resulted in calling the fire brigade to the site. Of these eight incidents, three were grass fires which started on adjacent land, one was on a construction site and four were minor gas fires. All were quickly controlled by ICI and fire brigade teams. The two false alarms were caused by the operation of fire sensors in the Research Building reacting to warm conditions with no fire or hazard occurring. This record can be compared with an estimate by the district fire brigades of a total of 10,500 calls in the same three year period.

The risks associated with ICI's operations at Botany do not constitute an environmental impact in the normal sense of the word. There are risks, but these are negligible compared with the wide range accepted in every day life. The following sections describe the basis on which ICI undertakes its hazard analyses to establish appropriate safety design criteria, and the methods and procedures for safety management and training.

4.3 PLANT HAZARD ANALYSES & DESIGN PHILOSOPHY

In a petrochemical plant an explosion will not occur without:

- A significant rate of leakage of hydrocarbons.
- Rapid vapourisation.
- The right weather conditions for sufficient but not excessive mixing with air (the mixture must not be too rich nor too lean).
- Sufficient of the air-vapour mixture being of explosive concentration (otherwise the result is a fire).
- Delayed but positive ignition.

In the early stages of design of a petrochemical plant possible hazards are identified through careful examination of the materials used in the processes and the nature of the process and plant equipment. As specifications for the siting, layout and detailed design of each plant are prepared, a variety of features and design constraints are included specifically to reduce the likelihood and possible effect of any hazardous incident. Both minor and major potential hazards are identified and appropriate planning and design criteria set for the design of plant.

When commencing design, attention is first given to avoidance of leaks, then to limiting the size of any which might occur. This is done by minimising quantities stored, rapid detection of leaks by automatic gas detector alarms, remotely operated valves to isolate any leak, and control of ignition sources. Liquid fires are localised by bunding (retaining walls to contain any liquid) and specially designed drainage facilities. The risks of explosion are further minimised by the spacing of plant to allow any leaks to disperse harmlessly. These methods ensure that the likelihood of a major fire or explosion occurring is negligible.

Additional attention is given to ensuring that, in the event of a fire or explosion, the main damage would be confined to the affected plant and there would be no structural damage to private property nor serious injury to members of the public. Plants are located such that an incident in one plant cannot trigger incidents in adjacent plants on the same site (the so-called 'domino effect').

Design of the plants described in Chapter 3 is still at a preliminary stage. However the safety design principles described above have been used in ICI's assessment of siting requirements. As design proceeds more comprehensive and detailed hazard analyses[1] will be undertaken and reviewed with the appropriate statutory authorities. These analyses comprise:

- A detailed check to ensure the design includes all safety features specified in the initial analyses.
- A thorough analysis of the production process, listing all the ways in which incidents may arise and checking the probability and severity of such incidents. This analysis leads to specification of further safety design requirements.
- A detailed and systematic audit of the final detailed process drawings for the plant to ensure that the plant can adequately cope with abnormal conditions.

Construction and commissioning of the new plants will be under close supervision by ICI with special attention given to the following safety aspects:

- Compliance with all statutory requirements.
- Scrutiny of the safety of any design modifications made during the construction phase.
- Requirements for the safety of operators of the plants, including the safety of walkways, protection from hot surfaces and access to controls.
- Development of plant operating procedures which maintain the integrity of the safety principles and features designed and built into the plant.

It is therefore emphasised that the chance of any of the incidents described below ever occurring is extremely remote. As noted above if such an incident did occur its impact beyond the site boundary would not be sufficient to seriously injure any member of the public nor to cause structural damage to private property.

4.4 ETHYLENE PLANT SAFETY CONSIDERATIONS

There are two potential hazards associated with operation of any ethylene plant, including ICI's present plant. These hazards are:

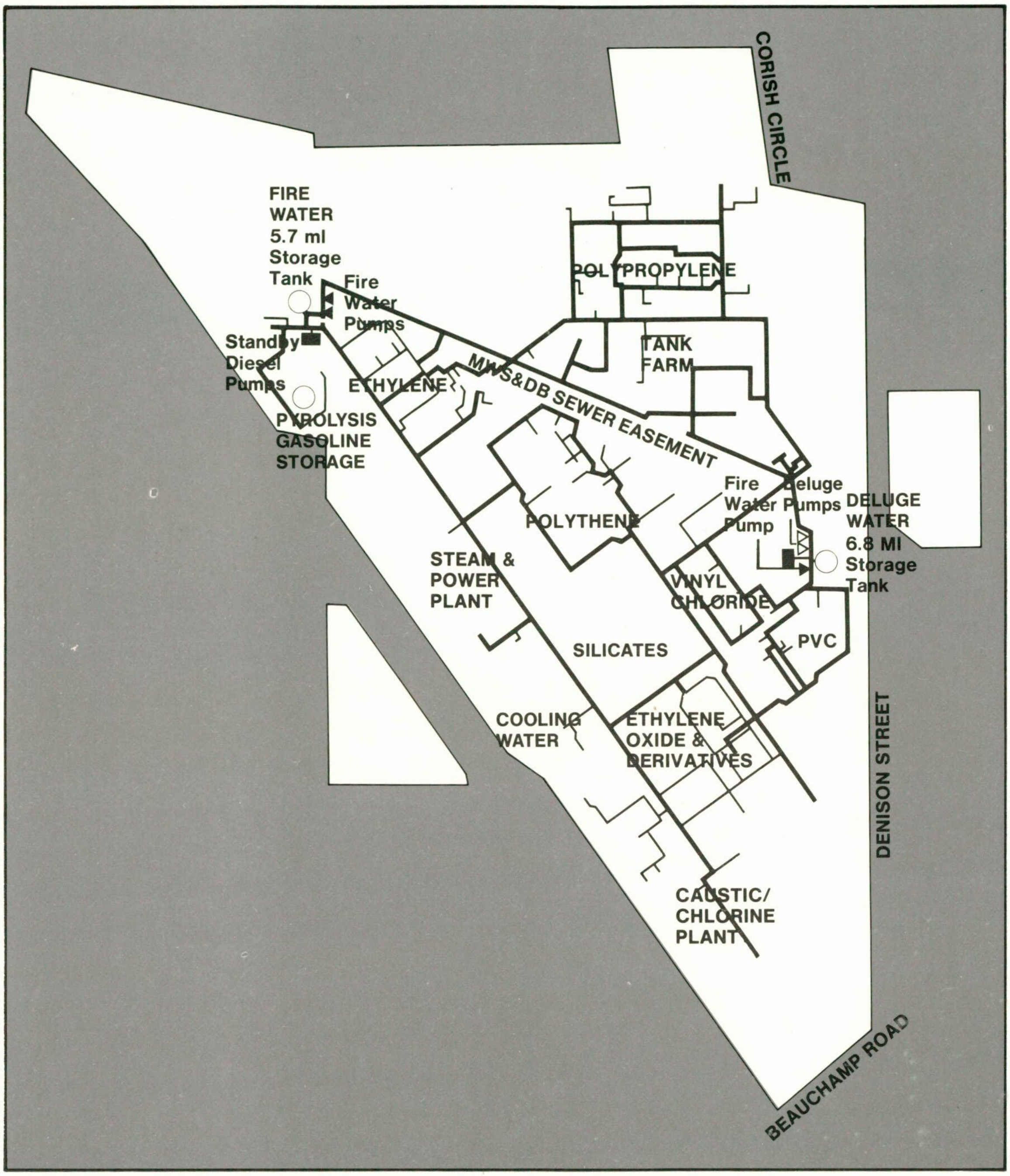
- fires
- vapour explosions

Ethylene plants process a variety of flammable liquids and gases. Any leak of these liquids and gases could be ignited and result in a fire, the severity of which would depend upon the material, the size of the escape and the location of the flame. In most cases the effects would be localised at the source of the leak.

The preventive and protective measures taken to avoid such incidents are:

- Observance of all statutory regulations administered by the Department of Industrial Relations and Technology in relation to 'registered pressure vessels'; ie vessels containing liquids or gases at pressure.
- Minimising the chance of potential leaks by strict design specifications and close supervision of construction and maintenance.
- Automatic detection of any leaks by flammable gas detectors.
- Rapid control of leaks by remotely operated shut-off valves.

1 See Appendix 4 for an explanation and example of 'hazards and operability' analysis for a small section of plant.



12 EXISTING SITE FIRE SERVICES NETWORK

- Control of the spread of liquid leaks by the use of bunds, suitably sloped ground, and specially designed drainage systems.
- Rapid dispersion of leaking gas by open layout of plant and careful placement of steam curtains.
- Elimination of ignition sources from areas in which leaks are more likely to occur (for example, the Botany site is a 'de-matched' site and smoking is permitted only in designated safety areas).
- Provision of permanent fire fighting facilities and deluge water systems on hydrocarbon storage vessels, as well as ready access for fire tenders and equipment.
- Protection of critical structures, equipment and cables by fire protection, thermal insulation, and cooling sprays.

13 SITE EMERGENCY EQUIPMENT

To prevent stock tanks or other vessels containing liquefied flammable gases from rupturing due to fire damage, particular attention is given to the following preventive and protective measures:

- Avoidance of flame impingement on storage vessels by sloping the ground around them so that any spills of flammable liquids drain away and do not accumulate in the vicinity of the vessels.
- Protection of the vessels by provision of external fireproof heat insulation material.
- Cooling the entire surface of the vessels with fixed deluge water sprays.

Botany site has an independent and fully pressurised fire water reticulation system, with standby diesel driven pumps and two fire water storage tanks of 5.7 Megalitres and 6.8 Megalitres capacity. Figure 12 is a plan of the site's existing fire water reticulation system and shows the location of fire water storage tanks and standby diesel pumps for use in the event of failure of power supply. Pumps for maintaining pressure are also duplicated against the possibility of a pump failing. Where appropriate, the fire fighting equipment is automatic and is fixed in location for instant operation, as shown in Figure 13.

The most serious incident which could occur within any ethylene plant is a vapour explosion. This would require a large and rapid escape of flammable gas from a pressurised, liquefied, gas system to disperse, mix with air and when in a fairly narrow range of explosive concentration, be ignited. Avoidance of such an incident requires particular emphasis on the reliable containment of liquefied flammable gases, limitation of the maximum leak rate and duration and avoidance of ignition sources.

The following preventive and protective measures will be taken for the ethylene plant:

- Limit the quantity of gas which could possibly leak by minimisation of inventories of liquefied flammable gas. This means maintaining a minimum amount of on-plant storage in any one location, and making the size of all vessels and pipes as small as practicable.
- Robust design of pipelines and attention to all other equipment to minimise the likelihood of leaks.
- Rapid isolation of leaks by use of remotely operated shut-off valves.
- Rapid and effective dispersion of leaks by open layout of the plant and judicious use of steam curtains.
- Strict control of ignition sources in all areas containing flammable liquids and gases.
- Location of sources of potential leaks at adequate distances from other plant areas and any public areas.

The separation of half a kilometre from the east side of the proposed ethylene plant to the nearest house is such that, even in the highly unlikely occurrence of a large vapour explosion at the east side of the plant, there would be no structural damage to housing, nor would the pressure wave injure people in the open.

4.5 ETHYLENE OXIDE AND DERIVATIVES PLANTS SAFETY CONSIDERATIONS

The extension of the ethylene oxide plant will involve processing a variety of flammable liquids and gases. The types of hazard which could in principle be associated with the ethylene oxide extension are similar to those potentially associated with the proposed ethylene plant. Thus the same range of safety design and hazard management procedures associated with the ethylene plant will apply for the ethylene oxide extensions.

The most likely cause of a fire would be ignition of an escape of ethylene oxide or hot oil used as a heat transfer medium. Permanent fire fighting facilities (similar to those shown in Figure 13) will be provided in areas where any flammable escape could occur. These facilities will be based on fire water sprays to cool equipment and structures and foam sprays to quench any oil fire. The emphasis in design will be on avoidance of leaks, rapid detection and isolation of any leaks that might occur, and provision of back-up fire fighting facilities.

Ethylene oxide mixes readily with water and this property greatly assists in the control of leaks and spillages. The boiling point of ethylene oxide is only slightly lower than atmospheric temperatures and hence vaporisation occurs very slowly. Therefore the chance of a vapour explosion is very low even if leakage occurs.

The preventive and protective measures against vapour explosion will be similar to those specified for the ethylene plant, with similar emphasis on restriction on size of inventories, avoidance of leaks, rapid detection and isolation of any leaks which may occur, rapid dispersion of any vapour cloud formed and removal of potential ignition sources.

A form of explosion which can occur with ethylene oxide is decomposition due to contamination or excessive overheating. Design requirements and operating procedures to avoid such incidents are well established and accepted worldwide and have been in use at Botany since 1964. For example:

- Protection is provided against contamination or backflow of impurities from downstream plants.
- Temperatures are closely monitored at all points of the process where ethylene oxide is

present and facilities are provided for rapid shutdown of the process and cooling of any heated area.

4.6 POLYTHENE PLANT SAFETY CONSIDERATIONS

The new polythene plant will not be handling ethylene in liquid form and because the quantity of gaseous ethylene present will be small, the effects of any incident would be correspondingly localised. As in the other plants, preventive and protective measures to counter any risk of fires are directed toward avoidance of leaks, rapid detection and isolation of any leak which occurs, open layout to facilitate harmless dispersion, and permanent fire fighting facilities. A fire is much more likely to be small than large, especially because of the limited quantity of flammable gas present, and could be easily controlled and extinguished.

Improvement of process control and installation of equipment has effectively eliminated explosive aerial decomposition of ethylene vented from polythene reactors under abnormal process conditions as demonstrated by the performance in recent years of the Botany polythene plant and similar plants elsewhere.

A leak of ethylene gas from other parts of the plant could, if ignited, perhaps explode. Because of the open layout of the plant it is most unlikely that the small quantity which could escape would ignite and explode. The small quantity of gas involved would mean that the effects of such an explosion would be very local.

4.7 RISKS FROM OUTSIDE EVENTS

The Botany site does not lie on the alignment of either the east or south runways of Kingsford Smith Airport and jets do not pass over the site on approach to or departure from the airport. Small propellor-driven aircraft occasionally cross the site but these present a very small risk.

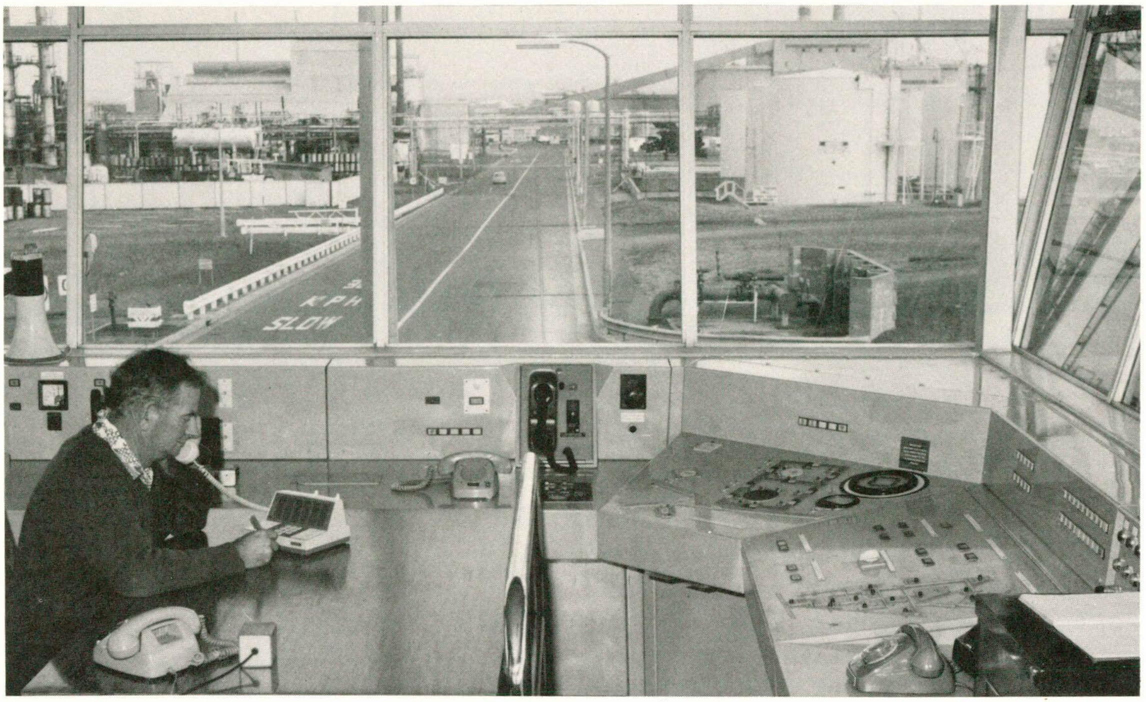
In the unlikely event of an aircraft crashing on the site, damage would be confined to the general area of the crash and would not spread to other parts of the site because of the buffer zones between plants. If an aircraft were to crash onto a hydrocarbon storage vessel a fire would result. This would prevent a build up of escaped gas to explosive concentrations.

The separation distances between ICI plants and adjacent industries are such that the spread of a fire from one site to another is extremely unlikely. Even if a fragment from an off-site explosion struck equipment on the ICI site it is most unlikely to cause sufficient damage to lead to an incident.

4.8 SITE EMERGENCY PROCEDURES

Manuals detailing emergency procedures are prepared for each plant on the Botany site. Similar emergency procedure manuals will be developed for the proposed extensions during the later stages of construction and reviewed to ensure that they are consistent with those already in existence. Employees at all levels are trained in their roles in the event of an emergency. The general approach for emergency procedures covers the following areas:

- Immediate action by employees on-site to limit the magnitude of any incident.
- Communication with local authorities, such as fire brigade, police and if required, hospitals.
- Notification of senior management and technical staff to ensure that maximum support is available at the site.



14 BOTANY SITE EMERGENCY SERVICES CONTROL CENTRE

- Support to, and guidance of, local authorities to ensure the maximum safety of the public and employees and limitation of the effects of any incident.

Emergency procedures are co-ordinated from a main control centre (Figure 14). This centre contains:

- Automatic alarms and monitors for gas detectors.
- The main fire alarm button, which also actuates the fire pumps.
- Wind speed and direction gauges.
- Controls for automatic booms and traffic lights to direct site traffic.
- Three independent site communications systems (normal telephone; separate site telephone cables; radios).
- A direct line to the Alexandria fire department.
- A direct outside line bypassing the site PABX system.
- Controls for remote actuation of deluges and steam curtains in the tank farm.

The combination of emergency facilities and training in emergency procedures is designed to ensure rapid control and containment of incidents should they occur.

4.9 TOXICITY

As a major chemical manufacturer ICI world-wide has developed over many years the knowledge and expertise to recognise and effectively handle potentially hazardous chemicals. Detailed operational procedures have been established with the aim of preventing deleterious effects on the health of ICI employees or the community.

In the UK ICI operates one of the largest toxicological centres in the world and information from this centre, together with that of leading industrial, government and academic agencies, is used to plan, design and operate plants on the Botany site with minimal hazard from toxic materials. The UK centre tests chemicals handled by ICI and also conducts pure research into the potential effects of these chemicals on the health of the community. The centre incorporates facilities to conduct a complete range of short and long term toxicity studies, including among others carcinogenicity, teratogenicity and foetoxicity.

Chemicals manufactured or used on Botany site undergo a toxicological assessment and based on this assessment, design specifications, operating standards and handling procedures are formulated and introduced for individual products. In the unlikely event of a potential toxicity problem arising, inbuilt safety aspects of plant and procedures covering handling on an off the site are such that the volume and concentration of material involved is greatly restricted with consequent minimising of any toxic hazard.

The raw materials, in-process materials and end products to be produced and used in Stage II plants have all been in use on Botany site for many years without any toxic effects on neighbouring residents or employees.

The handling of all materials on Botany site complies with the occupational health requirements of the New South Wales Department of Health. Where employees are required to work with toxic materials the nature of the problem is explained to them as is the need to take care and adopt safety procedures.

4.10 ROAD TRANSPORT OF HAZARDOUS MATERIALS

The nature of the processes at the various plants on Botany site result in the need to transport materials and products of a potentially hazardous nature to and from the site. Records show that about 30 truck trips each week are of this type. ICI pays particular attention to road transport safety measures and its record to date is sound. Over the past five years for 7500 trips involving transport of hazardous materials, seven minor incidents have been recorded. None of these involved damage to public or private property, or injury to employees or members of the public.

In collaboration with the fire brigade, police and other relevant public authorities, ICI has prepared comprehensive procedure manuals for the transport of hazardous materials. The manuals cover preparation of tankers, driver training, loading, emergency procedures, and first aid. Each tanker carries an emergency procedure card taken from the relevant Australian Standard and ICI has a team of technically qualified emergency co-ordinators who can be contacted at any time and who are able to call in and co-ordinate the appropriate support from police, fire brigade and other emergency services.

As in other fields of safety ICI continues to maintain close contact with overseas practice to ensure that the equipment and procedures used not only comply with the Dangerous Goods Act, but continue to improve in the light of overseas experience.

4.11 SAFETY MANAGEMENT

More than 20 years ago ICI set out and published a formal safety policy for all its operations. The policy is set out in Appendix 5. Over the past 20 years ICI's record of lost time injuries has been reduced to one-fifth its initial rate and the Company's industrial safety performance is one of the best in Australia.

Safety policy for ICI's operations is formulated by the Safety Council which is chaired by an Executive Director and is responsible to the Board. Membership of the Safety Council includes the Botany site manager, works managers, chief engineer, personnel manager, chief medical officer and distribution manager. In forming the Safety Council 34 years ago the Board clearly indicated its intention that ICI should be in the forefront of safety performance in Australia. At that time chemical manufacturing technology was in its comparative infancy in Australia and there were fewer codes and practices and statutory regulations than today. It was thus necessary for the Safety Council to establish its own safety practices in processing and engineering and it did so with safety manuals which became well known in industry. In later years the manuals have been largely replaced by relevant codes and practices established by the Standards Association of Australia to which ICI staff have made major contributions.

ICI's safety management philosophy is to hold its management strictly accountable for the safety of the surrounding community and those who work in the company. Carefully designed and applied procedures have been significant in establishing ICI's good performance. Among such procedures is the formal system which accompanies the handing over of manufacturing plant items from operating staff to maintenance staff or vice-versa when maintenance work is necessary. Such procedures ensure that responsibilities for safety are clearly understood at all times. Each manager and supervisor is responsible for monitoring safety in his area and taking whatever action is needed to correct adverse trends or to make further improvements. The technical strength of factory management is an important factor in ensuring that any unsafe situation is quickly recognised and corrected.

There is a parallel system for recording and analysing 'unusual occurrences'. Each factory has a safety officer whose role is to assist the works manager and all other employees to work safely. He helps conduct safety inspections, trains staff and operators, investigates accidents or unusual occurrences, recommends safety procedures and generally maintains constant awareness of the need for safety and the methods of achieving it.

ICI's continuing safety activities are coordinated by the safety and environment manager, who is secretary to the Safety Council. Reporting to the safety and environment manager is the project safety manager who is responsible with the line managers concerned for ensuring that new projects are designed and built to the best practical safety standards. Close contact is maintained with the development of safety practices overseas, particularly in the UK where ICI is an acknowledged world leader in the safe design and operation of petrochemical plants.

ATMOSPHERIC EMISSIONS

Chapter 5 ATMOSPHERIC EMISSIONS

5.1 INTRODUCTION

Since 1971, when significant levels of photochemical smog were first noted in Sydney, there have been extensive studies aimed at improving understanding of the problem and at providing a basis for pollution control policy. The SPCC believes the results of these studies show that:[1]

- Although ozone concentrations (the main constituent of photochemical smog) depend on the concentration of both nitrogen oxides and hydrocarbons (the precursors of photochemical smog), ozone concentrations in Sydney will be more readily reduced by controlling hydrocarbon emissions than by controlling nitrogen oxide emissions. The SPCC also believes the hydrocarbon reduction approach to be more practicable and cost effective. Overseas approaches do vary in this matter, with some pollution control agencies believing the absolute concentrations and ratios of both non-methane hydrocarbons and oxides of nitrogen to be important and others that reductions in both precursors are necessary.
- Because sunlight is needed to initiate and sustain the chemical reactions, ozone concentrations in Sydney are highest in the warmer months between about 11 am and 5 pm.
- The concentration of precursors and also of resultant photochemical smog is greatly dependent on weather conditions. Windy weather will disperse these pollutants, diluting them in the process. Heavily overcast conditions reduce the amount of sunlight available and thereby slow the photochemical reaction. Prolonged periods of sunny weather and low wind speeds will permit accumulation of the precursors and their photochemical products.
- The westerly drainage flow down the Liverpool and Parramatta Valleys in the morning and the opposing sea breeze in the early afternon cause the central, southern and western parts of Sydney to experience the highest concentrations of ozone. Ozone is carried with the seabreeze to Wentworthville, Warwick Farm, Campbelltown and beyond. The most significant source regions now for smog precursors are the Parramatta River Valley, the central business district and the Botany Bay region.

The SPCC has calculated sources of hydrocarbons in Sydney for a typical summertime weekday in 1976 and made estimates of levels of emission from each source in 1985, taking account of all current controls, but assuming no further controls. The sources and estimated hydrocarbon emission levels are shown in Table 4.

1 NSW State Pollution Control Commission, *An Assessment of Photochemical Smog in the Sydney Region*, SPCC, January 1979 p 11-12

TABLE 4 **Emissions of Hydrocarbons in the Sydney Region**[1]

Source	Tonnes per day Summertime Weekday 1976	1985
Motor Car and Derivatives — Exhaust	158	201
Motor Car and Derivatives — Evaporative	86	68
Commercial Vehicle — Exhaust	53	52
Commercial Vehicle — Evaporative	10	13
Crankcase — All Vehicles	35	8
Motor Cycles	4	3
Process Losses (Refineries, etc)	50	50
Storage and Transfer of Petroleum Products	54	67
Architectural Paints	20	25
Industrial Paints	19	25
Painting Motor Vehicles	26	35
Can and Miscellaneous Coatings	20	25
Printing	20	25
Adhesives	17	21
Degreasing	10	13
Dry Cleaning	9	12
Aerosol Cans	6	9
Lawnmowers	25	25
Incineration	8	12
Miscellaneous	31	40
TOTAL	661	729

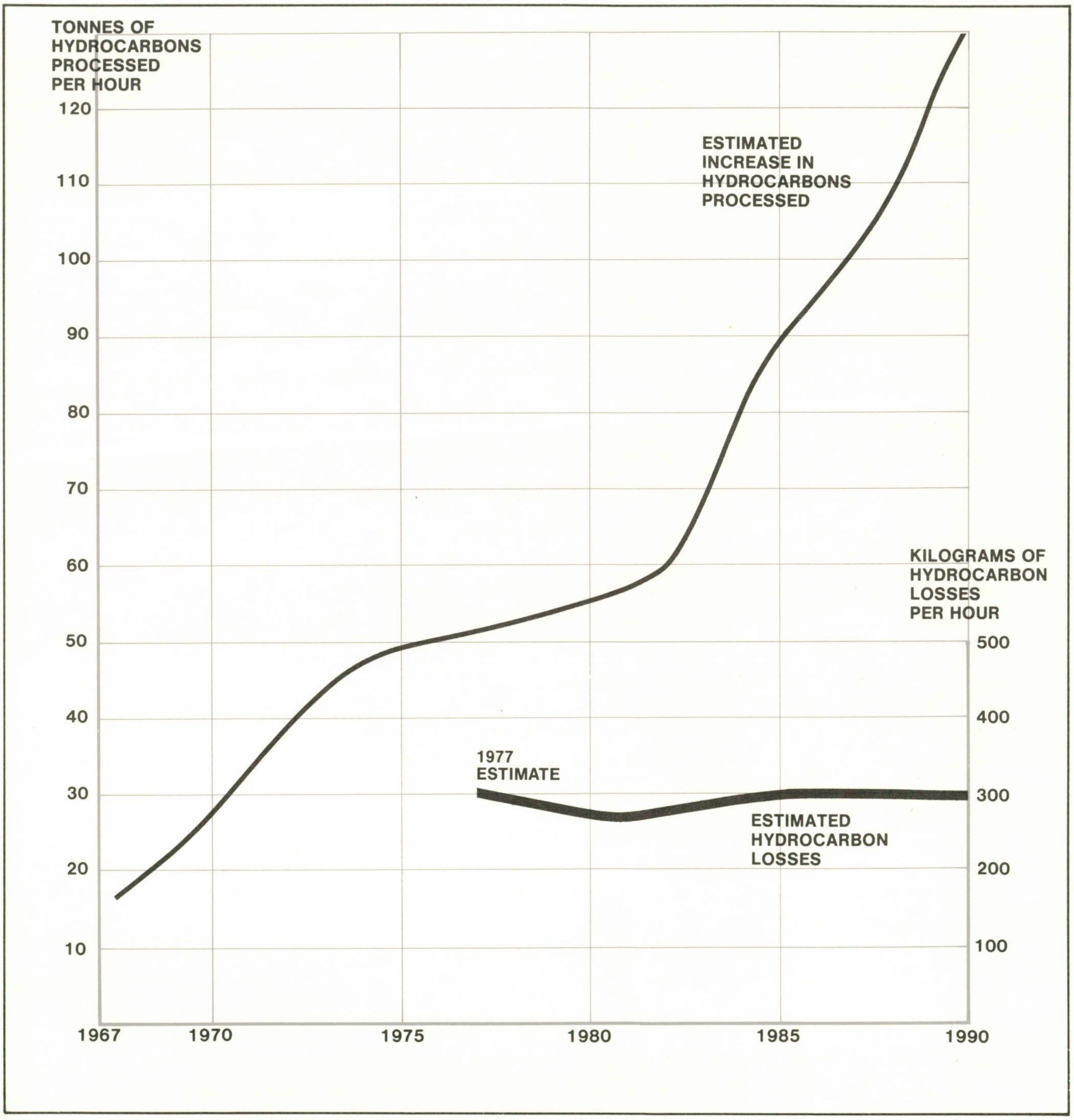
1 *Source:* NSW State Pollution Control Commission, *An Assessment of Photochemical Smog in the Sydney Region*, SPCC, January 1979, p 13.

The largest single group of hydrocarbon emission sources are those associated with the operation of private and commercial vehicles, these accounting for over 52% of estimated daily hydrocarbon emissions in 1976. The motor vehicle exhaust component, 24% of all sources, is expected to increase to 27% in 1985, but the overall level of vehicle related emissions is expected to remain constant, mainly through reductions in crankcase and evaporative sources.

Increases are allowed for in many industrial areas with the exception of 'Process Losses (Refineries, etc)' which are expected to remain constant at 50 tonnes per day. In 1976, this source represented 7.6% of all emissions and its contribution is expected to fall to 6.9% of all hydrocarbon emissions in 1985. These are estimates and not necessarily targets. Changes in a number of factors may warrant revision of the estimates and the development of revised policies in relation to the control of hydrocarbon emissions. However, for those sources of hydrocarbon emissions related to the nature of the operations of ICI and other Sydney region petrochemical producers, assuming continuing improvement in plant design and housekeeping, no measurable increase in emissions is presently anticipated — irrespective of any increases in total production and consumption of hydrocarbon based products that may occur in that period.

In the remainder of this chapter, the current level of ICI hydrocarbon and other atmospheric emissions (nitrogen and sulphur oxides) is described, together with the current program of reduction in emissions. This is followed by an assessment of estimated emissions from the proposed plant expansions, a description of emission control proposals, and a summary of net emissions.

The present efficiency with which hydrocarbons are handled and processed at ICI's Botany site is very high. As a result of improvements to existing plant, and the introduction of more advanced emission control equipment in new plants, there will be no measurable increase in current ICI hydrocarbon emission levels, notwithstanding a substantial increase in the volume of hydrocarbons processed on the Botany site, as shown in Figure 15. Relative to hydrocarbon production volume, emissions are and will continue to be negligible, but equally reductions in current emissions levels, coupled with increases in production capacity are not possible. This is because of the multiplicity of individually small sources of hydrocarbon emissions and the limitations of current practical technology to contain these losses.



15 COMPARISON OF HYDROCARBONS PROCESSED AND ESTIMATED HYDROCARBON LOSSES 1967-1985

5.2 EXISTING SOURCES OF HYDROCARBON LOSSES AT BOTANY SITE

Industrial pollution is generally perceived as the result of a lack of control of the disposal of wastes generated in the production process. In the Sydney region most concern focuses on hydrocarbon emissions, the most significant smog precursor. However, it must be stressed that hydrocarbons lost from the Botany site are not 'wastes' in the conventional sense of the word. Hydrocarbons are major feedstocks and products of the Botany plants, and prevention of loss of hydrocarbons is a most important ICI objective on economic, as well as environmental grounds. With the 1979 world price of ethylene at about $600 per tonne the incentive to prevent losses of ethylene to the atmosphere is very high.

In 1977, prior to the current expansion program, ICI estimated the sources and quantities of hydrocarbon losses from the Botany site for those hydrocarbons which are precursors of photochemical smog. These estimates are set out in Table 5.

TABLE 5 **Estimated ICI Botany C_2 and Higher Hydrocarbon Losses (1977) for Plants Proposed for Expansion**

Plants Proposed for Expansion		Quantity (kilograms per hour)
1	Existing Ethylene Plant	128
2	Existing Ethylene Oxide Plant	60
3	Polythene Plant	108
TOTAL		296 kg/hour

At the time these estimates were made, and immediately prior to the implementation of Stage 1, the principle was established that future expansion on the Botany site should not result in any net increase in hydrocarbon losses. Consequently ICI's program of reducing losses from existing plants was stepped up as described in the following sections.

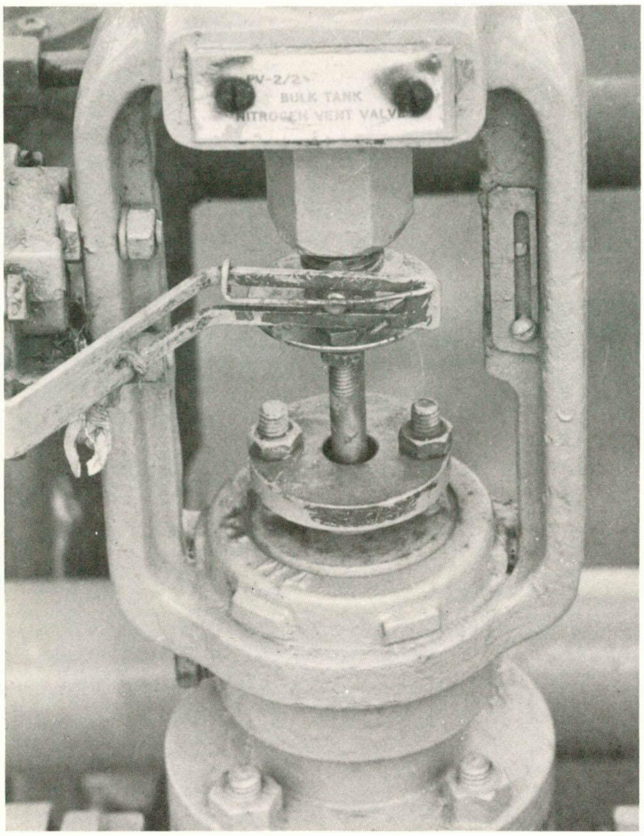
Existing Ethylene Plant

Hydrocarbon losses from the ethylene plant come from a wide variety of sources which can be minimized by modern design methods, but not eliminated. For example, valve glands (of which there are about 3500 in the existing ethylene plant) account for 13 kg/hour or 10% of hydrocarbon losses from the ethylene plant. Figure 16 illustrates some typical examples of the smaller pieces of equipment from which these losses occur. Because of the nature of the sources of hydrocarbon losses, emissions are generally continuous, rather than intermittent.

The principal sources of emissions within the existing ethylene plant are:

TABLE 6 **Estimated Hydrocarbon Losses from the Existing Ethylene Plant, 1977**

Source	Kilograms per hour
Loading Bay Vents	49
Storage Tanks	30
Waste Water Separator	14
Valve Glands	13
Safety Valves	11
Flaring	4
Pump Seals	3
Others (sampling, lubrication, etc)	4
TOTAL	128



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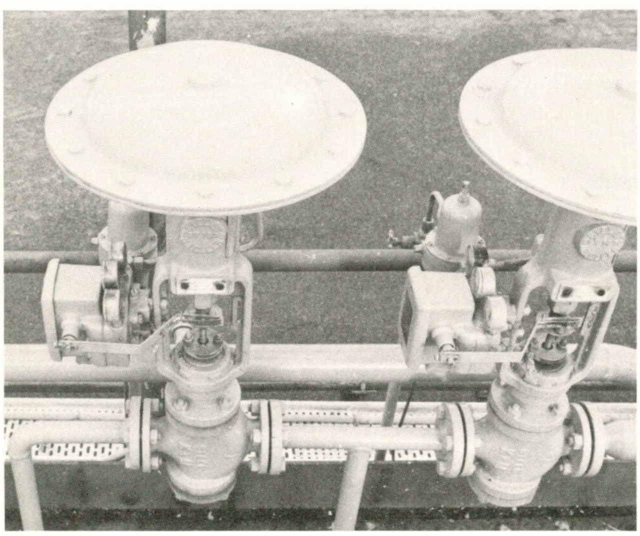

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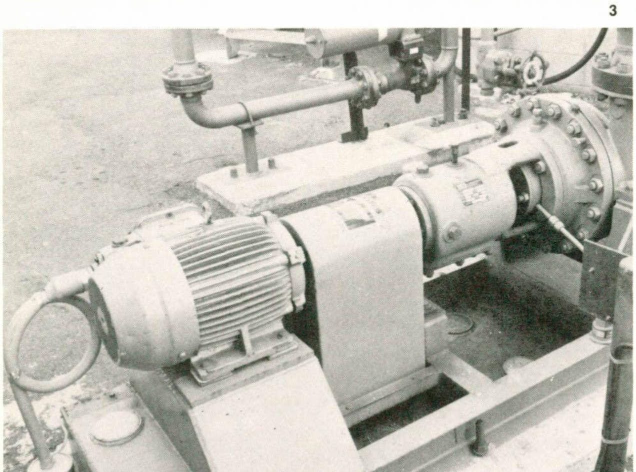

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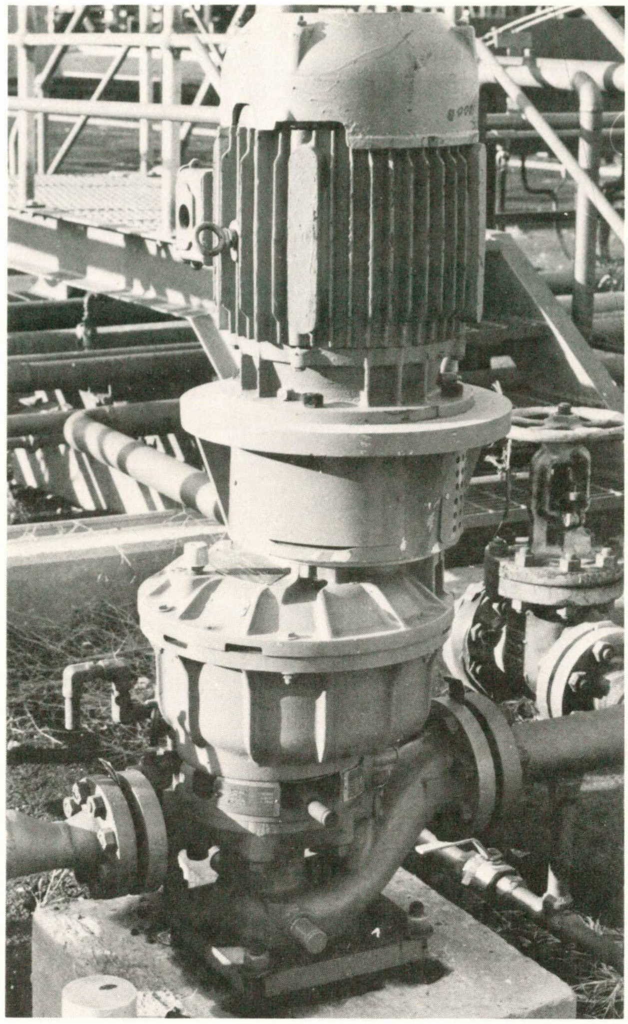

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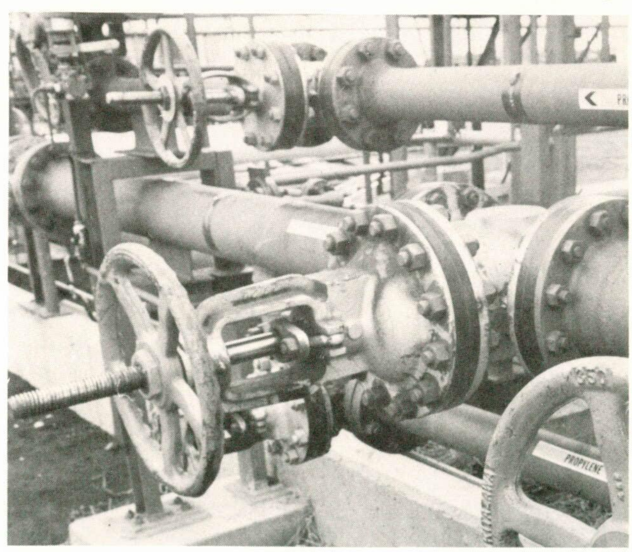

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1 Control Valve
2 Liquid Propylene Pump
3 Liquid Hydrocarbon Control Valves
4 Isolation Valves
5 Ethylene Pump

16 TYPICAL SOURCES OF HYDROCARBON LOSSES

Since 1977 further measures have been taken to reduce hydrocarbon losses from the existing ethylene plant.

These are:

- Improving LPG loading operations through better metering, better operating techniques and collection of gas previously vented to the atmosphere.
- Provision of a floating roof for the pyrolysis gasoline storage tank in accordance with the NSW draft regulations for control of hydrocarbon emissions from terminal tankage.
- Covering the waste water separator.
- Discharging additional safety valve releases to the flare.
- Installation of a ground furnace.

These measures are estimated to have reduced hydrocarbon losses from the existing ethylene plant from 128 to 98 kilograms per hour, a 23% reduction.

Existing Ethylene Oxide Plant

Ethylene oxide is produced by the reaction of ethylene and oxygen in a reactor. The oxygen fed to the reactor contains inert gases such as argon which tend to build up in concentration as the gases are recycled for efficient use of the reactants. To control this build up and to control the pressure in the reactor, a small part of the reactor gases is vented to the atmosphere. These vent gases contain some ethylene and to reduce these ethylene emissions ICI proposes to incinerate the vent gases, thereby converting the ethylene to carbon dioxide and water vapour.

In the process of absorption of the ethylene oxide in water before it is purified, a small quantity of ethylene and other gases are also absorbed in the water. To recover the ethylene oxide from this stream it is stripped and reabsorbed while the remaining gases including the ethylene are vented to the atmosphere. To reduce this emission of ethylene, incineration of vent gases is again proposed.

After uprating, the anticipated reduction in ethylene discharged to the atmosphere by the incineration of these two vent streams is 31 kilograms per hour.

Existing Polythene Plant

Current modifications to increase the capacity of the existing polythene plant will result in a reduction of hydrocarbon losses from 108 kilograms per hour to 104 kilograms per hour. These include:

- Elimination of precooler bypass inlet valves which had significant leaks from glands.
- Collection of ethylene which had previously been allowed to escape during draining of process equipment.
- Improved gasholder monitoring, improved gas leak detection systems and improved flow metering.

Total Reductions on Existing Plants: 1977-1981

Since the 1977 estimates of hydrocarbon losses, the improvements described above will result in total reductions of 65 kilograms per hour by 1981.

5.3 HYDROCARBON LOSSES FROM STAGES I AND II

The Botany site is a scheduled premises under the requirements of the Clean Air Act and all new plants must be approved by the SPCC. The new polypropylene plant, which forms Stage I of the expansion program, has been the subject of a separate EIS and all necessary planning and environmental approvals have been obtained for this plant. The plant is expected to be commissioned later this year. In operation hydrocarbon losses from the polypropylene plant will total 33 kilograms per hour from vents and fugitive leaks.

Hydrocarbon losses from Stage II are estimated as follows:

New Ethylene Plant

This plant will use similar technology to the existing plant, with many of the emission reduction measures described above incorporated in the design of the plant. As noted above there are real limits to the extent to which hydrocarbon losses can be practically contained. Significant design improvements will be:

- Minimal atmospheric vents.
- Discharging of vents and relief valves to the flare system wherever practical.
- Venting selected pumps to the flare system.

With these design measures, total hydrocarbon losses from the new ethylene plant are estimated at 70 kilograms per hour [1], compared to 98 kilograms per hour for the existing smaller plant. On closing down the existing plant and commissioning the new plant there will be a net reduction in hydrocarbon losses of 28 kilograms per hour.

Ethylene Oxide and Derivatives Plants

In the proposed expansion a furnace will be used to incinerate hydrocarbons vented from the ethylene oxide manufacturing process. Other losses of hydrocarbons will be limited by improvements in the design of pump seals and by careful maintenance. Total hydrocarbon losses from the ethylene oxide and derivatives plants extensions are estimated at about 20 kilograms per hour.

Polythene Plant

Hydrocarbon losses will arise from minor leakages from glands, valves or compressors together with a small amount of ethylene which is dissipated from freshly produced polythene granules. A vent recovery system will be installed on the plant to collect discharges from blow-offs and relief devices into an atmospheric pressure gasholder for re-use in processing.

Improved compressor design will also enable collection and recovery of some leaked gas. Total hydrocarbon losses from the Stage II polythene plant are estimated at 40 kilograms per hour.

1 A range of estimating methods are available. The principal references used for the new ethylene plant estimates are:

US Environmental Protection Agency, *Compilation of Emission Factors*, APA2, 1977.

US Environmental Protection Agency, *Survey Report on Atmospheric Emissions from the Petrochemical Industry*, Volume 2, 1974.

J. O. Ledbetter, *Air Pollution — Part A — Analysis*, Marcel Decker, New York, 1977.

Chemie Ingenieur Technik, February 1977.

5.4 ESTIMATED BALANCE OF HYDROCARBON LOSSES ON COMPLETION OF STAGES I AND II

Taking account of the effects of better hydrocarbon emission control, the closing down of existing plant and the introduction of more efficient plant, the resulting balance of hydrocarbon losses is estimated as follows:

TABLE 7 **Estimated C_2 and Higher Hydrocarbon Losses 1977-1985**

Plant	Emissions (kilograms per hour) 1977	1981	1985
Ethylene (existing)	128	98	—
Ethylene (new)	—	—	70
Ethylene oxide (existing)	60	—	—
Ethylene oxide (after uprating)	—	29	29
Stage II Ethylene oxide	—	—	20
Polythene (existing)	108	—	—
Polythene (after uprating)	—	104	104
Stage II Polythene	—	—	40
Polypropylene	—	33	33
TOTAL HYDROCARBON LOSSES (ROUNDED)	300	265	300

Better hydrocarbon emission control on existing plants, closing down existing plants and improved design of new plants means that significant increases in production capacity can be achieved with only minor changes in hydrocarbon emission levels at the completion of Stages I and II.

5.5 EMISSIONS OF OXIDES OF NITROGEN AND SULPHUR

While more emphasis is given to hydrocarbon reductions as the most effective approach to dealing with Sydney's photochemical smog problem, emissions of nitrogen and sulphur oxides (NO_x and SO_x) are strictly controlled by the SPCC.

The existing sources of oxides of nitrogen and sulphur emissions on the Botany site are the boilers and ethylene plant furnaces. In 1977 ICI estimated NO_x and SO_x emissions from these plants at 78 and 177 kilograms per hour respectively.

With Stage II the sources of nitrogen oxide emissions will be the fourth boiler, and the ethylene plant furnaces. Nitrogen oxides form during high temperature combustion from the oxidation of nitrogen either in the furnace fuel, or in the combustion air. The amount formed is a function of the temperature of combustion and the residence time of the gases in the combustion chamber. The new furnaces will incorporate latest burner technology and the fourth boiler will achieve a concentration of nitrogen oxides comparable to the emission concentrations from the existing coal fired boilers.

There will be only one new source of sulphur oxides from the proposed expansion. This will be the fourth boiler, which may be fired with coal with a maximum sulphur content of 0.65% by weight.

Table 8 shows estimated 1977 and new emission levels for NO_x and SO_x following completion of Stages I and II and decommissioning of the existing ethylene plant.

TABLE 8 **Estimated 1977 and 1985 NO_x and SO_x Emissions**

Plant	Gross Steam Capacity (Tonnes per hour)	Firing Mode	Year of Commiss--ioning	1977 NO_x (Kilograms per hour)	1977 SO_x (Kilograms per hour)	1985 NO_x (Kilograms per hour)	1985 SO_x (Kilograms per hour)
No 1 and 2 Boilers	56 each	coal	1966/67	63	177*	63	177*
No 3 Boiler	87.5	gas	1979	—	—	36	—
No 4 Boiler	87.5	coal	1983	—	—	46	136*
Ethylene Plant (existing)	NA	gas	1967	15	—	—	—
Ethylene Plant (new)	NA	gas	1983	—	—	36	—
TOTALS				78	177	181	313

* Based on 100% of sulphur in fuel appearing in the flue gases.

Wind direction and stack height are important considerations in assessment of dispersion of oxides of nitrogen and sulphur. The prevailing winds for Sydney are from the west in the winter months and are of the highest velocity from April through to August. There is also a wind from the north west which is consistent for about eight months of the year but is only of low velocity. These winds appear to be most consistent in the mornings. In the afternoon in the summertime the prevailing winds are east-north easterly. The easterlies have the highest velocity in the months from October through to March. There is a consistent but light southerly breeze on most afternoons throughout the year.

For the Stage II plants the condition of maximum ground level concentration of NO_x and SO_x will occur when the wind is from the south, the orientation in which the boiler plant and new ethylene plant are in line.

A recognised computer programme[1] for the estimation of gaseous dispersion from multiple stacks was used to calculate maximum three minute mean ground level concentrations of NO_x and SO_x for the emissions tabulated above. The calculations assume a stack height for the fourth boiler of 66 metres. The results are shown in Table 9.

TABLE 9 **Estimated 1985 NO_x and SO_x Ground Level Concentrations**

Emission	Wind Speed 6 metres/second: Maximum ground level concentration* (parts per 100 million)	6 metres/second: Distance (metres)	10 metres/second: Maximum ground level concentration (parts per 100 million)	10 metres/second: Distance (metres)
NO_x	17	1070-1160	17	880-900
SO_x	14	980-1220	12	790-1160

*This condition occurs with wind from the south.

1 The programme used is similar to that in use by the SPCC and uses the co-efficient of turbulent diffusion $C = 0.23 \text{ ft}^{1/8}$.

5.6 PARTICULATES

The existing Number 1 and 2 boilers are coal fired and after gas cleaning meet the SPCC emissions limits established for them. The estimated total emission rate for particulates in 1977 was 48 kilograms/hour. To achieve emission levels specified of less than 0.25 g/m^3 on the fourth boiler, mechanical separation will be used consisting of multicyclones for removal of coarse particles, followed by bag filters or other approved means for removal of the finer particles. Total particulate emissions for the fourth boiler will be about 24 kilograms per hour.

Delivery of coal by road has meant that the stockpiles are relatively small. Handling of coal from the present underground hopper to the boiler bunkers is completely under cover and coal dust is contained. If coal were delivered by rail a larger stockpile would be required, and dust control measures would be reviewed.

In the manufacture of polythene some polythene particulate matter is deposited around the polythene plant, but wholly within the ICI site. For the polythene expansion better materials handling will reduce deposition of polythene particulates.

5.7 ODOUR

Some odours are evident within the plant areas from the present production and usage of chemicals. These include odour from cracked gasoline around the ethylene area and organic chemicals used in the ethylene oxide derivatives plants area. There will be no offensive odours at the site boundaries as a result of Stage II.

5.8 FLARING

Provision must be made for safe disposal of surplus flammable material, and to deal with disturbances to operating conditions. An elevated flare and a ground furnace will be installed as part of the new ethylene plant. The ground furnace will be sized to dispose of frequent and prolonged loads of flammable material and the elevated flare to handle the maximum plant flaring rate. The location of these is shown on Figure 6. The existing ground furnace and elevated flare may continue to be used with that section of the existing ethylene plant not shut down.

The Ground Furnace

The term ground furnace is used to describe an arrangement of many small burners at the base of a refractory lined box which encloses the flames. Division of the gas flow among many burners assists mixing with combustion air. The box creates a strong natural draft and so generates turbulence to promote fast mixing of air. Enclosing the flames in a combustion chamber screens most of the luminosity and thermal radiation and effectively reduces the emission of combustion noise.

The ground furnace will be designed so that when operating at full load there are no visible flames and that the noise contribution is not significant at the nearest residence.

The ground furnace will handle:

- Routine flaring of excess gases.
- The gaseous products of the cracking furnaces during start-ups.
- Gas vented to flare during minor process upsets.

No inconvenience to residents is expected in terms of glare, noise, or smoke from the ground furnace.

The Elevated Flare

The elevated flare will be designed to handle loads in excess of the design capacity of the ground furnace. The estimated frequency and duration of elevated flaring is summarised in Table 10. This does not differ markedly from the pattern for the existing ethylene plant.

TABLE 10 **Typical Flaring Pattern for Proposed New Ethylene Plant**

Reason for Flaring	Average Duration of each event (hours)	Frequency (events per year)	Type of furnace in use ● ground furnace only ●● ground furnace and elevated flare
Routine flaring for miscellaneous minor purposes	Continuous	Continuous	●
Planned shutdowns	36	<1	●
Controlled startups following planned shutdown	36	<1	●
Unplanned shutdowns (initial high flaring rate)	0.5	4	●●
Unplanned shutdowns (after initial high rate period)	2	4	●
Controlled startups following unplanned shutdown	36	4	●
Major process upset	1	2	●●
Compressor trip or failure of key utility (eg power, instrument air, steam, cooling water)	0.5	<1	●●

NOISE

Chapter 6 NOISE EFFECTS

6.1 INTRODUCTION

The level of noise is an important indicator of the quality of the environment and very high and sustained noise levels can have adverse physiological and behavioural effects. The variables of noise which can be measured and related to these effects are loudness, duration and frequency.

Sound levels are measured in 'decibels' (dB(A)), being a logarithmic unit approximating loudness as perceived by the human ear, while frequency of occurrence and duration are best expressed by a noise level value where L represents the noise level (in decibels) exceeded 'x' percent of the time. Of these, the important levels are:

L_{90} — the level exceeded 90% of the time (which is a measure of ambient background noise).

L_{10} — the level exceeded 10% of the time, being the average maximum (and a measure of subjective reaction to noise.)

Some typical noise levels for every day events are set out in Table 11.

TABLE 11 **Typical Noise Levels**

Sound Pressure Levels dB(A).	
120	Jet plane take-off (at 70 m)
110	Pneumatic jack hammer (at 2 m)
100	Automatic punch press (at 1m)
	Inside a boiler room (oil fired)
90	Heavy trucks (at 7 m)
	Inside a printing press plant
80	Motor cars (at 7m)
70	Near a busy road
	Normal conversation
60	Inside a large store
	Inside an average home
50	
40	Residential area at night
30	Soft whisper (at 2 m)
	Inside a TV studio
20	Inside a quiet broadcasting studio
10	
0	Threshold of hearing for a youth

Source: SPCC *Noise Control Guide Data Sheet N 1003 — Typical Noise Levels*. Extracted from *Noise Control Seminar Notes 1976*. Noise Control Seminar for Council Authorised Officers.

Although the Botany site is located in a zoned industrial area and is sufficiently close to Kingsford Smith Airport to expect aircraft noise to contribute to the general noise environment, the proximity to the site of pockets of housing has created a greater awareness of noise and its effects than might be expected in a heavy industrial area.

In 1977 a study was carried out to investigate the sources of noise contributing to the ambient noise levels at residential properties in the vicinity of the ICI site. The general findings of the study were:

- Traffic noise is the major contributor to regional background (L_{90}) noise throughout the daytime to approximately 11.00 pm.
- The L_{10} levels at all test locations are high and are significantly influenced by traffic during day and night. The levels do not fall away to approach the L_{90} background level until after midnight when traffic is at a minimum.
- At the residential boundary in Denison Street after midnight the ambient level of 49-56 dB(A) is primarily due to noise emissions from the ICI site.
- The background noise levels at other test locations after midnight are generally similar or only slightly lower because of industrial noise from other sources.

Thus road traffic noise is a major factor in the acoustic environment of the region, and the contribution of traffic to the total noise level is likely to increase as Denison Street becomes a major link to the new facilities at Port Botany.

Existing noise abatement policies have resulted in a curfew on air traffic and limitations to 'broadband noise' generated by industrial plants. However, little has been done about reducing road traffic noise to appreciably lower levels.

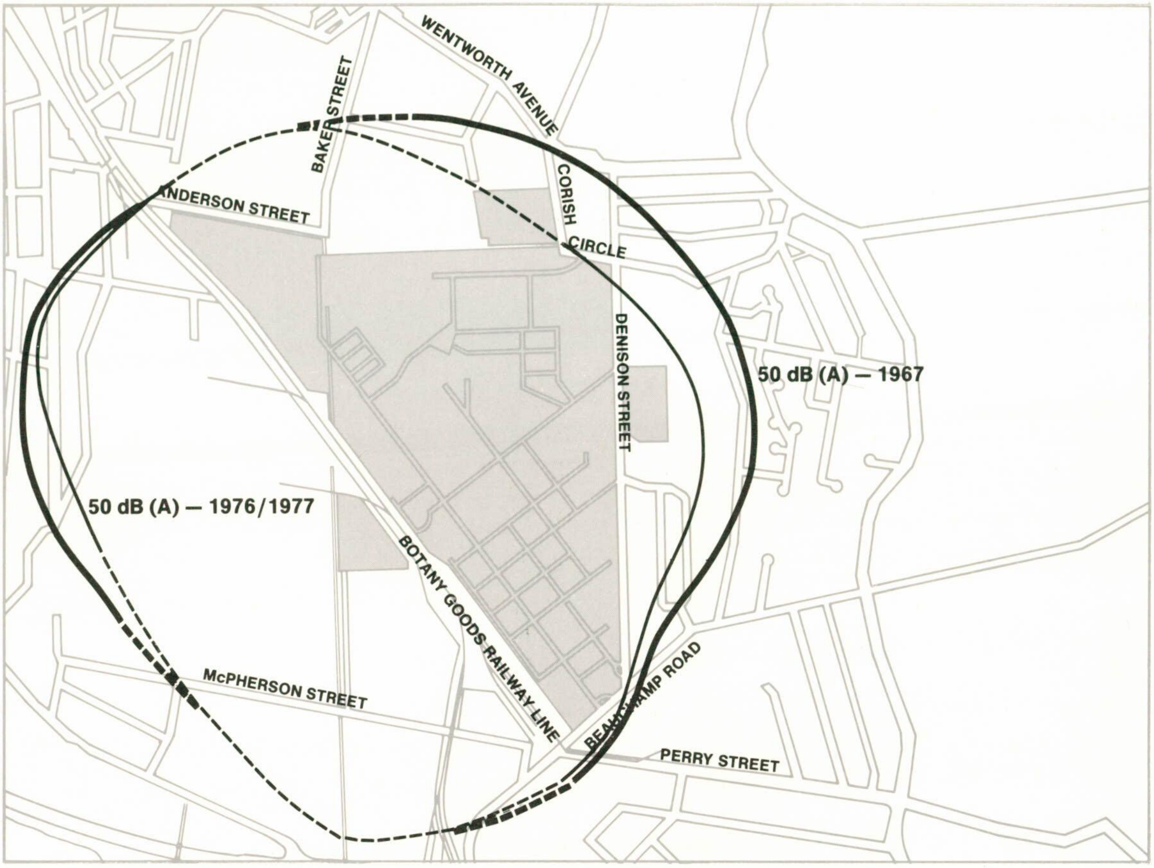
6.2 EXISTING BOTANY SITE NOISE LEVELS AND SOURCES

In 1966, in conjunction with Botany Municipal Council and the Department of Occupational Health it was agreed that noise levels in adjacent residential properties should be restricted to 55 dB(A). Over the ensuing 12 years ICI has followed a specific program of noise abatement. Steps taken have included the addition of silencers and baffles for existing equipment, the specifying of higher acoustic standards for new plant and equipment, elimination or reduction in the use of hooters and alarms, careful siting and shielding of new facilities, and a major acoustic screen landscaping project for the Denison Street and Corish Circle boundaries (as illustrated in Chapter 9).

As a direct result of these actions, noise from the site is now generally steady and broadband and free from tonal and impulse components. A progressive reduction in boundary noise levels has also been achieved even though a significant number of major plant extensions and new plants have been constructed since the program was initiated in 1966.

As part of planning for future development of the Botany site an investigation of all noise sources on the site was again carried out in 1976/77. The technique involved taking noise measurements in and around each plant then computing composite effects at a number of monitoring locations around the site boundary. These computations were checked against actual measurements at the monitoring locations. A ranking was prepared for each location and a comparison of these helped to identify the most effective noise abatement measures.

A comparison between noise contours for 1967 and 1976/77 investigations (Figure 17) show a reduction of L_{90} night time noise levels along Denison Street from 55-64 dB(A) to 50-57 dB(A).



17 NOISE CONTOURS 1967 AND 1976/1977

Following the 1976/77 study a further program of work was embarked upon with the objective of achieving additional reductions from selected high noise equipment.

The monitoring of noise levels on the boundary of ICI's site and in adjacent residential areas has highlighted the influence of weather conditions on noise levels. Industrial operations such as ICI's have a relatively constant day and night sound emission and sound attenuation with distance is very dependent upon wind strength and direction, humidity and temperature.

Along Denison Street, the range is ± 2 dB(A) of the mean for 70% of occasions, but at more distant residential locations is up to ±4 dB(A) for 70% of occasions and greater than ±6 dB(A) for 100% of occasions. Thus one residential location could observe noise levels in the range 44 to 56 dB(A) for the same noise source emission depending on weather conditions.

In 1978 the PEC approved the polypropylene Development Application subject to ICI undertaking 'all reasonable measures over the whole works complex to reduce noise emission in such a manner that there is a progressive reduction in noise to a night time limitation not exceeding 50 dB(A) in adjacent residential properties.' (Appendix 2).

The major noise sources for each Stage II plant have been identified and consideration given to locating them in positions shielded by other parts of the plant and providing appropriate acoustic treatment. The principal noise sources for the Stage II plants and abatement measures to be taken are as follows:

6.3 ETHYLENE PLANT

The proposed Ethylene Plant is located in the centre north of the Botany site approximately 500 m from the nearest residence. Major noise sources and abatement measures are:

Compressors and Turbines

The following measures will be taken to reduce noise emissions:

- Acoustic casings over the turbines.
- Acoustic lagging of pipelines.
- Low noise control valves.
- Silencers in suction and discharge lines.

Furnaces

Experience on the existing ethylene plant, manufacturers' advice and overseas plant experience with the use of burner acoustic suppressors, indicate that furnace noise can be reduced.

Cooling Tower

Noise reductions will be achieved by limiting fan tip speeds, providing acoustic treatment to outlet cones and directing water flow noise away from the boundary.

Air Coolers

Fan noise from these units will be controlled by limiting tip speeds and providing acoustic treatment to outlet cones.

Motors and Pumps

Noise reduction of the plant's pumping equipment will be achieved by using quiet motors fitted with uni-directional fans and/or cooling air inlet silencers. In some cases total enclosures may be required.

Total noise contribution of the equipment in the ethylene plant will be 40dB(A) in the vicinity of the Denison Street/Smith Street intersection.

6.4 ETHYLENE OXIDE AND DERIVATIVES PLANTS

The centre of the existing ethylene oxide plant is located approximately 200 metres from the nearest residence on Denison Street. Stage II will involve the installation of additional pumping equipment in several areas of the plant. The main noise sources will be the electric motors driving these pumps. By appropriate equipment selection, the specification of low noise motors and in some cases the fitting of acoustic enclosures, the noise contribution will be 40 dB(A) at the south end of Denison Street.

6.5 POLYTHENE PLANT

The polythene plant is located in the centre of the Botany site approximately 500 metres from the nearest residence. Major noise sources and abatement measures are:

Compressors

The noise from compressors will be controlled by:

- Lagging of pulsation bottles, piping and non-return valves.
- Oil pumps firmly embedded at foundation level.
- Jacketed pipe coolers designed to have maximum rigidity.
- Orientation of compressors, drive motors and coolers to mutually shield each other.
- Appropriate selection of drive motors with enclosures and silencers on motor cooling fans.

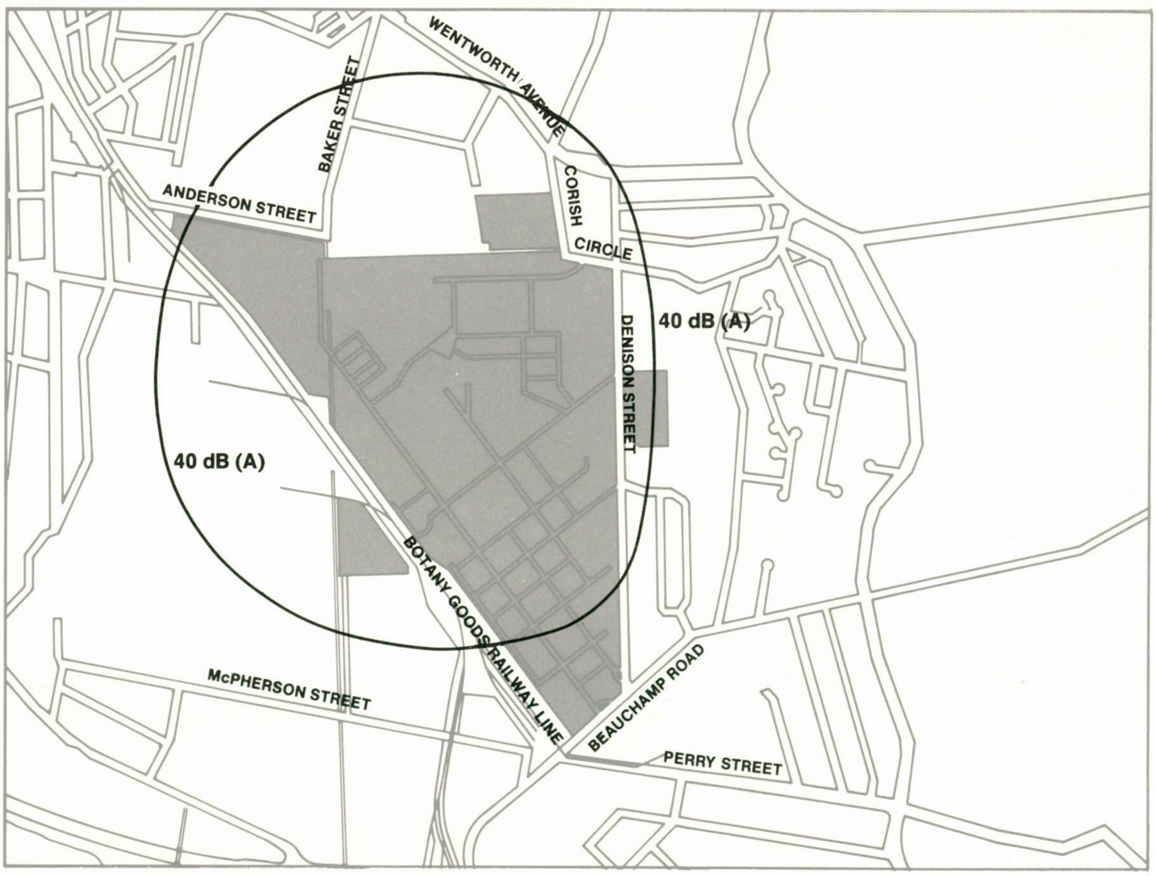
Cooling Tower

Noise reductions will be achieved by limiting fan tip speeds, providing acoustic treatment at the outlet cones and directing water flow noise away from the residential boundary.

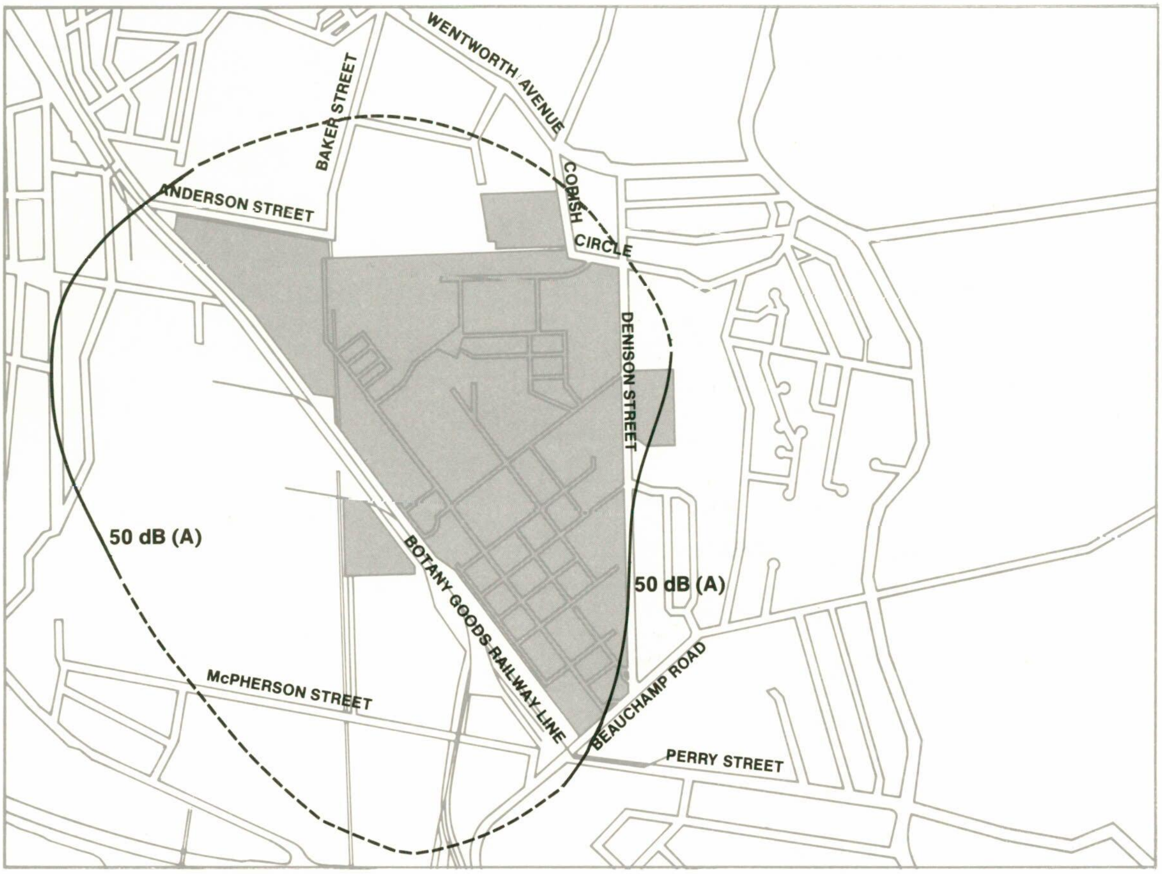
The total noise contribution of the equipment in the polythene plant will be 35-36 dB(A) in Denison Street.

6.6 NUMBER 4 BOILER

The boiler plant is located in the centre west of the Botany site, approximately 600 metres from the nearest residential area. The major noise sources are the forced draft and induced



18 STAGE II SOUND EMISSION CONTRIBUTION CONTOURS



19 ESTIMATED NOISE LEVEL CONTOURS ON COMPLETION OF STAGE II EXPANSION

TABLE 12 **Predicted Noise Contributions and Levels**

		Denison Street/Smith Street Intersection				Brighton Street				Denison Street (south end)			
Stage II Plants	L_w dB(A)	m	ISL	A	L_p dB(A)	m	ISL	A	L_p dB(A)	m	ISL	A	L_p dB(A)
Ethylene	116	550	63	13	40	920	67	12	37	850	67	16	33
Ethylene Oxide and Derivatives	104	780	66	18	20	1300	70	15	19	200	54	10	40
Polythene	114	690	65	14	35	880	67	12	35	650	64	14	36
Number 4 Boiler	104	780	66	15	23	850	66	12	26	650	64	14	26
TOTAL CONTRIBUTION OF STAGE II PLANTS					41				39				42
Anticipated Boundary Background L_{90} Noise level, excluding the existing ethylene plant.					49				49				49
TOTAL NOISE LEVEL					50				50				50

Key
- L_w Sound power value at source.
- m Distance in metres.
- ISL Inverse square law attenuation.
- A Air absorption, screening, ground. effects attenuation.
- L_p Sound pressure level — dB(A).

draft fans and feed water pumps. Acoustic treatment involving the fitting of silencers on fans, lagging of pipes and screening of the feed water pumps will ensure that the noise output from the proposed fourth boiler does not make a significant contribution to the overall site noise level.

6.7 NET NOISE EFFECT

The acoustic assessment of the proposed plant extensions has indicated that their individual noise contribution in adjacent residential properties should not exceed 40 dB(A), as shown in Table 12 and illustrated in Figure 18. The overall level of noise emission from the site is predicted to be 50 dB(A) in adjacent residential properties, as shown in Table 12 and in Figure 19.

Based on this assessment and the noticeable progress of its current noise abatement programme, ICI is confident that the proposed expansion will have little effect on existing noise levels around the Botany site.

A formal submission for approval under Section 27 of the Noise Control Act, 1975 will be made to the SPCC when the required supporting documentation from equipment suppliers is available.

LIQUID &
SOLID WASTES

Chapter 7 LIQUID AND SOLID WASTE

7.1 LIQUID EFFLUENT

Three basic liquid effluent streams are associated with the petrochemical plants proposed in Stage II. These are:

- domestic sewage.
- process wastes.
- stormwater.

7.2 DOMESTIC SEWAGE

Domestic sewage from offices, toilet and change rooms will be discharged to the Metropolitan Water Sewerage and Drainage Board (MWS&DB) sewer system.

7.3 PROCESS WASTES

Stage II plant process wastes, which could include chemical effluent and cooling tower blowdown, will be collected, treated and discharged to the sewer. The treatment will produce an effluent quality which complies with the MWS&DB standards set out in Table 13, using the processes described in the following sections.

TABLE 13 **Standards for Acceptance of Liquid Trade Waste to Sewers**

Temperature	Not to exceed 38°C if the waste contains grease. Otherwise not to exceed 48°C.
pH	To be in the range 6.8 to 10.0.
Grease	Not to exceed 200 mg/l (milligrams/litre).
Bio-chemical Oxygen Demand (5 days)	Not to exceed 600 mg/l.
Suspended solids	Not to exceed 600 mg/l.
Sulphides	Not to exceed 10 mg/l.
Toxic Metal or Compounds (the discharge to be subject to prior approval in each case) — not to exceed:	
	mg/l
Arsenic	100
Cadmium	30
Chromium	100
Cobalt	200
Copper	5
Cyanide	7
Lead	10
Nickel	100
Zinc	30
Organic herbicides	5
Organic insecticides	5

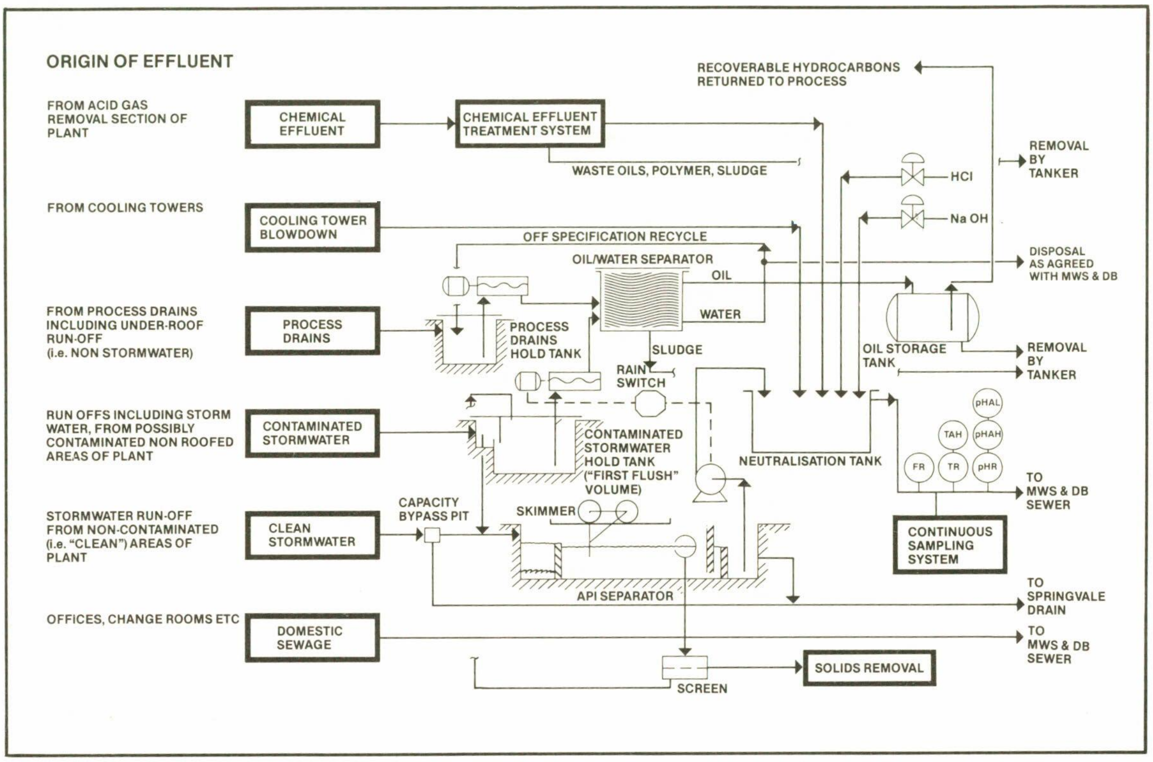
1 No mercury may be discharged.

2 When two or more heavy metals are discharged together the total concentration shall be limited to that applicable to the most toxic component, except where otherwise authorised.

3 Volatile solvents shall not be discharged unless miscible with water and then only with special approval. The use of solvents in discharging the contents of grease traps to the sewer is prohibited.

Ethylene Plant

A typical effluent schematic diagram for an ethylene plant is shown in Figure 20. The process waste stream consists of a chemical effluent from the acid gas removal section of the plant, cooling tower blowdown and process drains including wash-down water from within roofed areas. This waste water will contain dissolved organics and suspended solids. A suitable collection tank will be constructed for collection of these wastes and after suitable pH control they will be discharged direct to the MWS&DB sewer main.



20 WASTE WATER TREATMENT PROCESS

Ethylene Oxide and Derivatives Plants

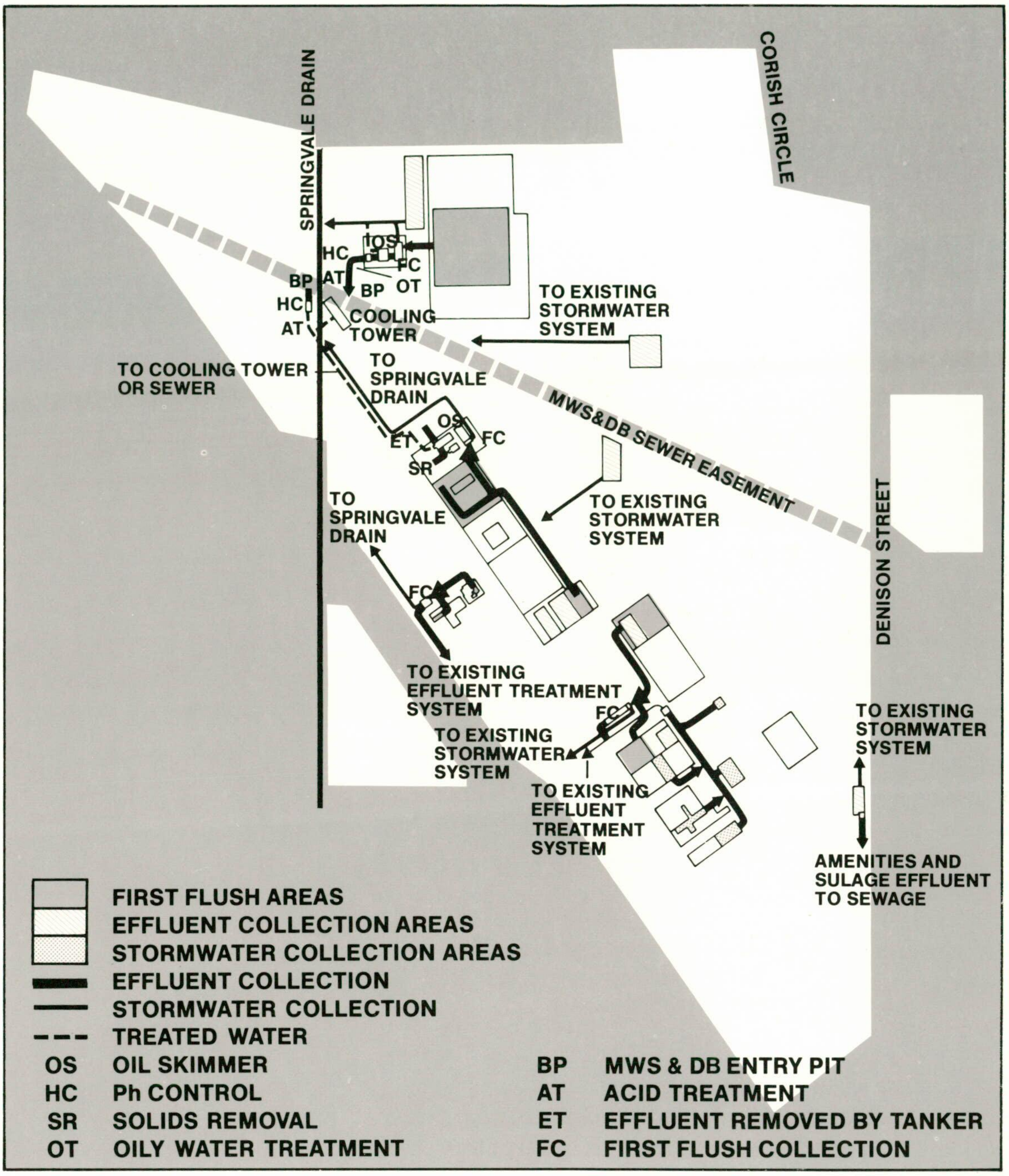
The process waste stream will contain some water soluble non-ionic surfactants, glycol ethers and other dissolved organics with some carbonate solution. The composition of the waste water will be the same as for the existing plant, but there will be an increase in volume of about 50%. Product storage tank areas will be appropriately bunded to guard against any spillage draining to the stormwater system.

Polythene Plant

The process waste stream consists primarily of wash-down water from the plant and will contain some oil, catalyst residues and polythene particles. A special provision will be a sump tank to collect run-off and spillage in the catalyst area. Oils and solids will be separated and disposed of in an approved manner (see Section 7.5).

Number 4 Boiler

The process waste stream will contain excess water from ash quench, floc blowdown from the demineralisation plant and some regeneration chemicals. Control of pH will be provided to correct any acidity/alkalinity present. The chemical storage area is bunded and will drain to an effluent interceptor pit within the treatment plant.



21 STAGE II SITE DRAINAGE PROPOSALS

Trade Waste Applications will be submitted to the MWS&DB for each plant. Approvals will also be sought from the Clean Waters Branch of the SPCC for the stormwater drainage system and the Metropolitan Waste Disposal Authority for the disposal of oily residues and sludges removed from settling pits.

7.4 STORMWATER DRAINAGE

Stormwater will be considered in two categories: firstly runoff from contaminated areas where there is a possibility of stormwater containing oil or particulate material; and secondly runoff from clean areas. The areas designated 'contaminated' will be separated from areas designated 'clean' by suitably grading the kerbing to direct runoffs into the appropriate system. Contaminated stormwater will discharge into a hold tank where it will be treated prior to disposal by means to be established with the MWS&DB and to the satisfaction of the SPCC.

After collection of the first flush of contaminated stormwater, subsequent stormwater falling on these areas will be automatically diverted to the stormwater runoff system.

The clean stormwater system will collect stormwater runoff from non-contaminated areas as well as stormwater in excess of the first flush volumes. This clean stormwater will discharge via a sand interceptor into a separator. During dry weather any flows entering the separator will be discharged along with the process waste stream to the sewer, thus ensuring no dry weather discharge to the Springvale Drain. During wet weather a rain switch will stop the pumps and stormwater will pass through the separator and into Springvale Drain. Underflow and overflow baffles will be provided at the outlet end of the separator. The effluent pumps will start again at a specified time after the rain has stopped. Any solids will be screened out of the skimmings from the separator and discharged into an industrial waste container. A by-pass pit will be located upstream of the separator to by-pass clean stormwater directly to Springvale Drain during periods of heavy rain. The stormwater drainage system is shown diagrammatically in Figure 21.

7.5 SOLID WASTE

Ethylene Plant

The main solid wastes will be catalysts and desiccants which have reached the end of their useful lives. These materials are used in the process in fixed beds within pressure vessels and their purpose is to remove water from the gas stream and to promote chemical reactions.

Approximately 120 cubic metres will be replaced each year. Similar materials have been in use in the existing ethylene plant since 1967 and present no disposal problems when used as landfill.

Ethylene Oxide and Derivatives Plants

Every two to three years approximately 30 tonnes of non-toxic spent catalyst will be sold to a smelter company.

Approximately 12 tonnes per annum of diatomaceous earths used in the surfactants manufacture as a filter aid will be disposed of by land fill. The filtered material is a non-toxic inorganic salt.

Polythene Plant

Although there is a need to dispose of a small quantity of oil contaminated polythene granules from the existing polythene plant, the new plant will incorporate design modifications to minimise this waste. Apart from the usual packaging wastes there will be no other major solid wastes.

Number 4 Boiler

The principal solid waste is ash from the boiler and this will be generated at the rate of up to 25 tonnes per day. The ash, which will be wet and therefore not pose a dust problem, will be disposed of at an approved waste disposal site.

TRANSPORT

Chapter 8 TRANSPORT EFFECTS

8.1 INTRODUCTION

The ICI Botany site is bounded by Beauchamp Road to the south, Denison Street to the east, Corish Circle and Anderson Street to the north and the Sydenham-Botany railway to the south-west. Denison Street/Beauchamp Road are classified main roads (MR610) and provide direct links to Botany Road and Wentworth Avenue which in turn distribute traffic to most parts of the region (Figure 22). The site and environs are served by an adequate main road system but traffic authorities have noted a requirement for additional road capacity in the vicinity of the airport.

8.2 EXISTING TRAFFIC PATTERNS AND VOLUMES

Beauchamp Road carries an estimated 7800 vehicles per day (vpd) north of Botany Road to Denison Street, while Denison Street has a volume of 5700 vpd. Since 1975 the increase in traffic use of these roads has been 5.2% and 8.8% per annum respectively although the closure of the Beauchamp Road-Botany Road intersection for the construction of an overbridge has probably influenced these figures. A recent survey has shown peak hour volumes of 920 vehicles per hour (morning) and 1070 vehicles per hour (afternoon) for Denison Street and 440 vehicles per hour (morning) and 580 vehicles per hour (afternoon) for Beauchamp Road.

By comparison Wentworth Avenue carries 22400 vpd and Botany Road near Beauchamp Road intersection about 13700 vpd building up to over 30000 vpd north of General Holmes Drive. Some local streets such as Smith Street and Corish Circle carry fairly high traffic volumes (e.g. afternoon peak hour of 410 and 260 vehicles respectively) which could be attributed to parking patterns and avoidance of major intersections. However, all intersections within the vicinity of the site are well within traffic capacity limits even at morning and afternoon peaks.[1]

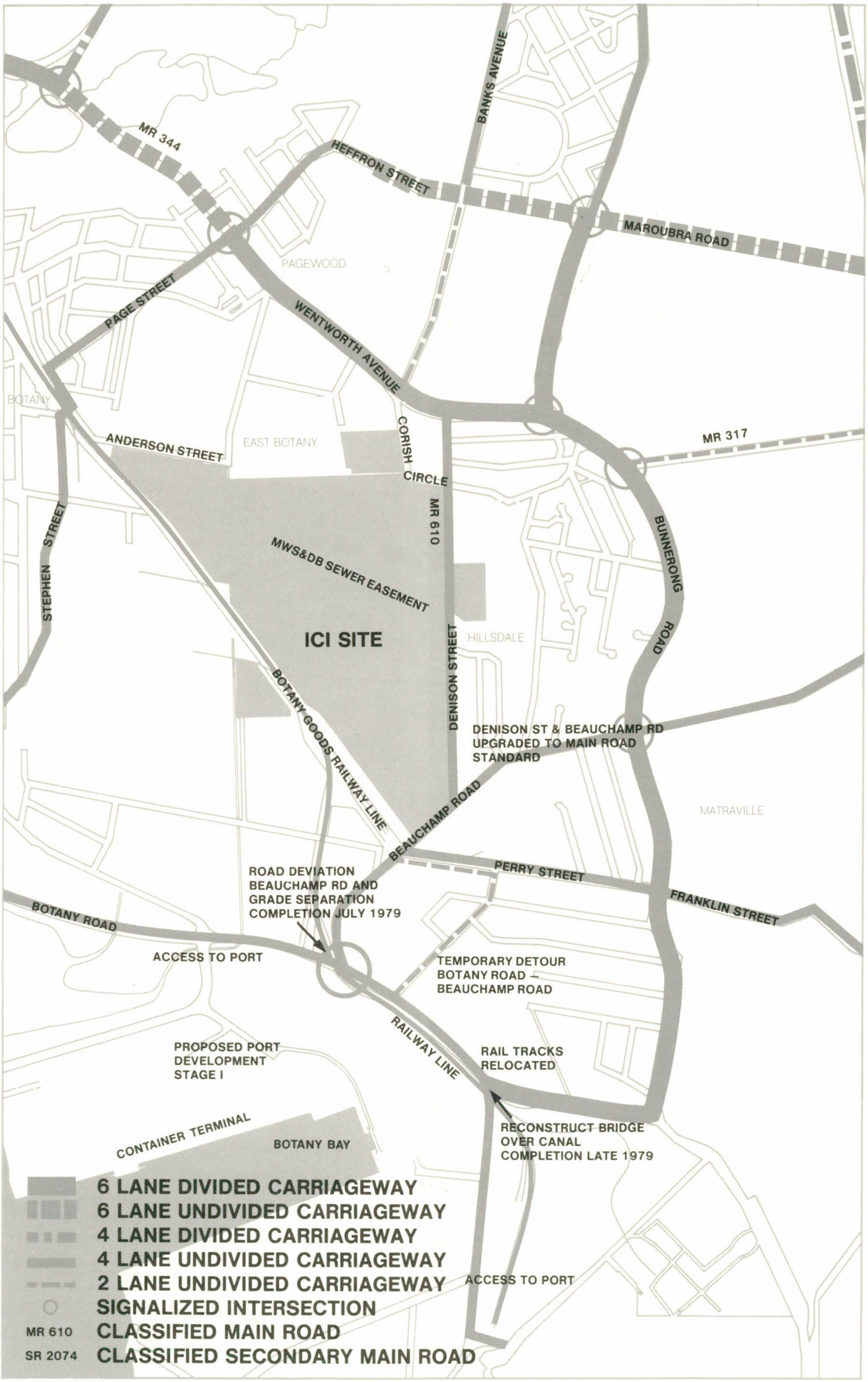
8.3 EXISTING SITE LAYOUT, PARKING AND MOVEMENT PATTERNS

Figure 23 shows the location of existing and proposed off-street parking areas and entrances to the ICI site. Over 1400 parking spaces are provided on-site against an estimated demand for 1060 spaces (580 for staff and visitors; 480 for construction workers).

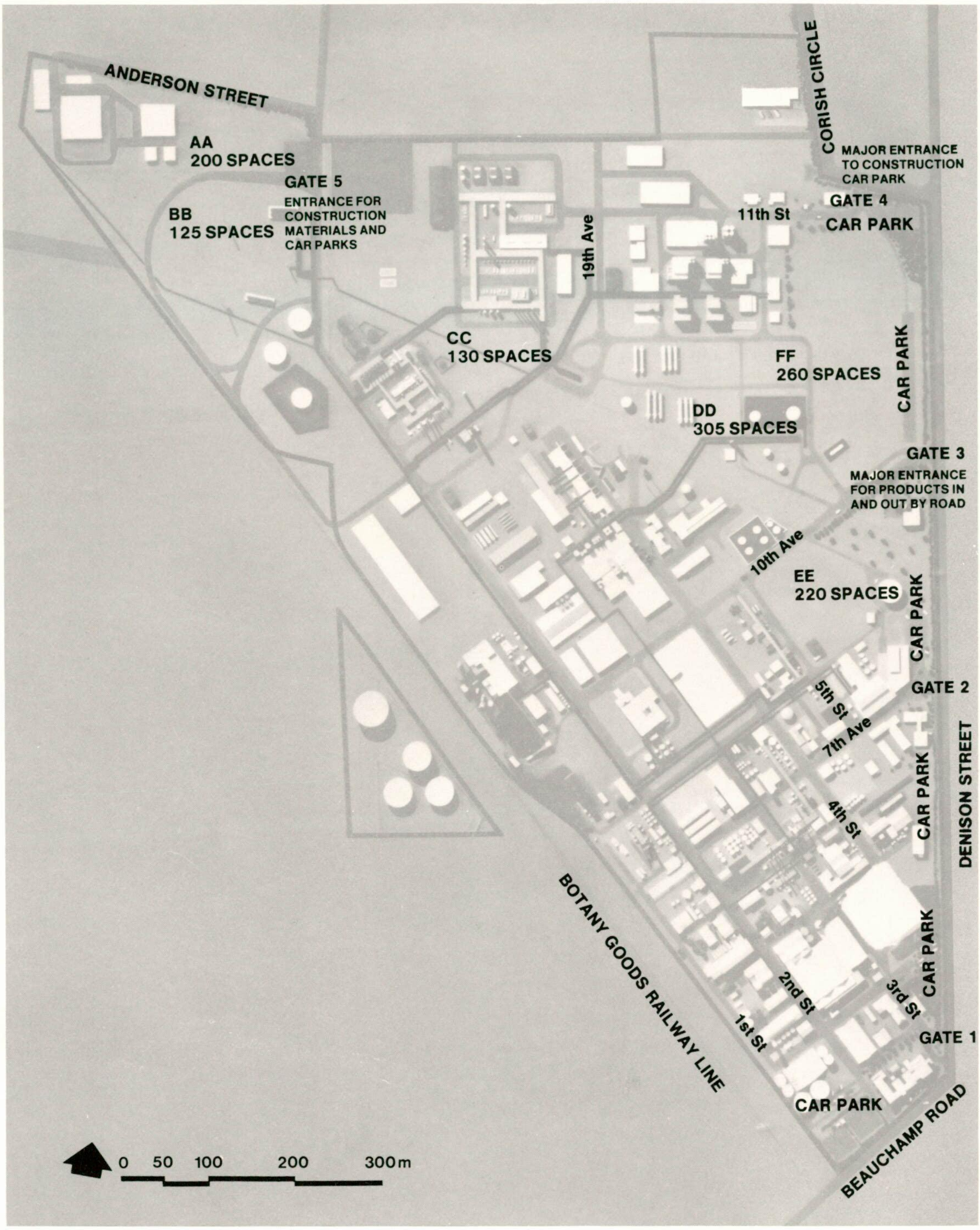
Gates 3 and 4 are the major vehicular entrances with Gates 1 and 2 permanently closed to traffic. This means that most of the heavy traffic is channelled through two main access points to the public road networks. However, most car parks have their own crossovers to the streets and their use is almost exclusively in the morning and afternoon peaks.

The activities of the site generate about 4000 car and light commercial vehicle trips per day (95% between 6.30 am and 6.00 pm) and approximately 570 truck trips per day (only about 15% outside of normal working hours). Peak arrivals in the morning are about 850 vehicles per hour and afternoon departures 500 vehicles per hour. Of all truck movements about a quarter are related to construction works and the majority of all truck trips (approximately 75%) are by way of Wentworth Avenue. The total number of truck movements increases by an additional 400 trips per day from time to time by the delivery of salt to the site.

1 A calculation based on the 'Sum of Y method' shows the worst intersection to be Wentworth Avenue-Banks Avenue-Corish Circle with a peak hour value of 0.45 compared with the tolerable design capacity of 0.70.



22 BOTANY AREA TRANSPORT NETWORK



23 SITE ENTRANCES AND OFF STREET PARKING

8.4 BASIS FOR ESTIMATED CHANGES IN TRAFFIC MOVEMENTS

Table 14 shows the estimated increase in the site workforce during the main period each day in Stage II. The most significant impact on traffic will be during the construction of Stage II when there will be an average of 350 more personnel on site during the day shift and a peak of 1200 more than in April 1979 when Stage I was nearing completion.

TABLE 14 **Estimated On-Site Personnel Before and After Completion of Stage II Expansion Program (7.00 am-3.00 pm Typical Working Days)**

Work Force Category	During Construction of Stage I (Polypropylene) Apr. '79-Dec. '79	After Commissioning of Stage I (Polypropylene) Jan. '80-June '80	Daily Average During Construction of Stage II July '80-Mar. '84	After Commissioning of Stage II April 1984-
A ICI Personnel				
● daywork	765	822	822	903
● shiftwork (8.00 am-3.00 pm)	123	134	134	156
SUBTOTAL	888	956	956	1059
B Contract Employees (maintenance and construction)	570	200	850	230
TOTAL ON-SITE PERSONNEL	1458	1156	1806	1289
C Change from April 1979	0	−302	+348	−169
● ICI Personnel	0	+8%	+8%	+19%
● Contract	0	−65%	+49%	−60%
TOTAL	0	−21%	+24%	−12%

When Stage II is fully operational, ICI estimates that the volume of raw materials and products to be transported by road will have increased by about 26%. ICI has initiated an investigation into the role that direct rail transport into and out of Botany site could play in reducing road traffic in the immediate environs. The study has shown that it is technically feasible to accommodate both a coal siding and a container terminal facility in the area immediately adjacent to the Botany site. Discussions have been held with the Public Transport Commission (PTC) on the viability of despatch of products by rail. A key factor is the need to despatch products from the site at a sufficient rate and quantity to demand a full train per shipment. This has led to further investigations with a freight forwarder on the possibility of a general freight terminal being located at Botany. It is ICI's intention to undertake detailed investigations of both facilities to determine if there is an economic and operational justification to implement these proposals.

8.5 PROJECTED CAR PARKING REQUIREMENTS

Table 14 set out the number of employees on-site between 7.00 am and 3.00 pm excluding shift overlap. It thus represents the maximum potential for parking during those hours if every employee travelled singly and by car. This is not the case however, and by using estimates of car to employee ratio and taking account of absence on recreation and sick leave, the peak projected car parking requirement between 2.30 pm and 3.15 pm (that is during the shift overlap period), is estimated in Table 15.

Prior to the commencement of Stage II construction and after its completion, ample off-street parking will be available and will exceed the requirements of the Botany Municipal Council. However, the forecasts suggest a likely shortfall of 200 spaces on average with a deficiency of almost 1000 during the peak construction phase.

TABLE 15 **Estimated Peak Car Parking Demand (2.30 pm-3.15 pm Typical Working Day)**

Workforce Category	Apr-Dec 1979	Jan '80- Jun '80	Jul '80- Mar '84	Apr '84-
ICI Dayshift & Daywork	736	736	736	815
ICI Afternoon Shift	134	134	134	156
Contract	182	765	1532	182
TOTAL	1052	1635	2402	1153

Investigations have shown that about 1160 additional car spaces could be provided in temporary car parks for construction workers. These would be located in the six areas shown on Figure 23. Four of these proposed temporary car parks are on the MWS&DB easement and its use will require the approval and cooperation of the Board.

In order to better disperse construction traffic it is proposed that areas AA, BB and CC be prepared first and used during construction of the ethylene plant. Entry and exit is proposed by way of Baker and Anderson Streets to the arterial road system.

8.6 PROJECTED TRAFFIC GENERATION

When Stage II is operational, the site will generate about 450 vehicle arrivals per hour in the morning peak and 520 departures per hour in the afternoon peak. These figures are in fact noticeably less than the corresponding figures for April 1979 when the large number of contractors and construction workers on site completing Stage I were added to the trips generated by permanent employees.

In early 1983, during the peak of Stage II construction activity, up to 1300 arrivals could be expected in the morning peak hour (6.30 am to 7.30 am). Although these peak hour conditions are well below the tolerable capacities of intersections in close proximity to the site, the following steps could be taken to minimise the impact of the traffic generated by the peak construction workforce.

- Early preparation of car parks AA, BB and CC and the restriction of construction traffic to Baker and Anderson Streets.

- Early improvements, including line marking, to the existing car park between Gates 3 and 4 (these steps should ensure traffic movement in Denison Street and Corish Circle does not exceed April 1979 levels).

- Introduction of staggered starting and finishing times for construction workers.

- Preparation of parking areas DD and EE with access from Gate 3 for use during the 1983 construction peak.

An additional site entrance, with a full-time gatekeeper and weighbridge, will be provided in Corish Circle to serve the polypropylene and new ethylene plants.

These measures should accommodate the additional traffic generated by the construction of Stage II, assisted by better traffic distribution resulting from improvements to Botany Road and the opening of the new foreshore road.

Chapter 9 VISUAL EFFECTS

9.1 INTRODUCTION

Individual perceptions and values make it difficult to evaluate aesthetic effects. However, based upon the anticipated design of Stage II, a qualitative analysis has been carried out considering the following:

- The existing regional and local visual environment.
- Current controls, standards and guidelines which affect the appearance of new buildings in Botany.
- The existing visual character of the ICI site and changes resulting from Stage II.
- Techniques for ameliorating adverse visual effects.

The photographs of the model of the site and Stage II plants (Figures 5, 6, 7, 9 and 11), and the artists' impressions (Figures 24, 25, 26 and 27), illustrate the Stage II plants in as much detail as is available at the time of a development application.

9.2 REGIONAL AND LOCAL CONTEXT

ICI site lies within the Botany Bay visual catchment, an area defined by the SPCC[1] as the 'landscape visible from (Botany Bay's) shores and waters'. The extent of the comparatively flat coastal plain associated with Botany Bay results in quite a large catchment enclosed by the Miranda-Cronulla ridge to the south, the Forest Road ridge line to the west and less well defined boundaries to the north as the land rises gently towards the city and eastern suburbs of Sydney. Because of this extent, the catchment contains most land uses typical of an urban area, but the northern sector, including the ICI site, is dominated by industrial, transportation and port activities and its general visual character is established by these uses. This sector is regarded as 'one of the most prominent landscapes of the Bay area because of the height and scale of the industrial structures . . . (but) what may be described as poor housekeeping of both private and public property is a major visual problem.'[2]

The ICI structures are visible from a number of distant vantage points, contributing to the general industrial skyline when viewed from Brighton-le-Sands and the near port revetment in particular.

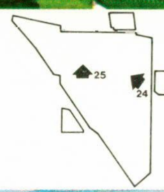
The immediate vicinity of the site is predominantly industrial with some pockets of residential land. Large tracts of vacant land and the general topography of the area result in the site being visible from parts of the nearby residential areas and from major roads. The immediate residential neighbours of ICI, along Denison Street, are the least likely to be visually affected by Stage II because their skylines are generally the existing peripheral installations on the north-east boundary and short range views will be effectively screened by landscaping along Denison Street.

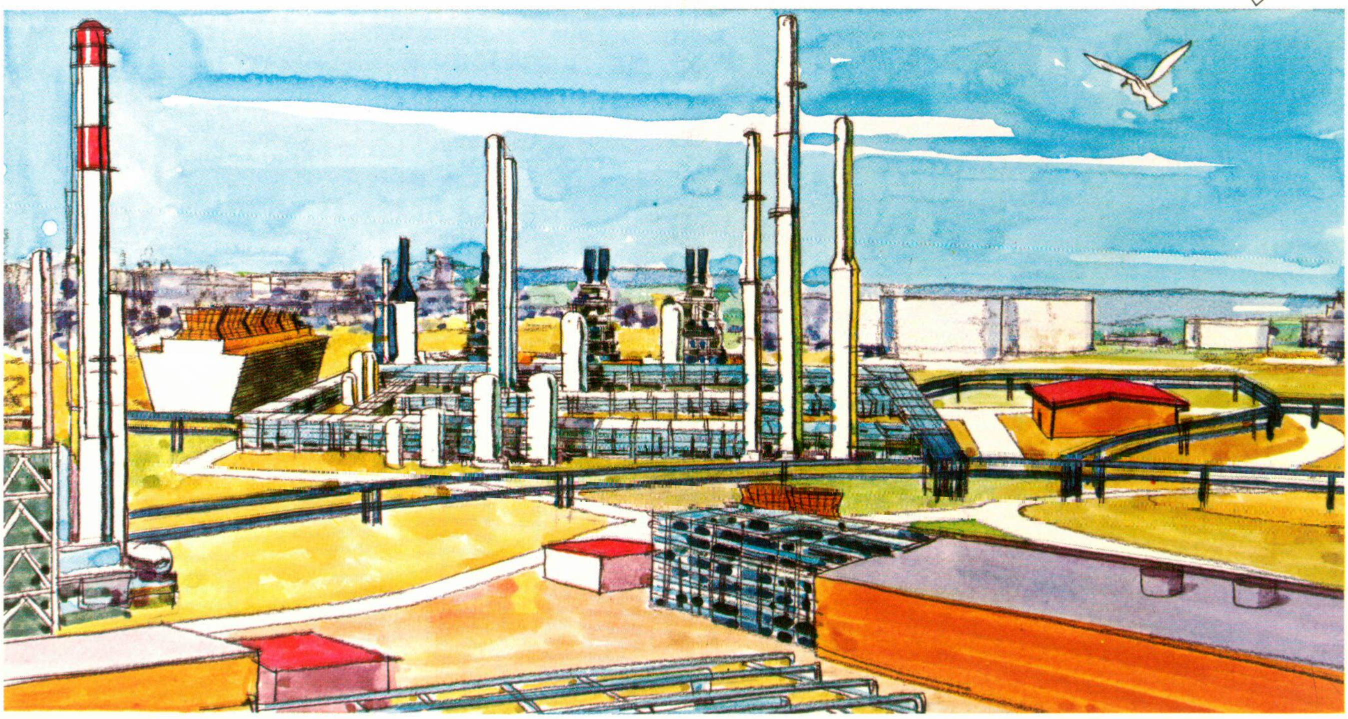
Controls, Standards and Guidelines for Visual Appearance

Few planning controls relating to visual aspects of development exist apart from landscaping conditions and a requirement to consider the probable aesthetic appearance of the land

1 State Pollution Control Commission of N.S.W. *The Landscape of Botany Bay: A Visual Study*, 1978, p 6.
2 SPCC, ibid, pp 156 and 160.

24 IMPRESSION OF THE PROPOSED ETHYLENE PLANT FROM DENISON STREET





25 AERIAL VIEW OF THE PROPOSED ETHYLENE PLANT (LOOKING NORTH)

when viewed from a main road, railway or public reserve. When assessing a Development Application, the Botany Municipal Council has guidelines for new industrial development as a whole and in its visual survey the SPCC has drafted some general guidelines for the visual aspects of new development. The SPCC visual survey notes, among visual problems in the Botany Industrial Area, that 'many industrial installations have untidy grounds with no planting or tree cover, and storage areas visible from the road, (whilst) many industrial buildings are visually unattractive because of poor design and unimaginative colour schemes.'[1] However, apart from promoting a more sensitive use of colour as a tool for improving the regional environment, no specific aesthetic guidelines for industrial buildings in Botany are suggested.

9.3 EXISTING VISUAL CHARACTER OF THE SITE

Like many petrochemical plants the Botany site has developed in stages and has a visual character of functional large-scale buildings, storage tanks, open-structured plant and equipment and a number of vertical elements such as the boiler stacks and distillation columns. The visual character of some of the existing major plant elements is shown in the frontispiece and the photographs showing the development of the site since 1945 (Figure 4).

9.4 FORM AND GENERAL CHARACTER OF STAGE II

The general character of Stage II will be in keeping with existing facilities on the site. The ethylene and ethylene oxide plants will consist of outdoor elements connected by piping while the existing boiler house will be extended in its present form and a further stack (the fourth) will be added. The sites of Stage II plants have been chosen on the basis of safety considerations, availability of land and linkages with other plants. Vertical elements in the Stage II plants will be about the same height as the existing facilities.

Figures 24, 25, 26 and 27 are artists' impressions of parts of the Stage II plants. Figure 24 shows the ethylene plant as viewed from Denison Street near the main entrance, but Figures 25, 26 and 27 are views of plants from the interior of the site as existing development on the site will screen all but the tallest elements of Stage II from nearby streets. Figure 25 shows a general aerial impression of the ethylene plant as viewed from the south. Figure 26 is a view of the proposed number 4 boiler, again from the interior of the site, and Figure 27 is a view of a typical section of the proposed ethylene oxide and derivatives expansion.

The polythene plant will consist of a group of conventional industrial buildings with several silos located above the roof line and will not be dissimilar in appearance to the existing polythene plant, which is shown in Figure 28.

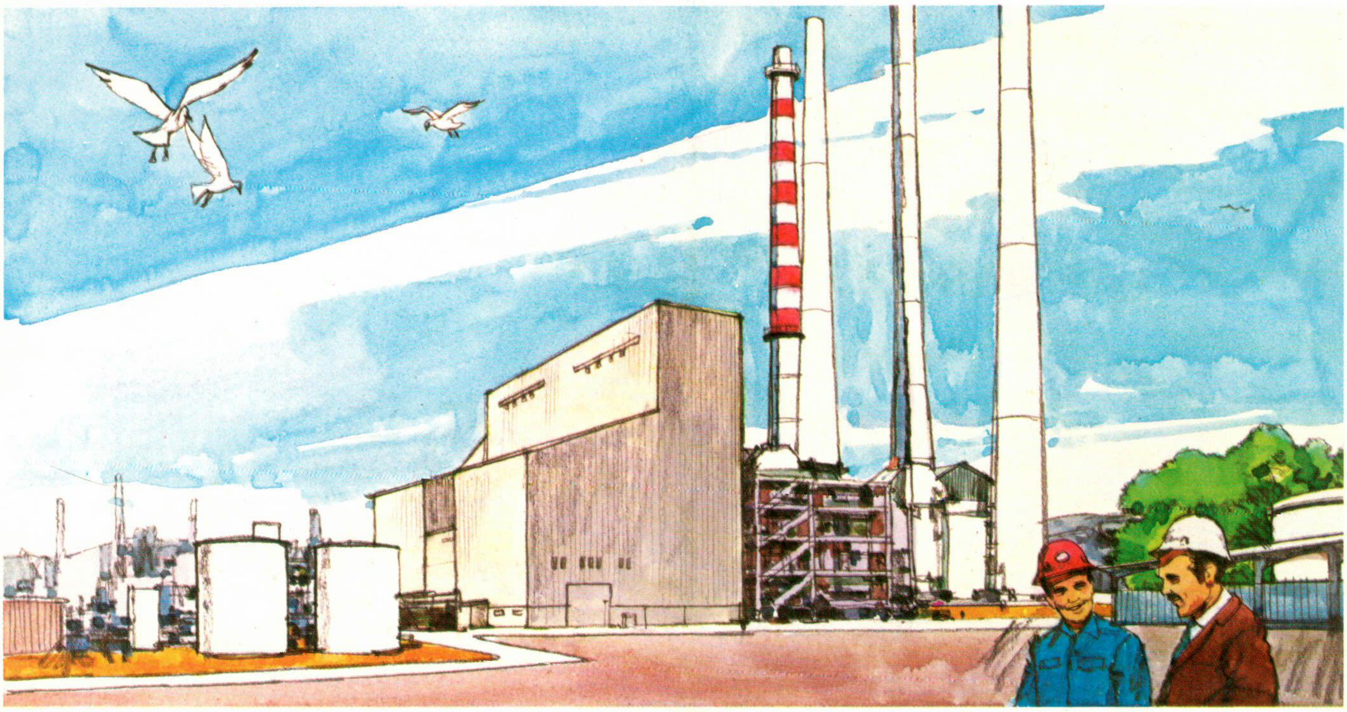
9.5 TECHNIQUES FOR REDUCING VISUAL IMPACT

Given the constraints of siting and functional building form, few techniques are available to change the visual effect of Stage II. The selective use of colour and landscaping can however minimise the apparent bulk of a structure or screen areas of plant from view.

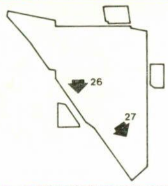
Use of Colour to Reduce Visual Impact

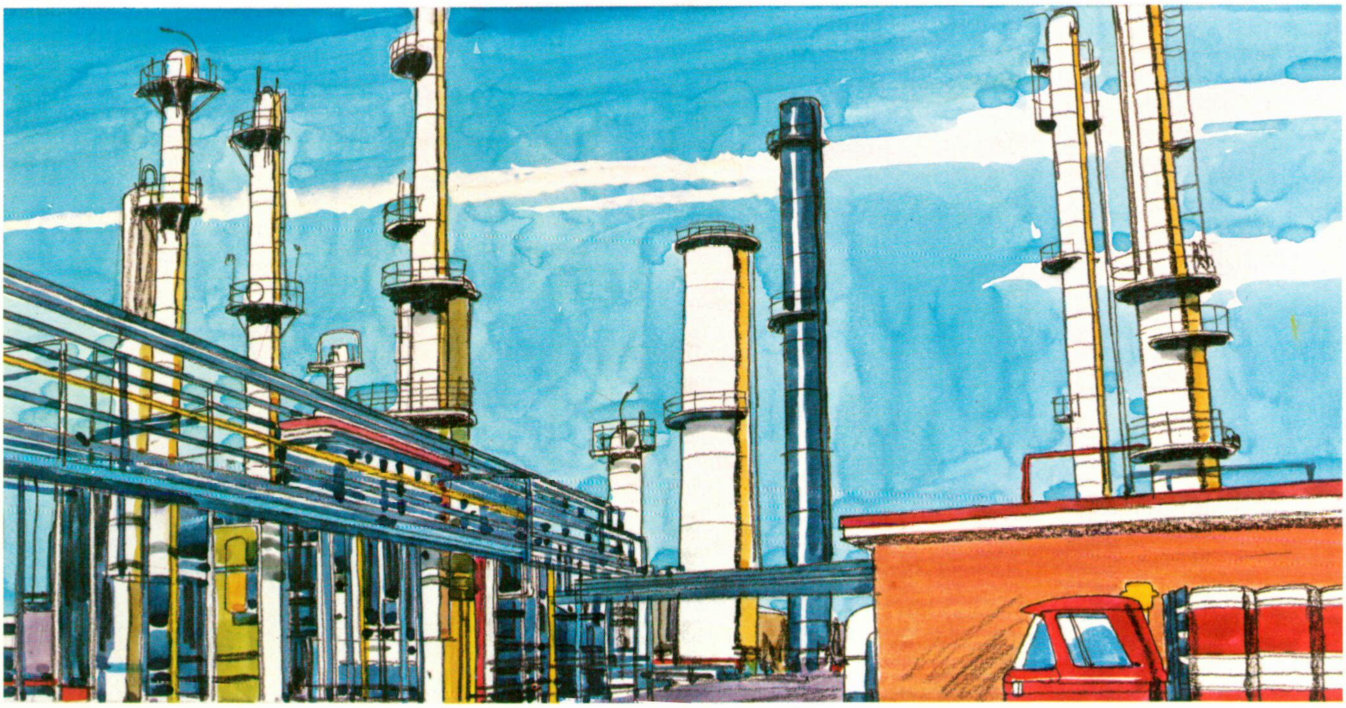
The taller of the proposed new installations will be viewed against a backdrop of sky so the choice of colour can affect their visual impact. To reduce this impact, colour selection will, where feasible, range from mid shades for lower parts to very light shades for upper extremities. If plants are viewed against a backdrop of vegetation, the visual impact of the

1 SPCC 1978 ibid p 460.



26 IMPRESSION OF THE NUMBER 4 BOILER EXPANSION





27 IMPRESSION OF SECTIONS OF THE PROPOSED ETHYLENE OXIDE AND DERIVATIVES PLANTS EXPANSION

28 BUILDINGS AND STRUCTURES TYPICAL OF THE PROPOSED POLYTHENE PLANT

vegetation will be enhanced by the selection of similar colour ranges and values for the structures. There are, however, limits to the application of these principles as many elements of plants require safety colours or in some cases cannot be painted at all.

Landscaping

Landscaping can play a major role in softening the impact of industrial plants and in screening industrial activities from adjacent areas. ICI has been implementing a comprehensive landscaping program, commencing with the landscape improvements associated with Stage I.

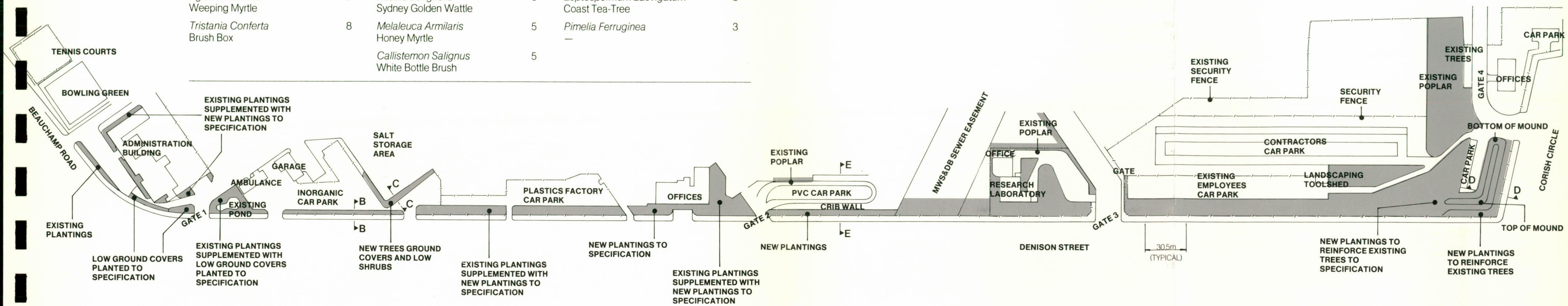
The extent of existing and proposed landscaping along Denison Street and Corish Circle is shown in Figure 29. These plans will be extended along Corish Circle and Anderson Street as part of Stage II. Figure 30 shows the results of the first stage of the landscaping program along Denison Street. At the time these photographs were taken, planting had been established for about 15 months. As the landscape matures it will provide a highly effective screen along the boundaries which are viewed from residential areas.

Landscaping will be carried out within the interior of the site where safe and appropriate.

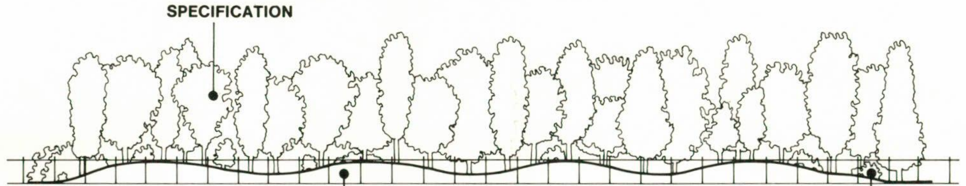
29 STAGE I AND II LANDSCAPING PROPOSALS

SCHEDULE OF PLANTINGS

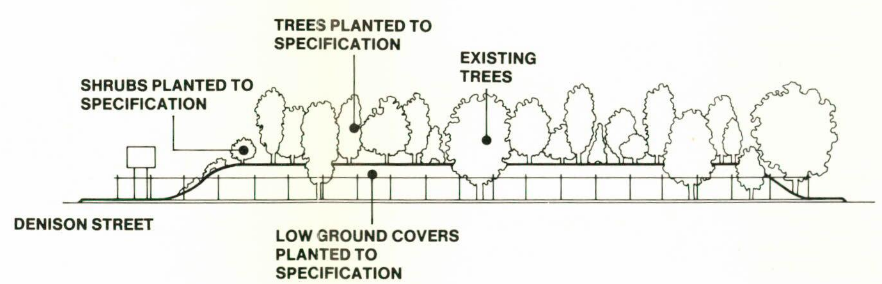
TREES	ht/m	TREE/SHRUBS	ht/m	SHRUBS/GROUND COVERS	ht/m
Melaleuca Quinquenervia Paper Bark	8m	*Banksia Ericifolia* Heath Banksia	4	*Westringie Fruiticosa* Coast Rosemary	1.5
Eucalyptus Robusta Swamp Mahogany	7	*Casuarina Distyla* She Oak	4	*Senecio Lautus Maritimus* —	1
Agonis Flexuosa Weeping Myrtle	8	*Acacia Longifolia* Sydney Golden Wattle	3	*Leptospermum Laevigatum* Coast Tea-Tree	3
Tristania Conferta Brush Box	8	*Melaleuca Armilaris* Honey Myrtle	5	*Pimelia Ferruginea* —	3
		Callistemon Salignus White Bottle Brush	5		



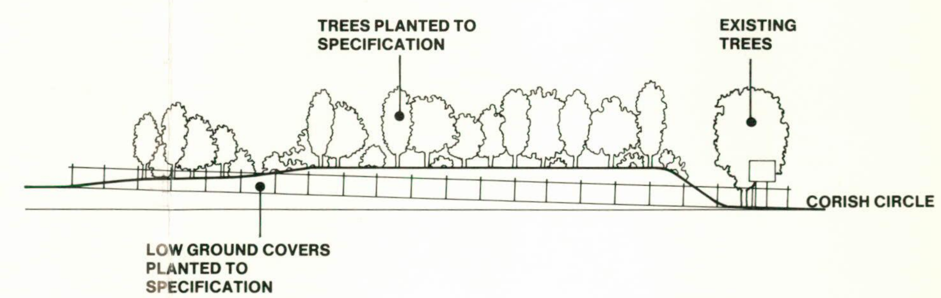
PLAN VIEW



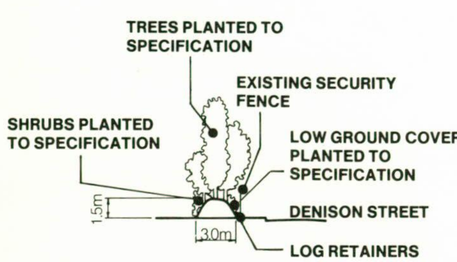
TYPICAL ELEVATION LOOKING WEST FROM DENISON STREET



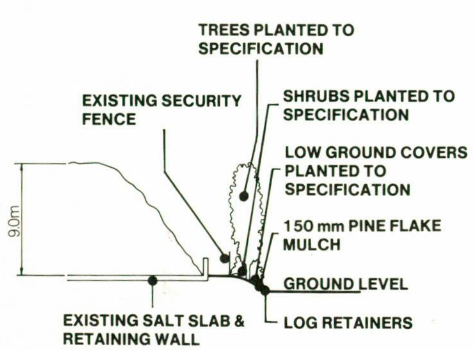
ELEVATION TO NORTHERN BOUNDARY — CORISH CIRCLE



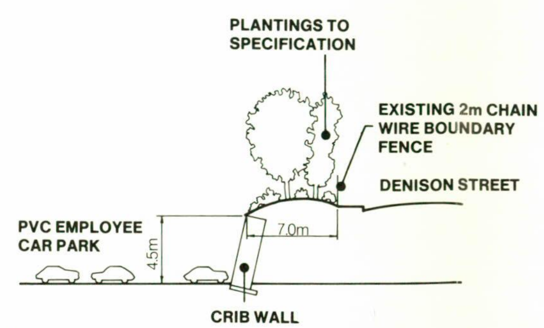
ELEVATION ALONG EASTERN BOUNDARY — DENISON STREET



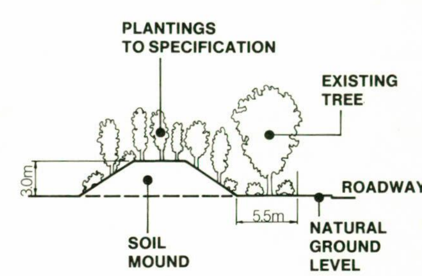
SECTION B-B



SECTION C-C



SECTION E-E
TYPICAL CROSS-SECTION THROUGH CRIB WALL LOOKING NORTH



SECTION D-D
TYPICAL SECTION THROUGH SOIL MOUND

TYPICAL CROSS-SECTION LOOKING NORTH

30 ESTABLISHED STAGE I LANDSCAPING ALONG DENISON STREET

ECONOMIC IMPACT

Chapter 10 ECONOMIC IMPACTS

10.1 INTRODUCTION

The proposed investment on Botany site is part of a continuing process of expansion, improvement in technology and adaptation to changing market circumstances that has characterised development of the site over the 37 years since production first began in 1942.

As a result of development of new products and expansion of market demand the Australian chemical industry has needed to sustain an above average rate of growth. According to the Australian Government Green Paper on Policies for Manufacturing Industry (the 'Jackson Report') the industry is the most productive in the Australian manufacturing sector in terms of value added per employee and also one of the most capital intensive sectors of manufacturing industry. The industry is characterised by rapid change in market and technology, high levels of capital investment and above average labour productivity and wage levels.

For the industry to remain competitive and efficient in this environment continued capital expenditure on plant upgrading and expansion is needed, while closure of obsolete plant will continue as part of the industry cycle. The Stage II investment is needed to maintain the long term viability of the existing plants and to support further growth in employment levels through the commissioning of new plants.

While employment has declined over recent years in some of the older manufacturing industries of the inner Sydney suburbs, expansion of the Botany plants can be seen as a desirable part of the restructuring process within Australian industry that State and Federal governments are keen to encourage. The report of the Study Group on Structural Adjustment (the 'Crawford Report') published in March 1979, contained a number of conclusions of which the first is:

The growth opportunities in the manufacturing sector are mainly in industries that are capital and skill intensive.

This follows closely the conclusions of the White Paper on Manufacturing Industry published in May 1977:

Having regard to Australia's endowment in capital, labour, skills and natural resources, the best prospects for manufacturing industry development appear to lie in activities which are based on our natural resources; which are innovative in terms of skill or design; which meet specialised local needs; or which have a high degree of natural protection. Industry policy also needs to take important account of the existing structure of Australian industry, with its established patterns of employment and capital investment.

In Australia the largest market areas for the output of the Botany plant are the manufacturing industries of the large metropolitan areas, particularly Sydney and Melbourne. ICI continues to invest on its Botany site because of proximity to markets, the availability of a suitable workforce, the presence of existing plant, infrastructure and services as a result of past private and public investment.

Operations on the site are highly integrated and most plants produce more than one product. Many of the chemicals produced are transferred around the site to be transformed into other chemicals. A chemical used internally in this manner is called an intermediate product. The choice of the particular plant components to be expanded at Botany has been largely determined by the integrated nature of the existing plants and the changing needs of the markets that it has traditionally served. ICI's strategy has been to develop the most efficient integrated plants that are practicable given the size of the Australian market. This has been a central consideration in the choice of Botany for Stage II.

It can be firmly stated that because of this need for integration Stage II would not be built anywhere else in New South Wales.

10.2 ECONOMIC IMPACT OF THE CONSTRUCTION PHASE

Construction Expenditure

The immediate economic impact of the investment plans at Botany will be in the form of construction expenditure and employment generated over the three and a half years taken to construct Stage II. The estimated distribution of this expenditure by location and type is set out in Table 16.

TABLE 16 **Distribution of Construction Expenditure ($ million and percent).**

	Location of Expenditure							
Type of	Within NSW		Other States		Overseas		Total	
Expenditure	$m	%	$m	%	$m	%	$m	%
Equipment and materials	96	24	40	10	48	12	184	46
On-site labour	108	27	—	—	—	—	108	27
Engineering and management	56	14	20	5	32	8	108	27
TOTAL	260	65	60	15	80	20	400	100

Table 16 shows that of the total $400 million investment in the Stage II plants, it is estimated that 80 percent will be spent directly within Australia and 65 percent within New South Wales. The expenditure is planned to be evenly spread over the three and a half years indicating a direct stimulus of about $75 million a year to the New South Wales economy and about $91 million a year to the Australian economy.

The four Stage II plants will take varying times to build. The work will be phased to avoid the peak expenditures and employment for each component occurring at the same time in order to provide a steady work load for contractors, suppliers and the construction workforce. The estimated construction time for the four plants is shown in Table 17.

TABLE 17 **Construction Time and On-Site Construction Employment**

Plant	Construction Time (years)	Average Employment (number)	Total Employment (person-years)
Ethylene	2.5	600	1500
Ethylene Oxide	1.0	400	400
Polythene	2.5	250	625
No. 4 Boiler and services	1.5	100	100
TOTAL			2625

Direct Employment During Construction

Based on the estimates set out in Table 17 construction of the plants will require 2625 person-years of on-site construction employment or an average of about 750 people on-site continuously over the three and a half years of construction. In addition to on-site employment, there will be considerable off-site employment in the fabrication and manufacture of components by contractors to ICI. Table 16 shows that about $96 million will be spent with suppliers in New South Wales and about $40 million in other States of Australia. The number of jobs created in these suppliers' factories is difficult to estimate, but should be of the order of a further 2000 person-years of employment. Of this about 70 percent would be in New South Wales factories and about 30 percent elsewhere in Australia.

Multiplier Effects of Direct Construction Expenditure

The income and employment generating effects of a large investment like that proposed by ICI at Botany are not limited to the direct impacts discussed above. When the wages and salaries of the directly employed workers are spent and when component suppliers purchase labour and materials inputs from other parts of Australian industry, the effect of the initial investment is multiplied by a significant amount. A further induced multiplier effect results from subsequent diminishing cycles of expenditure and employment creation throughout the economy.

It is probable that the total direct, indirect and induced multiplier for income and employment generation would be of the order of a factor of three times the direct effect alone.[1] The construction industry is generally thought to have a high multiplier effect because of the many inter-industry and inter-firm trade flows that arise from construction industry activity. On this basis, additional employment of about twice the direct employment might be created by Stage II. A summary of the order of magnitude of direct and multiplier employment that might flow from the construction phase is set out in Table 18. The location of the multiplier component is assumed to follow the expenditure allocation described in Table 16.

TABLE 18 **Order of Magnitude of Direct and Multiplier Employment Creation Due to Construction Expenditure (Person-Years)**

	Location		
Category	NSW	Other States	Total Australian
Direct — on-site	2600	—	2600
— off-site	1400	600	2000
Indirect and induced	8000	1200	9200
	12000	1800	13800

The construction employment at Botany and its multiplier employment effect will be a valuable contribution to overall employment in the Sydney area over the next three to four years. This employment will also help to sustain the construction sector which traditionally has employed a large number of unskilled and semi-skilled workers. These groups of workers, who are subject to higher than average unemployment rates, will therefore benefit from the construction work generated by Stage II.

1 For example, the recently announced aluminium plant to be built in the Hunter Valley has been estimated to have an employment multiplier of between 2.5 and 3.0.

10.3 ECONOMIC IMPACT OF PLANT OPERATION

Industry Linkages

The industry structure and the principal inputs and outputs from the plants have been described in detail in Chapters 2 and 3. The main components of the proposed expansion at Botany will utilise processes similar to those already operating on the site. Therefore the existing economic linkages between the plants and outside suppliers and customers are likely to be strengthened and expanded.

With regard to inputs of raw materials, it is ICI's policy to design the new plants to operate largely on indigenous feedstocks. This contrasts with the 10 to 20 percent of materials inputs which have been imported in recent years. The inputs to the plants are relatively few, as shown in Table 19.

TABLE 19 **Main Inputs to the Production Processes**

Item	Source of Input
Materials	
• Naphtha/LPG	NSW and Victorian refineries
• Salt	Australian producers
• Coal	NSW western coalfields
• Oxygen	Plant on or near Botany site
• Other raw materials in small quantities	Mostly from NSW suppliers with some imports
Utilities	
• Water	Metropolitan system
• Power	Metropolitan system
• Council services	Botany Council
Labour	
• ICI employees	Approx. 33% live within 3 km of the site and 72% live in the southern and eastern suburbs of Sydney.
• Labour content of maintenance and minor capital works	Mainly Sydney manufacturers and service companies

The main outputs from the ICI plants and their downstream uses are summarised in Table 20 and demonstrates the diversity of economic activity which is dependent on products from the Botany plants.

TABLE 20 **Outputs from Botany Plants and Downstream Uses**

Plant	Output	Downstream Uses
Ethylene	Ethylene	Intermediate use, external sales
	Petrol	Fuel, solvents
	Butadiene	Rubber
	Fuel gas	Fuel
	Fuel oil	Fuel, carbon black
	LPG	Fuel for heating
	Propylene	Intermediate use, polypropylene, chemicals, LPG
Polythene	Polythene	Household goods, insulation, packaging film
Polypropylene	Polypropylene	Automotive parts, ropes, twine, packaging, carpet backing
Ethylene oxide	Glycols	Anti-freeze, plastics, fibres, explosives, chemicals
	Glycol ethers	Brake fluid, solvents, paint
	Non-ionic surfactants	Detergents, wool scouring, agriculture, degreasing
	Ethanolamines	Detergents, chemical intermediates, concrete additives
Vinyl chloride	Polyvinylchloride	Household goods, cables, floor tiles, pipes
Chlorinated solvents	Carbon tetrachloride	Refrigerant, propellants manufacture
	Perchlorethylene	Drycleaning
Caustic Soda/Chlorine	Ferric chloride	Sewage treatment, water purification, metal etching
	Sodium hypochlorite	Sterilising, bleach, swimming pools
	Caustic soda	Soap, detergent, alumina refining
	Soda ash	Glass, general manufacture
	Hydrogen	Welding, margarine, chemicals
	Hydrochloric acid	Chemicals, steel pickling, foods
	Chlorine	Water treatment, swimming pools, chemicals
	Silicates	Catalyst, adhesives, detergents.

Direct Employment

Direct employment on the Botany site comprises ICI staff, operations and maintenance personnel as well as staff employed by contract maintenance and other service companies engaged by ICI. Estimates of additional employment resulting from Stage II expansion are shown in Table 21, together with present employment levels.

TABLE 21 **Present and Proposed Operations and Maintenance Employment**

Category	1979	1981	1985
ICI Staff	520	523	557
ICI Operations and maintenance	830	867	1 005
Contract	205	205	230
TOTAL	1 555	1 595[a]	1 792[b]

a The expansion between 1979 and 1981 is due to the minor ethylene oxide and polythene plant upratings.
b The expansion between 1981 and 1985 is due to Stage II.

Of the on-site jobs created by Stage II about 85% will be permanent ICI employees allocated between skill categories approximately as follows:

TABLE 22 **Skill Categories (per cent)**

Category	Percent
Unskilled or semi-skilled	60
Skilled tradesmen	20
Supervisory and technical	20
TOTAL	100%

ICI has taken a sample survey of employees on the Botany site to establish the place of residence of the workforce. The results of the survey for various suburban sectors of metropolitan Sydney are set out in Table 23. The majority of employees live in the southern part of the Sydney metropolitan area with operations employees living closer to the site than staff employees. The employment opportunities for construction and other contracts will also probably be filled mainly by people living in the southern parts of Sydney.

TABLE 23 **Location of Workforce by Sector of Metropolitan Sydney (percent)**

Location	All Employees (percent)
East and south eastern	29
Inner southern	18
Outer southern	25
Inner western	2
Outer south western	16
North shore	10
TOTAL	100%

Unemployment in the Botany area is recorded at the Commonwealth Employment Service (CES) offices at Mascot and Kingsford. The Kingsford office records a higher level of unemployment than the Mascot office. The number of unemployed persons and vacancies registered at these two offices at the end of March 1979 is set out in Table 24. It is reasonable to expect that a significant number of the new employees needed to construct and operate the plants will be drawn from the areas served by these two CES offices. This would particularly apply to the semi-skilled and unskilled component of the construction and operating workforce. The more specialised technical and staff skills will be attracted from the wider Sydney area, a pattern that can be seen already in the location of residence of the existing workforce.

TABLE 24 **Number of Registered Unemployed in Botany Area, March 1979**

	CES Office	
	Mascot	Kingsford
Registered unemployed	1254	3349
Registered vacancies	753	Not provided

Source: Commonwealth Employment Service

The CES has reported that several long established industries (for example paper making, rope manufacture, furniture manufacture) have closed down in the Botany area recently. By increasing employment in the area, ICI's Stage II project will to some extent compensate for these recent closures in other industries, without placing undue pressure on existing social services and community facilities.

Multiplier Effects of Direct Employment and Income Creation

In a similar way to that attributed to direct construction expenditure, there will be indirect and induced employment and income created throughout the economy as a result of operation of the Stage II plant. Because of the considerable interdependence between firms in the chemical industry, the multiplier effect of the Botany operation is probably on the high side of a range of possible multiplier factors. If a factor of three is used as the long term multiplier for employment, the increment in employment due to the investment will be as shown in Table 25.

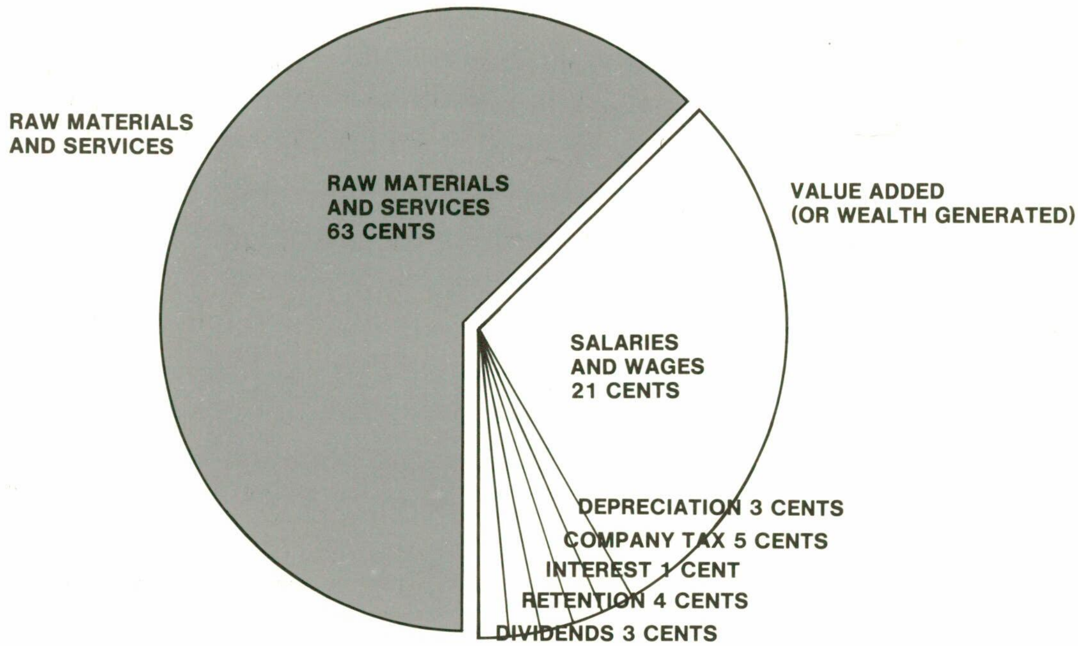
TABLE 25 **Order of Magnitude of Direct and Multiplier Employment Creation Due to Operation of Stage II Plants**

Category	Approximate Number of New Jobs
Direct on-site	
— ICI employees	172
— Contract	25
Indirect and induced	394
TOTAL NEW JOBS THROUGHOUT AUSTRALIAN ECONOMY	591

Value Added

The contribution of the plants to the Australian economy is measured by the value added resulting from plant operations. An approximate forecast of this has been made on the basis of the expected operating costs, input costs and selling prices that will prevail during the mid 1980's.

The total annual receipts due to Stage II expanded production are estimated to be in excess of $300 million (in 1988 dollars) when the Stage II plants are producing at full capacity. The value added will be the cost of wages and salaries, interest, taxes and profit and its distribution is shown in Figure 31.



31 VALUE ADDED PER DOLLAR SALES

Balance of Payments Effects

In the event that the proposed Botany Stage II expansion does not proceed, ICI would have to import the equivalent quantity of product to satisfy the needs of its customers throughout Australian industry. These products, such as polythene and ethylene oxide, would have to be purchased in the international petrochemical markets at the then ruling prices. ICI has estimated the cost of importing the forecast quantity needed to substitute for the production of the Botany plants using estimated future prices including transport costs but excluding any tariff component. The Stage II expansion is intended primarily to serve existing markets but in the early years, when there will be surplus capacity, an export drive will be mounted. The expansion will service, and allow for expansion of, the existing export market in ethylene oxide specialty products which is currently limited by capacity.

The benefit to the balance of payments of the expansion programme over the first eight years of the plant's operation up to 1991 is estimated to be $840 million. For the next seven years of the project's life up to 1998, the additional benefits are estimated to be $2 200 million, all expressed in future money values. There is to be offset against this benefit that portion of the capital cost which will be imported. This is a once only cost and is estimated to be $80 million as shown in Table 16.

The project clearly has a major favourable effect on the balance of payments. The additional benefit to Australian industry of certainty of supply and independence from the vagaries of the international markets has not been quantified in monetary terms. Nevertheless this is an important part of the benefit arising from this project. Both in 1973/74 and again in 1978/79 supplies of polymers and petrochemicals in the world market suddenly became scarce because of crises in the supply of oil. Expansion at Botany, based firmly on local feedstock, will remove the threat of political uncertainty in other parts of the world disrupting supplies to Australian customers.

10.4 SUMMARY OF ECONOMIC IMPACTS

The proposed expansion will bring considerable benefits to the Australian economy in general and to the people of South Sydney in particular. The Stage II investment will ensure the viability of the whole Botany complex for the foreseeable future and must be seen as a necessary and positive part of the normal cycle of the chemical industry. The project is compatible with the increasing employment, productivity, and living standards to which Australians aspire. The chemical industry is precisely the type of resource based, raw material upgrading industry which the Government's White Paper on Manufacturing Industry and the recently published Crawford Report envisages as providing future growth opportunities.

The Botany site has been chosen for this expansion because of the advantages of utilizing existing plant and external services infrastructure. In the event that the proposed Stage II expansion does not proceed at Botany it would not be built elsewhere in New South Wales.

Direct construction expenditure of $400 million would be spent over the three and a half years of construction time, creating about 2620 person-years of on-site employment. It is estimated that total direct, indirect and induced employment due to the construction expenditure would be about 13800 person years, the great majority within New South Wales.

The operation of the Stage II plants will create around 200 new jobs on the site, with around 60 percent of these classified as semi-skilled or unskilled. With the majority of workers presently living in South Sydney and about one third living within three kilometres of the site, the new on-site jobs are likely to be filled by people living in the region. It is estimated that including the multiplier effects, there will be about 600 new permanent jobs created throughout the Australian economy, with most of these in New South Wales.

In addition to its direct contribution to the domestic economy, Stage II will have very considerable external benefits for Australia. The expansion will assist the balance of payments by some $3000 million over the project's 15 year life. It will also ensure that Australian indigenous feedstock is upgraded within Australia, thus making this sector of manufacturing industry independent of the uncertainties of the world petrochemical markets.

10.5 FUTURE DEVELOPMENT ON BOTANY SITE

It is planned to extend the polypropylene plant as Stage III of the overall site expansion plan (see Section 2.4). The production of by-product propylene from the Stage II ethylene plant will exceed the requirements of the polypropylene plant. It is expected that in due course the market for polypropylene will require the enlargement of that plant thus converting this valuable raw material into a useful product instead of using it as fuel. It is planned that this plant extension be commissioned in 1986, subject to the necessary statutory approvals being obtained.

From time to time there may be extensions to existing plants and the installation of other new processing plant where appropriate on the site.

APPENDIX 1

EXTRACTED FROM THE POLYPROPYLENE ENVIRONMENTAL IMPACT STATEMENT, AUGUST 1977

'POSSIBLE FURTHER DEVELOPMENT OF THE BOTANY SITE'

Growing Australian needs for petrochemicals and plastics will require construction within the next few years of a new olefines plant together with associated downstream units of low density polythene and ethylene oxide. Preliminary studies suggest such an extension project would be economically viable at Botany. A number of major chemical companies are developing plans for similar projects in conjunction with State Governments, but there is room for only one project to proceed within the period.

As viewed at present, such extensions could be accommodated within Botany site and site services are largely available, although there would be some expansion of boiler facilities. Because of the interaction with the existing ethylene plant, and downstream converting plants, the Botany site is the natural location for an expansion of these similar activities.

With new technology coming forward it is possible to construct plants which will be significantly lower in their emission levels than has been possible previously. Along with continuous attention to reducing emissions from existing plants, it is expected that these later expansions can be accommodated without detrimental effect on the environment. These plants are not of a type associated with emissions of dust or odour. Moreover, as with the polypropylene plant a new ethylene plant would carry out any disposal of waste gases in a ground furnace.

The raw materials for such an expansion would largely be piped in from Port Botany. The resulting finished products would be destined for consumption within Australia, and would leave the site by road and rail, although it is not anticipated that this would result in a significant increase in road traffic — perhaps 30 trucks per day.

The plants would also operate to requirements set by the SPCC for noise limits at the site boundaries.

Site landscaping will continue around the boundaries to improve the visual appearance of the site from the various roadways.

The new plants would provide additional employment opportunities during both the construction phase (1200-1750 jobs) and subsequently during normal operation (500 jobs). These jobs would be available to people with important construction skills within Australia and provide employment in a high technology, highly productive area of Australian industry.

The possible future projects would each be submitted to the appropriate authority for statutory approval and would not proceed until this was obtained. Each of the developments would be extensions, technically and commercially, of ICI Australia's existing business in areas where the company is highly experienced and competent.

The possible two-stage development would be:

STAGE II

Olefines	Completion 1981. Further manufacturing plant of the most modern design would be erected to increase the production capacity for ethylene, propylene and related materials which are used both on the site, and by other manufacturers for the production of petrochemicals and plastics.
Polythene	Completion first phase 1981. Additional polythene plant would be built to increase production of this widely used plastic.

STAGE III

Polythene	Completion second phase 1983.
Ethylene Oxide	Completion 1983. An additional ethylene oxide plant to supplement the existing one which has operated since 1964.

An aerial photograph illustrating these stages is shown overleaf.

DESCRIPTION OF THE PROCESS

Ethylene plant

It is not practical to increase the capacity of the present ethylene plant much further. A second plant would use an almost identical process to the present one. The feedstock would be similar and would come onto the site via a pipeline.

Ethylene plants as well as making ethylene produce a considerable volume of co-products such as petrol and LPG. A new plant would produce similar co-products to the current operating plant and although considerably larger in capacity, would occupy only about 3 hectares of vacant land at the northern end of the site.

Installation of a ground furnace on the existing ethylene plant and construction and operation of a new ethylene plant with ground furnace would result in considerably reduced elevated flaring compared with the present position.

Modern technology will enable hydrocarbon emissions and noise from the plant to be less, despite its increased size, than the present ethylene plant. This same technology is enabling emissions to be reduced in the existing plant. It would be expected therefore that the total emissions from the two plants would not exceed current levels.

Polythene plant

The first phase of expansion could include a polythene plant, required to be in operation about 1981 with a further extension in about 1983. The process for this plant would again be almost identical to the plant operating at present.

A feature of the new plant would be the installation of production equipment with output somewhat larger than presently installed but which would occupy less space. The raw material for these plants is the ethylene manufactured on site.

There is no waste gas for disposal in these plants, and they are not significant generators of noise.

Modern technology will again enable hydrocarbon emissions to be less on any new plant than on existing operations.

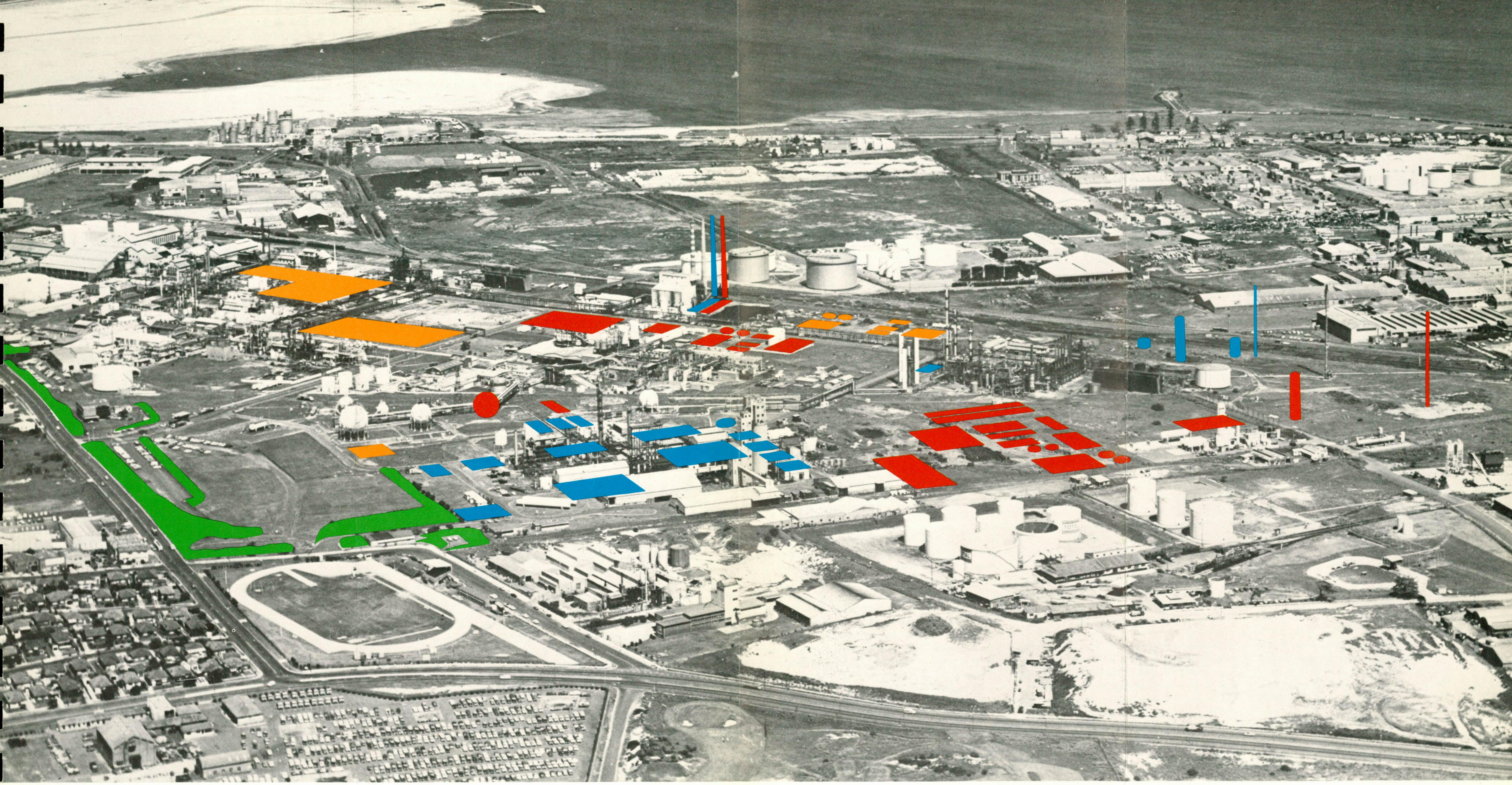
Ethylene oxide

An expansion in this product would again involve constructing a new plant. This plant would be commissioned about 1983 and be of similar capacity to the existing plant and use the same process.

Raw material would be ethylene, available on site, and the ethylene oxide produced would be used on site to make the same variety of liquid products as produced at present.

A new plant would not emit dust, fumes, or odours, and would not be a significant noise generator.

Hydrocarbon emissions can be limited to negligible quantities by modern technology.



Stage 1 Stage 2 Stage 3 Landscaping

APPENDIX 2

THE NEW SOUTH WALES PLANNING AND ENVIRONMENT COMMISSION

APPROVAL OF INTERIM DEVELOPMENT APPLICATION REFERRED IN PURSUANCE OF SECTION 342V(3) OF THE LOCAL GOVERNMENT ACT, 1919.

APPLICANT'S NAME AND ADDRESS:
ICI Australia Limited
69 Macquarie Street
SYDNEY 2000

LAND SUBJECT OF APPLICATION:
Part Lot 1, D.P. 584643
Nos 16-20 Beauchamp Road
MATRAVILLE 2036

APPROVAL:
The New South Wales Planning and Environment Commission, having considered an application by the abovementioned applicant for permission to carry out interim development on the land referred to above (such application having been referred to the Commission by the Botany Municipal Council pursuant to a direction issued under section 342V(3) of the (Local Government Act, 1919), hereby approves on the subject land the erection of a Polypropylene Plant on Part Lot 1, D.P. 584643 (Nos 16/20) Beauchamp Road, Matraville generally in accordance with the plans 5294—16A—BDSK—1, 5294—123A—BDSK—1, 5294—14B—BD—2, 5294—11A—KD—225 prepared by C. F. Braun & Company together with Drawing No 6102/00 — 03—21 and the Environmental Impact Statement prepared by ICI Australia Limited dated August 1977 subject to the following conditions.

1 The developer small comply with Botany Municipal Council's Standard Industrial Conditions Nos 1, 2, 4—14 inclusive, 38, 40, 41 and 48;

2 The developer shall comply with any specific conditions imposed by the State Pollution Control Commission under the provisions of the Clean Air Act, Clean Waters Act and Noise Control Act and the Regulations related thereto;

3 The developer shall ensure that the development at all times complies with the Acts and Regulations referred to in condition 2 above;

4 The developer shall undertake all reasonable measures over the whole works complex to reduce noise emissions in such a manner that there is a progressive reduction in noise to a night-time limitation not exceeding 50 dB(A) in adjacent residential properties. That this reduction shall be acheived not later than 31st December, 1980;

5 The developer shall make arrangements for the disposal of waste products to the satisfaction of the Metropolitan Waste Disposal Authority and these arrangements shall include:

i the recycling of polypropylene wastes unless the Metropolitan Waste Disposal Authority is satisfied that such is not practical;

ii the containing of powdered waste to the satisfaction of the Metropolitan Waste Disposal Authority before disposal;

iii entering into a firm agreement to the satisfaction of the Metropolitan Waste Disposal Authority and the State Pollution Control Commission ensuring that spent, faulty or redundant toxic catalyst are returned to the overseas manufacturer;

iv compliance with all other requirements of the Metropolitan Waste Disposal Authority.

6 The developer shall arrange for liquid wastes and surface water to be treated in a pH control tank or other suitable system approved by the Metropolitan Water, Sewerage and Drainage Board before being disposed of into the sewer.;

7 The developer shall comply with all other requirements of the Metropolitan Water, Sewerage and Drainage Board;

8 As far as is practical after 6 pm at night and before 7.30 am daily the developer shall arrange for all heavy traffic to enter the site by means of Corish Circle.

9 The site shall be landscaped to the satisfaction of Botany Municipal Council in the event of any disagreement on this issue the New South Wales Planning and Environment Commission to act as arbiter;

10 Arrangements satisfactory to the State Pollution Control Commission and Botany Municipal Council shall be made for the collection, separation and treatment of the 'first flush' of any contaminated surface stormwater prior to disposal in accordance with the Clean Waters Act and Regulations;

11 The developer shall comply with all requirements of the Inflammable Liquids Act, 1915 and the Explosives Act 1905;

12 The developer shall comply with all requirements of the Board of Fire Commissioners;

13 Prior to the development hereby approved becoming operational the developer shall prepare a 'Disaster Plan' for the whole works complex and obtain the approval of same from the New South Wales Planning and Environmental Commission. Such plan shall include details of organisational arrangements and upon approval a copy shall be lodged with Botany Municipal Council;

14 In the event of abnormal environmental conditions arising either in the development hereby approved for the operation of the whole works complex the developer shall

promptly take remedial action in order to minimise any inconvenience to the public at large;

15 Should the abnormal environmental conditions referred to in condition 14 above occur, the developer shall also promptly advise the Police, the State Pollution Control Commission, Botany Municipal Council and any other statutory body that may be appropriate;

16 In the event of any disagreement arising between the parties in respect of the above conditions, the New South Wales Planning and Environment Commission shall act as arbiter.

This approval does not relieve the applicant of the obligation to obtain any other approval required under the Local Government Act, 1919, and Ordinances (including approval of building plans) or any other Act.

Signed at Sydney this 25th day of January, 1978 under delegation from the New South Wales Planning and Environment Commission.

CHAIRMAN

APPENDIX 3

A Development Application for a minor expansion of the existing low density polythene and ethylene oxide plants was lodged in March 1979 and approval was granted in July 1979.

The minor ethylene oxide uprating comprises: —

- Shutdown of two existing reactors and these replaced by a single reactor of increased capacity together with its ancillary equipment.
- Instal larger heat exchangers and pumps for uprating the purification section.
- New distillation columns, larger pumps and heat exchangers for glycols and glycol ethers plants.
- Additional reactor and ancillary finishing equipment for the Non Ionic Surfactants (N.I.S.) plant.
- Additional storage tanks for products in the derivatives plants.

The Polythene Plant minor extensions include: —

- Gas compression and cooling equipment.
- An additional reactor cooler and separator.
- Extension of the cutting room building and in it the installation of granulation equipment, storage hoppers and catalyst equipment.
- Construction of two product silos and a small prepacking silo.
- Warehousing extension, extra cooling tower, electrical switchrooms, additions to control room, laboratory and catalyst storage facilities.

A copy of the conditions of approval follows:

THE NEW SOUTH WALES PLANNING AND ENVIRONMENT COMMISSION

APPROVAL OF INTERIM DEVELOPMENT APPLICATION REFERRED IN PURSUANCE OF SECTION 342V(3) OF THE LOCAL GOVERNMENT ACT, 1919.

APPLICANT'S NAME AND ADDRESS:
I.C.I Australia Limited,
16-20 Beauchamp Road,
Matraville N.S.W. 2036.

LAND SUBJECT OF APPLICATION:
Part Lot 1, D.P. 584643, Nos. 16-20
Beauchamp Road, Matraville.

APPROVAL:
The New South Wales Planning and Environment Commission, having considered an application by the abovementioned applicant for permission to carry out interim development on the land referred to the Commission by the Botany Municipal Council pursuant to a direction issued under section 342V(3) of the Local Government Act, 1919, hereby approves on the subject land the extension and modernisation of the polythene and ethylene oxide plants, generally in accordance with Drawing Nos. BP2069 I C I Australia Ltd., drawn by M. Walsh and dated 6/79, and B9030 drawn by P.M.K., and updated to 8th June, 1979 subject to the following conditions: —

a the developer shall comply with any specific conditions imposed by the State Pollution Control Commission under the provisions of the Clean Air Act, Clean Waters Act and Noise Control Act and the Regulations related thereto;

b the developer shall ensure that the development at all times complies with the Acts and Regulations referred to in condition (a) above;

c noise levels emanating from the whole work complex, including the proposed uprated plants shall not exceed a night time limitation of 50 d B(A) in adjacent residential properties;

d disposal of waste products from the site shall be to the satisfaction of the Metropolitan Waste Disposal Authority;

e effluent discharge from the site into the sewers shall meet with the Metropolitan Water, Sewerage and Drainage Board's requirements;

f arrangements satisfactory to the State Pollution Control Commission and Botany Municipal Council shall to made for the collection, separation and treatment of the 'first flush' of any contaminated surface stormwater prior to disposal in accordance with the Clean Waters Act and Regulations, provided that no such stormwater or other effluents may be discharged into the Council's stormwater system without the prior approval of the Council;

g the site shall be landscaped to the satisfaction of Botany Municipal Council and such landscaping also maintained to the satisfaction of the Council;

h the developer shall comply with all requirements of the Board of Fire Commissioners of New South Wales;

i the developer shall comply with the requirements of the Dangerous Goods Act, 1975. The development shall be conducted at all times to the satisfaction of the Department of Labour and Industry;

j prior to the development hereby approved becoming operational, the developer shall prepare a detailed hazard impact analysis for both uprated plants. This hazard plan shall meet with the approval of the New South Wales Planning and Environment Commission;

k prior to the development hereby approved becoming operational, the developer shall prepare detailed emergency procedures for both the uprated plants. These procedures should include organisational arrangements and be incorporated into the overall emergency plan for the whole works complex to be prepared as a condition of consent for the polypropylene plant. This emergency plan shall meet with the approval of the New South Wales Planning and Environment Commission and upon approval a copy shall be lodged with Botany Municipal Council;

l in the event of abnormal environmental conditions arising either from the development hereby approved or the operation of the whole works complex, the developer shall promptly take remedial action in order to minimise any inconvenience to the public at large;

m should the abnormal environmental conditions referred to in condition (l) above occur, the developer shall also promptly advise the Police, the State Pollution Control Commission, Botany Municipal Council and any other statutory body that may be appropriate;

n the development shall comply with the requirements of all statutory bodies having interest in any aspect of the proposal;

o in the event of any disagreement arising between the parties in respect of the above conditions, the New South Wales Planning and Environment Commisssion shall act as arbiter; and

p the developer shall comply with Botany Municipal Council's Standard Industrial Conditions Nos. 2, 4, 6, 8, 11, 12, 51 and 53, as set out in the Council's submission to the hearing on 15th June, 1979, including therein the modification to Condition No. 2 contained in paragraph 6.25 of that Submission.

Signed at Sydney this 12th day of July, 1979, under delegation from the New South Wales Planning and Environment Commission.

Janet Thomson
REGIONAL PLANNING DIRECTOR
BOTANY BAY SUB-REGION

APPENDIX 4

HAZARD STUDIES FOR CAPITAL PROJECTS

Hazard studies are an integral part of ICI's planning, design, construction, commissioning and operation of new and/or modified plants. The overall objective of these studies is to ensure that safety is built into new plants and their operating procedures from the outset.

Hazard studies are generally undertaken in six stages — although this may vary with the complexity, scale and timing requirements of different projects. The six stages, and their basic objectives are as follows:

STAGE 1 — BEFORE STARTING DESIGN

- Identify possible hazards inherent in the proposed materials or processes.
- Define broad design safety requirements and constraints including site planning and broad layout implications.

STAGE 2 — ON RECEIPT OF FLOWSHEETS

- Comprehensively identify possible hazardous incidents.
- Assess the probability and severity of each potential incident.
- Define resulting detailed design requirements.

STAGE 3 — ON COMPLETION OF PROCESS AND INSTRUMENTATION DESIGN

- Systematically audit the ability of the design to cope with abnormal and normal operating conditions.
- Define the resulting design modifications and operating requirements.

STAGE 4 — DURING CONSTRUCTION

- Inspect works to ensure incorporation of all requirements specified in Stages 1 – 3.

STAGE 5 — AT COMPLETION OF CONSTRUCTION

- Inspect works to ensure safety of operation and compliance with all statutory requirements before start up.

STAGE 6 — AFTER STARTUP

- Review of any necessary post startup modifications using the methods of Stage 3.

In Stages 1 and 2 the Company aims to satisfy itself and the relevant statutory authorities that there is nothing inherently unsafe or potentially hazardous about the proposed project. The latter studies are concerned with very detailed systematic checking and modification of design and construction to ensure that the original safety objectives are met.

The Stage 3 study is often called a 'hazard and operability study'. Its objectives are, as the title implies:

1. to identify any potentially hazardous activities or procedures, and through design modifications or management instruction, eliminate or minimize them.
2. to facilitate smooth, safe and timely commissioning of new plant without extensive last-minute modifications, and to ensure safe, efficient and maintenance free operations of plant.

Hazard and operability studies basically comprise a series of studies and examinations of the design, line by line, by a group of senior representatives from design, project and operating staff using a comprehensive checklist of guidewords or questions about possible plant problems. These studies facilitate recognition, before design is hardened, of a large number of potential hazards or operational problems which can be avoided by mainly minor redesign or suitable operating procedures. The studies also provide an excellent medium for teaching operating staff about design concepts and operating requirements, and design staff about operational realities. However, hazard and operability studies are not seen in any way as a replacement for proper project planning and staff training.

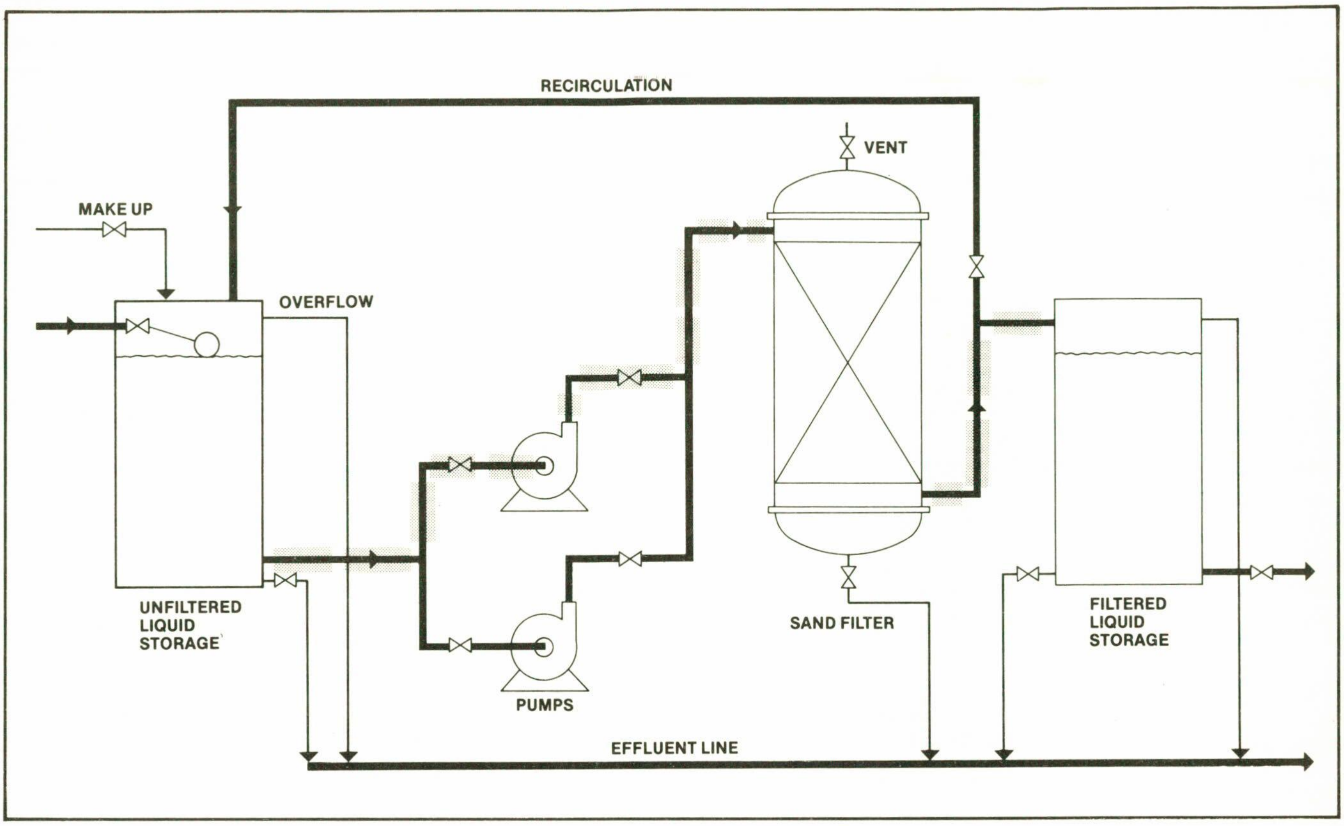
A hazard and operability study is conducted by senior project personnel under the direction of a Study Manager. Personnel involved in the study may include the following:

- Process Design Engineer
- Engineering Design Engineer
- Instrument Engineer
- Commissioning Engineer
- Plant Superintendent
- Maintenance Engineer

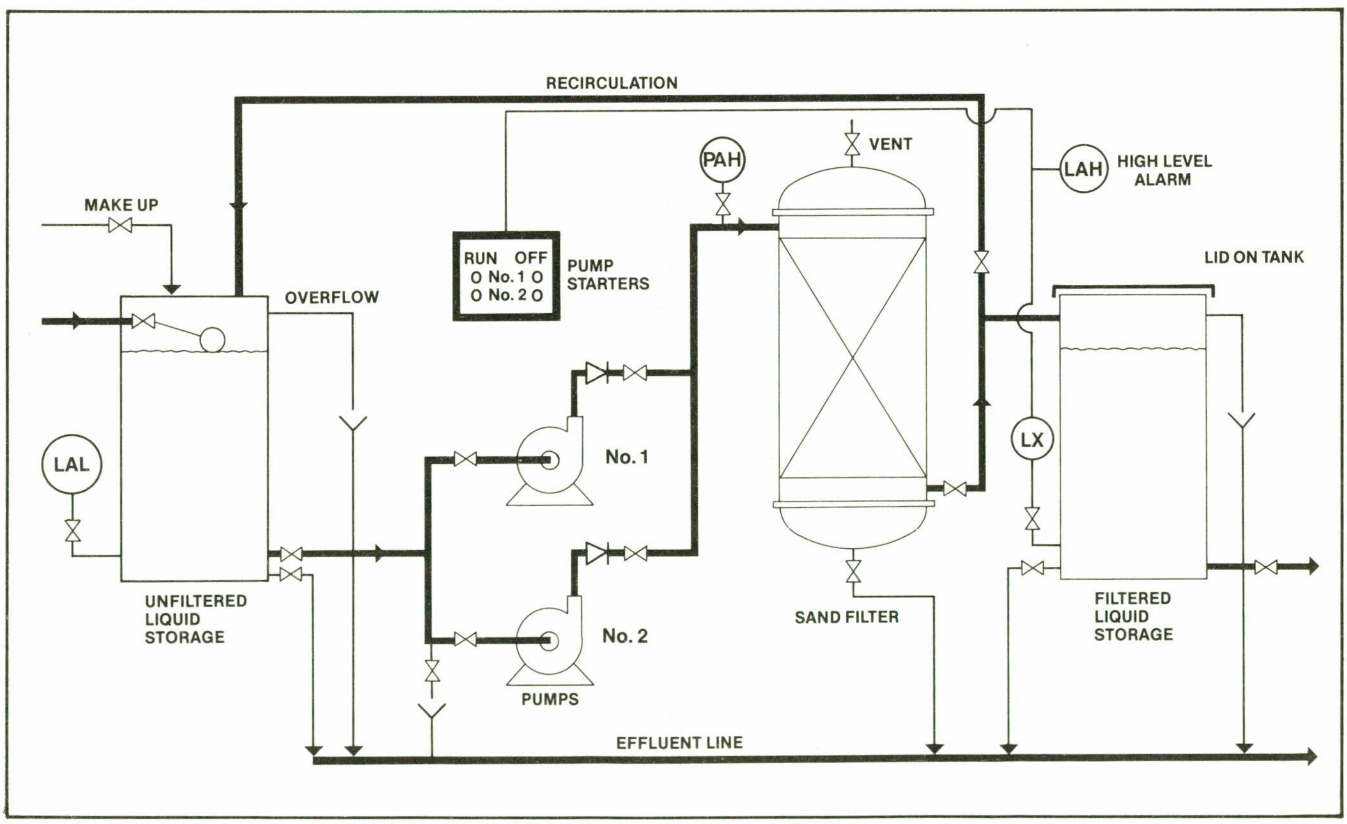
If a major part of the design is being done by a consultant or by the equipment supplier (as would be the case with a turnkey project or a commercial process) then a representative or representatives of these groups is included. Other specialists may participate for specific aspects of the design, eg:

- Electrical
- Computer
- Fire Prevention
- Effluent Treatment
- Combustion Control

Considerable attention is given to establishing the working environment, format and guidelines for the study team to ensure that the analyses are carried out systematically.



1 ORIGINAL FLOW DIAGRAM



2 AMENDED FLOW DIAGRAM AFTER COMPLETION OF HAZARD AND OPERABILITY ANALYSIS

At the outset of the analysis of a section of plant a design engineer with in-depth knowledge of the process depicted on the flow diagram (for example, as shown in Figure 1) explains to the study team the purpose of the plant or process. One particular line in the beginning of the process is selected for study and is marked intermittently with a coloured felt pen to highlight it (see Figure 1) and the design engineer details the equipment contained within this line.

When general understanding is reached, the Study Manager starts the critique by reference to the first of the check words in the series aimed at logical questioning of the safety, operability and maintainability of the equipment contained within the line. Table 1 is a partial list of these checks, the left hand column showing the different 'conditions' to be examined, and the right hand column, the 'causes'.

The first words 'High Flow-High Level' prompt a discussion on what events may lead to high flow in the line or high level and what the consequences of these conditions are. A typical set of considerations with decisions on 'High Flow' with respect to Figure 1 are shown in Table 2. As additions and/or deletions are agreed they are marked up in red pen on the flow diagram for future inclusion on the master drawing.

The team then proceeds to the next check words 'Low Flow-Low Level' and repeats the questioning noting decisions or items for further investigation. One such latter item may be for a nominated team member to check the manufacturer's data concerning pump net positive suction head and specify the safe level for installation of the low level alarm on the unfiltered Liquid Storage Tank. Actions such as this are minuted as shown in Table 3.

All check words down to and including 'Instruments' on Table 1 are considered in a similar manner and when this is done the line under consideration is marked as complete by over marking the intermittent colouring with full colouring. The second line is then brought forward for examination, and so on through the full process design.

Figure 2 shows how the original line in Figure 1 may be modified after completion of that stage of the hazard and operability study.

The above summary description and tables are for one line, considered at one stage of the overall hazard and operability study. Depending upon the project, the complete study can be most extensive — one recent project analysis by ICI involved eight professionals in 99 half day meetings and resulted in 1310 specific design modifications, or operational recommendations.

Safety, operability and reliability are integral concerns. Apart from the need to design and operate for safety objectives, hazards and operability studies have substantial financial and operational benefits because they lead to more reliable and more efficient plants.

TABLE 1 **List of Abnormal Conditions to be Considered**

Condition	Possible Causes
High Flow — High Level	Pump over speed, delivery vessel pressure lost, suction pressurised, scale dislodged, leak in heat exchanger, loss of auto control, operator error, failure of pipe or vessel, etc.
Low Flow — Low Level	Pump failure, partial blockage, low suction, valve jammed, ... joint failure, etc.
Zero Flow — Empty	Pump failure, gaslocking, blockage, suction loss ... pipe failure, etc.
Reverse Flow	Pump failure, pump reversed, poor isolation, ... pipe failure, etc.
High Pressure	Boiling, cavitation, freezing, ... weather conditions.
Low Pressure	Boiling, cavitation, freezing, ... weather conditions.
High Temperature	Boiling, cavitation, chemical reaction, zero flow, ... external fire.
Low Temperature	Boiling, freezing, chemical reaction, ... weather conditions.
Impurities — Gaseous	
— Liquid	
— Solid	
Change in composition.	
Change in concentration.	
Two phase flow.	
Testing — Equipment	How do we know they are O.K. Vacuum & Pressure testing with harmless material.
— Product	
Plant Items — Operable	Access, Isolation, Purging, Drying, Cooling ....
— Maintainable	Special Equipment, Techniques, Skills ....
Instruments	Sufficient for Control? Too many? Correct location? — Control valve action on air or power loss?

TABLE 2 **Example of High Flow Deliberations from Figure 1**

High Flow Through	Possible Cause	Effect(s)	Possible Action
Unfiltered Storage Tank	Pump delivery greater than make up to tank.	Tank may run dry — interrupts flow pattern.	Instal low level alarm on tank. Instal level control in tank acting to limit pump flow.
Pumps	Low delivery pressure (a) Broken delivery line. (b) Channelling through sand filter.	Safety. Loss of product. Poor filtration. Contaminated product. Sand in filtered liquid storage tank. Pump cavitation.	Instal flow meter with alarm on high flow.
Sand Filter	High inlet pressure (a) due to increased pump speed (b) two pumps running in parallel	Overpressurise vessel — distortion or failure of internals and/or the shell.	Monitor pressure differential across the filter. Alarm high inlet pressure. Have indicator lights to show pumps running.
	Channelling through sand	Poor filtration.	See action under 'Pumps' above.

In this instance the study team decided it would be safer, economic and improve operability to instal:—

1 Low level alarm on Unfiltered Liquid Storage Tank.
2 Indicator lamps to show which pump is on line.
3 High pressure alarm on inlet to Sand Filter.

TABLE 3 **Hazop Study No.-2 Minutes**
22 August 1978 S & P BOTANY — DEMIN PLANT Present: LCK, DHC, PTE, JTY, HMT, GR.

Q No.	Problem	Action	Person Responsible For Action
1	Does PLC check that air flow/pressure is established before proceeding with sequence during regeneration.	Check with designers	DHC
2	Can reverse flow of water enter blowers?	Check design of N.R. valve with supplier.	LCK
3	With one blower on line the other may run backwards.	Instal check valve in each blower line.	DHC
4	Does water getting into air pressure regulator matter?	Check with supplier-delete V84 if not required.	PTE
5	Continuous pressure in degassed water line to HCL ejector for cation regen.	Fit air operated spring close valve to open only during cation regen.	GR
6	Unknown function of V115, V114 (caustic to anion regeneration).	Check purpose with supplier.	PTE
7	Unknown function of V123, V124, V125.	Check purpose with supplier.	PTE
8	Alfloc dosing pump may feed into dead end line.	Interlock starters of dosing and de-aerator feed pumps.	LCK
9	How does salt dissolve in caustic brine tank?	Add stirrer to design.	JTY
10	How are effluent sump discharge valve V149, and closing valves V140, 141 & 143, & 144 controlled by pH?	Query supplier re operation and ensure automatic sequencing from P.L.C including pH control.	PTE

APPENDIX 5

ICI AUSTRALIA LIMITED

SAFETY AND OCCUPATIONAL HEALTH POLICY

1 The safety and occupational health of all people involved in the Company's activities is a matter of greatest concern. It is our policy to conduct our business at all times as far as possible without risk to our employees and the community.

2 The improvement in the Company's safe working record over three decades has shown that people can be trained and encouraged to work more and more safely, to recognise hazards and to take action to reduce and remove them.

The Company is determined to continue its support for this effort and to do everything reasonably possible to maintain a healthy environment and safe working conditions, to define and teach safe working practices and to comply with statutory requirements.

3 Everyone working in the Company is asked to share in the commitment to this policy.

Each Manager and each Supervisor has a responsibility for the safety and health at work of the people working under his direction.

Every employee is expected to play his vital and responsible part in avoiding accidents and in acting safely at all times, for his own welfare and that of his fellow employees as well as of the community.

4 The Safety Council which is responsible to the Board of the Company will ensure that appropriate rules and management guidelines are established and maintained up-to-date to support the Company policy. It monitors performance in all Company establishments and periodically reports progress to the Board.

APPENDIX 6

GLOSSARY OF TERMS.

ACETIC ACID A simple organic acid used in the manufacture of glycol ether acetates.

ACID GASES Acidic components of CRACKED GAS such as carbon dioxide and hydrogen sulphide.

ALKYL PHENOLS A group of phenol related organic compounds used in the manufacture of condensates.

AMINES Organic compounds containing nitrogen in an NH_2 — grouping as well as carbon and hydrogen.

AROMATIC COMPONENTS Organic compounds in which the carbon atoms are arranged in six sided rings and are found as a component of PYROLYSIS GASOLINE. Their smell gives rise to use of the term 'aromatic'.

ASH QUENCH The process of cooling hot boiler ash with water.

BAG FILTERS Large containers in which fine particulate ash is separated from boiler flue gases by passing them through a woven cloth filter material.

BLOW-DOWN (see COOLING TOWER BLOW DOWN)

BLOW-OFFS (as from safety valves etc.) A quick release of gas to atmosphere to lower the pressure in a vessel.

BROADBAND Covering the whole audible spectrum (of noise) and thus not limited to a specific frequency or range of frequencies.

BUNDS Low impermeable walls around a process or storage area to contain liquids in case of spillage.

BURSTING DISCS Carefully machined discs designed to burst at a predetermined pressure. They are inserted in the shell of a pressure vessel, merely protecting it from overpressurisation; equivalent to a fuse in an electric circuit.

BUTADIENE A co-product from cracking naphtha or propane, containing 4 carbon atoms. Separate as a liquid under pressure (LPG) and used for making synthetic rubber.

BUTANOL An alcohol containing four carbon atoms used for making plastics.

CARBON BISULPHIDE A volatile solvent manufactured by reacting wood charcoal with sulphur vapour at a high temperature. It is used in the manufacture of a family of chemicals known as xanthates used in mineral ore separation and also in the manufacturing of viscose rayon.

CARCINOGENICITY The ability of a substance to induce cancer.

CATALYST A material which promotes a chemical change in other substances.

CAUSTIC WASHED Contact with dilute caustic soda solution to neutralise acidic components.

CHLOR ALKALI A term used to describe a range of inter-related products and manufacturing techniques using the ammonia soda process and sodium chloride brine electrolysis. The products include caustic soda, soda ash, bicarbonate of soda and chlorine.

CHLORINATED SOLVENTS (See Solvents)

COOLING TOWER An elevated structure in which warm water is cooled by evaporation through contact with an air stream.

COOLING TOWER BLOW DOWN Water deliberately removed from a cooling tower system to prevent the accumulation of dissolved salts caused through continuous evaporation of water during cooling.

CRACKING FURNACE A furnace in which liquid or gaseous feedstock (naphtha, propane and butane) is broken down into a range of hydrocarbons under conditions of high temperature.

CRACKED GAS The mixture of gases including ETHYLENE, PROPYLENE and BUTADIENE produced in the CRACKING FURNACE.

CRYOGENIC DISTILLATION Separation of chemicals by distillation at very low temperatures, down to $-120°$ C.

DECOMPOSITION A rapid breakdown of ethylene to carbon, hydrogen and methane which may occur if temperature within the polythene reactor exceeds the control limit. Decomposition leads to a sharp rise in pressure which activates safety devices and decomposition products are released to atmosphere through vent stacks.

DESICCANTS Substances which remove water.

DIATOMACEOUS EARTHS A naturally occurring filtering medium used in the non-ionic surfactants plant.

DILUTION STEAM Steam mixed with NAPHTHA or propane before cracking.

DISTILLATION COLUMNS Towers in which product is separated by repeated evaporation and condensation.

DOWNSTREAM PRODUCTS Products of subsequent stages of processing.

ELEVATED FLARE Device for safely burning off a temporary surplus of gas at the top of a tall chimney. An elevated flare can dispose of gas at the very high rates when a plant is shut down.

ETHANOL The chemical name for common alcohol.

ETHANOLAMINES A group of organic compounds formed by the reaction of ethylene oxide and ammonia.

ETHYLENE Compound containing two carbon and four hydrogen atoms. The basic building block of the petrochemical industry; used for making ETHYLENE DERIVATIVES.

ETHYLENE DERIVATIVES Products made by polymerization or reacting ethylene. These products include polyethylenes, vinyl choloride, ethylene oxide, vinyl acetate.

ETHYLENE DICHLORIDE A sweet smelling organic liquid with strong solvent properties. Moderately volatile and inflammable.

ETHYLENE GLYCOL A chemical produced by reacting ethylene oxide and water. Used as antifreeze and in the manufacture of polyesters and explosives.

FATTY ACIDS Organic acids generally containing a 'chain' of carbon atoms. Examples are lactic acid and stearic acid.

FEEDSTOCK Raw material used for making ethylene, eg. NAPHTHA, propane.

FEED GAS GOOLER Cools purified cracked gases before compression in order to save energy used in compression.

FLAKING A process for producing solid materials in the form of small flat flakes, for ease of handling.

FLOC A fine suspended material generated during removal of organics and solids from water prior to the demineralisation process.

FOETOXICITY The ability of a substance to produce a toxic manifestation in a foetus.

FUEL OIL FRACTIONS Mixture of liquid HYDROCARBONS containing seven or more carbon atoms, condensed from CRACKED GASES.

FUGITIVE LEAKS Small, random gas leaks to atmosphere past pipe joints, valve glands etc.

GLYCOL ETHERS Materials formed by reacting together alcohols and ethylene oxide. Used as solvents and in the manufacture of hydraulic brake fluids.

GLYCOL ETHER ACETATES Products made by reacting GLYCOL ETHERS with ACETIC ACID. Their main use is as solvents in automotive lacquers.

GROUND FURNACE Enclosed but roofless furnace for safely burning off temporary surplus of gas at moderate rates.

HEAT TRANSFER MEDIUM A material such as water, or oil used to transfer heat between processing areas.

HORIZONTAL PRESSURE VESSELS Long horizontal cylinders used for storing liquefied gases under pressure.

HYDROCARBONS Family of compounds of carbon and hydrogen including natural gas, LPG and entire range of components of crude oil.

INERT GASES Gases such as nitrogen, carbon dioxide which do not support combustion and which are non-reactive.

JACKETED PRODUCT COOLER A length of pipe fitted with a 'jacket' (ie. a concentric outer pipe). A coolant is passed through the jacket to cool the process fluid flowing through the inner pipe.

kPa A contraction of kiloPascals, a unit of pressure in the SI system. 100 kPa is approximately one atmosphere of pressure.

LPG Liquefied Petroleum Gas, typically propane, propylene, butane and butenes.

MASTER BATCH A concentrated mixture of additives in a plastic material (eg. polythene, PVC etc). When added to freshly made pure plastic at a low percentage it has the effect of distributing the additives throughout the freshly made plastic, modifying its properties.

METHANOL A simple organic alcohol used in the manufacture of GLYCOL ETHERS.

MULTICYCLONES A mechanical device used to remove coarse solid matter from a moving gas stream by centrifugal action.

NAPHTHA Petroleum product obtained from oil distillation boiling below 130°C, ie. lighter than kerosine.

NITROGEN BLANKETED The process of using nitrogen to displace air from above a liquid chemical in storage which would otherwise react with oxygen in the air.

NITROGEN OXIDES Gases produced by the chemical combination of oxygen and nitrogen under conditions of high temperature as in a furnace or boiler. The most common of these gases is nitrogen dioxide.

NONIONIC SURFACTANTS Condensates which are produced by reaction of ethylene oxide and/or PROPYLENE OXIDE with other raw materials.

LONG CHAIN ALCOHOLS Alcohols containing a long unbroken 'chain' of carbon atoms. Used in the manufacture of biodegradable surfactants.

ORGANIC A general term used for all chemicals based on carbon.

ORGANIC PEROXIDES Chemicals characterized by having at least two oxygen atoms in the centre of each molecule. These chemicals break down under the action of heat, and start the growth of plastic (polymer) molecules.

PARTICULATES Solid material usually in suspension in a gas stream as with fine ash in the flue gas of a boiler.

PELLETISER A device for chopping plastic materials into pellets; usually consists of a plate containing a multitude of holes, and a series of blades rotating close to the outside face of the plate. The plastic is extruded through the holes and chopped into pellets by the blades.

PETROCHEMICALS Family of chemical products for which petroleum, LPG or natural gas is the basic raw material.

pH A measure of the acidity or alkalinity of a solution.

POLYMER MELT The plastic in a molten form.

POLYOLS Speciality condensates based on PROPYLENE OXIDE. Used in rigid and flexible urethane foam manufacture.

POLYPROPYLENE Polymerised propylene, a synthetic themoplastic resin used for moulding, films, ropes etc. Has high melting point (168°C to 191°C) and unusual ability to withstand repeated flexing.

POLYTHENE A widely used plastic material constituted of many molecules of ethylene chemically bonded into a long chain.

POLYVINYL CHLORIDE A dense colourless inert plastic resin manufactured as a powder. Naturally hard and rigid, but is made flexible with plasticizers. Durable against weathering and will not burn without assistance from other fuel.

PRESSURE WAVE From an explosion in the open air the wave of pressure travels outwards in all directions at the speed of sound but rapidly decreasing in intensity. It is the main mechanism by which an explosion does damage at a distance.

PROCESS DRAINAGE The pipework system through which process waste is conducted to the effluent treatment plant.

PROCESS WASTE Liquid effluent from a process that contains unwanted chemicals and/or solid material and which is unsuitable for reuse.

PRODUCT SEPARATOR Used in POLYTHENE manufacture. A vertical cylinder in which molten POLYTHENE is separated by gravity from unreacted ethylene.

PROPYLENE OXIDE A chemical similar to ethylene oxide, an ethylene derivative.

PULSATION BOTTLES Pressure vessels inserted between compressor cylinders or after compressors, to smooth out pressure pulses produced by the compressor.

PYROLYSIS GASOLINE Pyrolysis is the cracking of NAPHTHA under heat; pyrolysis gasoline is one of the liquid HYDROCARBON fractions condensed from the CRACKED GAS stream. It is sold to oil companies for blending into petrol.

REACTOR BAY A reinforced enclosure made up of concrete walls, but with no roof.

SOLVENTS Solvents are liquid organic chemicals used in industry for dissolving oils, fats, waxes, resins and other similar materials. The most commonly used are the chlorinated solvents namely trichlorethylene, 1,1,1-trichlorethane, carbon tetrachloride and perchlorethylene. The latter is the solvent most commonly used in dry cleaning.

STEAM CRACKING The cracking of NAPHTHA and/or propane mixed with DILUTION STEAM.

STEAM CURTAINS A barrier of steam sprays placed between a potential source of ignition such as a furnace, and possible points of leakage of flammable gases. Gas detection instruments automatically turn on the steam to disperse any leaked gas.

SULPHUR OXIDES Gases produced by the chemical combination of sulphur and oxygen during a combustion process as with sulphur in coal in a boiler. The most common is sulphur dioxide.

TERATOGENICITY The ability of a substance to induce malformations in a foetus.

TUBULAR PYROLYSIS FURNACES (see CRACKING FURNACE).

VAPOUR EXPLOSIONS Explosion of a flammable vapour which has been released into and mixed with air and then ignited.

VINYL CHLORIDE MONOMER A sweet smelling liquefiable flammable gas with physical properties similar to LPG, which is polymerised to provide PVC.

WATER SCRUBBERS Towers which remove impurities from a gas stream by washing with water.

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