Contamination management strategy for East Perth Gasworks site and adjacent areas of the Swan River

State Energy Commission of Western Australia (SECWA)

Report and recommendations
of the Environmental Protection Authority

Environmental Protection Authority
Perth, Western Australia
Bulletin 651
October, 1992

THE PURPOSE OF THIS REPORT

This report contains the Environmental Protection Authority's environmental assessment and recommendations to the Minister for the Environment on the environmental acceptability of the proposals.

Immediately following the release of the report there is a 14-day period when anyone may appeal to the Minister against the Environmental Protection Authority's recommendations.

After the appeal period, and determination of any appeals, the Minister consults with the other relevant ministers and agencies and then issues his decision about whether the proposals may or may not proceed. The Minister also announces the legally binding environmental conditions which might apply to any approval.

APPEALS

If you disagree with any of the assessment report or recommendations you may appeal in writing to the Minister for the Environment outlining the environmental reasons for your concern and enclosing the appeal fee of $10.

It is important that you clearly indicate the part of the report you disagree with and the reasons for your concern so that the grounds of your appeal can be properly considered by the Minister for the Environment.

ADDRESS

Hon Minister for the Environment
18th Floor, Allendale Square
77 St George's Terrace
PERTH WA 6000

CLOSING DATE

Your appeal (with the $10 fee) must reach the Minister's office no later than 5.00 pm on 23 October, 1992.

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Summary and recommendations

The former Gasworks site at East Perth was used for the production of gas from coal between 1922 and 1971. Since decommissioning of the gas plant in 1971, structures have been progressively demolished. The site is now used as a services depot by the State Energy Commission of Western Australia, which is the owner of the site. As a result of past operations, extensive contamination by coal tars, including known carcinogenic and toxic organic chemicals, exists on the site and in adjacent areas of the Swan River and the Claisebrook Drain. The site is regarded as a seriously contaminated industrial site.

Following concerns concerns of its own, concerns expressed by the community and requirements of the Environmental Protection Authority (EPA), the State Energy Commission of Western Australia commenced an assessment in 1989 of contamination on the site and in the Swan River, to formulate plans for management of the contamination.

In a separate proposal to this assessment, the East Perth Redevelopment Authority proposes to construct an artificial waterway called the Claisebrook Inlet. The waterway would be a focal point of the town centre for the redeveloped East Perth area, and would provide an aesthetic amenity and direct connection with the Swan River. The waterway would be located at the existing outlet of the Claisebrook Drain, which enters the Swan River adjacent to the southern boundary of the Gasworks site. Construction of the inlet and access channel would involve excavating material from the Claisebrook Drain and the Swan River, parts of which would include contaminated sediments. Movement of contaminants from the Gasworks site could have major deleterious effects, particularly in combination with the East Perth Redevelopment Authority's Inlet proposal. The proposed Claisebrook Inlet and the redevelopment of the East Perth area are therefore constrained by the necessity to properly manage the contamination within and around the Gasworks site.

The State Energy Commission of Western Australia referred its proposed contamination management strategy for the Gasworks site and adjacent areas of the Swan River to the EPA in July 1991 and the level of assessment was set at Public Environmental Review. The Public Environmental Review was released for an eight week public review period on 4 May 1992, closing on 25 May 1992. Thirty six submissions were received by the EPA.

The key environmental issues identified during the assessment process were:

- nature and clean-up of contamination in the Swan River and Claisebrook Drain;
- nature and containment of contamination within the Gasworks site;
- co-ordination of contamination management with construction of the Claisebrook Inlet ;
- clean up of the Gasworks site to a standard appropriate for its present land use (industrial) and which ensures no threat to the Swan River from the contaminants in the long term;
- determination of the future use of the Gasworks site;
- clean-up of the Gasworks site to a level compatible with its determined future use; and
- disposal of any hazardous wastes resulting from the clean-up process.

The EPA has assessed the potential environmental impacts of the proposal, both as described in the Public Environmental Review and from the State Energy Commission of Western Australia's responses to issues raised during the public submission period (Appendix 1). The EPA has made a number of recommendations to the Minister for the Environment on how the contamination at the Gasworks site should be managed by the State Energy Commission of Western Australia and the State Government. These recommendations are predicated on the

assumption that the site will continue to be used for industrial purposes, as at present, or change to a higher value land use in the future.

The EPA's recommendations are based on the following key points:

1. The State Energy Commission of Western Australia should be required to immediately clean up contamination off the site that has originated from previous operations of the Gasworks.
2. The State Energy Commission of Western Australia should be required to prevent further export of contaminants from the Gasworks site by taking appropriate containment measures immediately.
3. The State Energy Commission of Western Australia should be required to co-ordinate its clean-up of contamination in the Swan River and the Claisebrook Drain and the construction of containment structures with the activities of the East Perth Redevelopment Authority for the construction of the Claisebrook Inlet.
4. The State Energy Commission of Western Australia should be required to clean up the Gasworks site as soon as possible, to a standard that is suitable for its present land use (industrial) and ensures that there is no long term threat to the Swan River, using the following strategy:

   (i) trials to determine the most effective clean-up method (including bioremediation) within three years; and

   (ii) implementation and completion of the clean-up within a further seven years.
5. Should a higher value land use for the former Gasworks site be required, the State Government is requested to determine the following:

   (i) the future land use of the site;

   (ii) when the land use will change;

   (iii) the time frame in which rehabilitation of the site should occur; and

   (iv) the source of funding for the rehabilitation of the site.
6. Should a higher value land use for the former Gasworks site be required, then clean-up of the Gasworks site for the nominated use should be carried out to EPA's requirements.
7. Regardless of the final end use of the site, the EPA anticipates that some contaminated material may not be amenable to treatment. Consequently the State Government is requested to initiate a process for identifying and setting aside an environmentally acceptable site for the disposal of that hazardous waste.

Clean-up of off-site contamination

The State Energy Commission of Western Australia has identified that a significant area of the Swan River and the Claisebrook Drain adjacent to the Gasworks site has been contaminated. Analyses of benthic river organisms suggested a decline in the number of species and organisms. The levels of polynuclear aromatic hydrocarbons (PAHs) found in these sediments exceeds those shown to cause tumours in fish and general toxicity to biota. Bioaccumulation of PAHs was found in Swan River mussels. The EPA is concerned about the potential for these contaminants to affect both human health and river biota.

The EPA considers that the contaminated materials in the Swan River and the Claisebrook Drain need to be removed, because their removal would be beneficial to the Swan River.

The EPA considers that the management of the contamination arising from the former Gasworks site is the responsibility of the State Energy Commission of Western Australia. Accordingly, the EPA considers that the State Energy Commission of Western Australia should clean up off-site contamination originating from the Gasworks site.

Recommendation 1

The Environmental Protection Authority recommends that the State Energy Commission of Western Australia should ensure that off-site contamination originating from the former Gasworks site is cleaned up to the requirements of the Minister for the Environment, on advice of the Environmental Protection Authority.

To demonstrate how this objective would be met, the State Energy Commission of Western Australia should submit a plan giving details to the Minister for the Environment within three months of any conditions set on the proponent under the Environmental Protection Act 1986.

The plan should be developed in consultation with the Environmental Protection Authority, the Swan River Trust and the East Perth Redevelopment Authority, and include, but not necessarily be limited to:

- **dredging of about six hectares of the Swan River to remove contaminated sediments;**
- **construction and operation of a separation plant for the removal of contamination from the dredged sediments to a quality permitting the return of the clean component of the sediments to the Swan River;**
- **contingency planning in the event of a release of contaminated material to the environment during dredging or separation of sediments;**
- **excavation and removal of contaminated sediments in the Claisebrook Drain; and**
- **monitoring and reporting of dredging of the Swan River and associated fauna, and the sediment separation system.**

The State Energy Commission of Western Australia should implement and regularly review the plan within time-frames and to standards that meet the requirements of the Environmental Protection Authority, on advice from the Swan River Trust.

As investigations in the Swan River were limited to 0.5 metres, monitoring would be required during the removal stage, to ascertain whether all contaminated sediments had been removed to an acceptable level. Following removal and separation, all contaminated materials should be initially stored in a secure manner on the Gasworks site, to await further treatment, pending the outcome of decontamination research trials.

Containment and management of contamination within the former Gasworks site

The State Energy Commission of Western Australia has identified that soil contamination occurs over most of the Gasworks site to depths reaching approximately 12 metres and well below the water table. Of major environmental concern are the polynuclear aromatic hydrocarbons (PAHs), phenols and aromatic hydrocarbons, many of which have toxic and carcinogenic properties and could impact on human health.

Major contamination of the groundwater under the Gasworks site by the more soluble contaminants has been shown and appears to be localised in areas of high tar levels.

Groundwater from the site is generally unsuitable for domestic and general use without treatment. The contaminated groundwater is expected to eventually transport pollutants off-site into the Swan River where further impacts may occur.

The EPA considers that the State Energy Commission of Western Australia should ensure that no further off-site contamination from the former Gasworks site occurs.

Recommendation 2

The Environmental Protection Authority recommends that the State Energy Commission of Western Australia ensures that no further off-site impact occurs from the former Gasworks site to the requirements of the Minister for the Environment, on advice of the Environmental Protection Authority.

To demonstrate how this objective would be met, the State Energy Commission of Western Australia should submit a plan giving details to the Minister for the Environment within three months of any conditions set on the proponent under the Environmental Protection Act 1986.

The plan should be developed in consultation with the Environmental Protection Authority, the Swan River Trust, the East Perth Redevelopment Authority, and the Water Authority of Western Australia, and include, but not necessarily be limited to:

- **measures to fully contain contaminated soils, sediments, ground and surface waters on site, including:**
  - **construction of a low permeability in-ground barrier wall to prevent off-site migration of contamination;**
  - **construction of an up-gradient drainage trench against the barrier wall to collect contaminated groundwater; and**
  - **construction and operation of a dedicated treatment plant to treat this groundwater to a quality permitting discharge to the Swan River;**
- **monitoring and reporting of groundwater outside the site boundaries, the groundwater treatment system, and discharge of water from the site to the Swan River; and**
- **contingency planning if monitoring shows emissions from the site are occurring.**

State Energy Commission of Western Australia should implement and regularly review the plan within time-frames and to standards that meet the requirements of the Environmental Protection Authority, on advice from the Swan River Trust and the Water Authority of Western Australia.

The EPA considers that the impermeable barrier wall, drainage trench and water treatment plant to be constructed by the State Energy Commission of Western Australia should prevent off-site impacts of contamination from occurring in the short term, and should form the basis of the contamination management plan.

The State Energy Commission of Western Australia should be required to monitor and take appropriate action to ensure that ground and surface water quality, and noise, dust and gaseous emissions associated with the works to clean up and contain the contamination, are within standards set by the EPA to protect the environment and public health. These aspects can be controlled through conditions imposed by Works Approval and, subsequently, a Licence, under the Environmental Protection Act.

Co-ordination of contamination management with construction of the Claisebrook Inlet

The EPA notes the plans by the East Perth Redevelopment Authority to develop the Claisebrook Inlet. The EPA considers that it is important that clean-up of contamination in the Swan River and the Claisebrook Drain and the construction of containment structures by the State Energy Commission of Western Australia should be co-ordinated with the activities of the East Perth Redevelopment Authority.

Recommendation 3

The Environmental Protection Authority recommends that the preparation and implementation of the plans by State Energy Commission of Western Australia identified in Recommendations 1 and 2 should be co-ordinated with those parts of the East Perth Redevelopment Authority's construction programme for the Claisebrook Inlet which are related to the contamination from the gas works site, including the dredging of the entrance channel, the excavation of the lower parts of Claisebrook Drain, the connection of the Inlet with the Swan River and the commissioning of the entrance channel for public use. The objective of this recommendation is to ensure that the clean-up of off-site contamination is completed at the same time or before the completion of the Inlet construction programme, and meets the requirements of the Minister for the Environment, on advice of the Environmental Protection Authority and the Swan River Trust.

Recommendation 4

The Environmental Protection Authority recommends that the State Energy Commission of Western Australia should construct the barrier wall between the Gasworks site and the Claisebrook Inlet to prevent the movement of further contaminants from the Gasworks site. This work should be carried out prior to the start of dewatering for the construction of the Inlet, to the requirements of the Minister for the Environment on the advice of the Environment Protection Authority.

Contaminated materials from previous operations at the Gasworks may have been buried along the foreshore of the Swan River and the Claisebrook Drain, outside the cadastral boundaries of the Gasworks site. The EPA considers that any contaminated materials encountered during the excavation of the Inlet are the responsibility of the State Energy Commission of Western Australia to manage. The EPA believes that the State Energy Commission of Western Australia should be held liable at any time in the future for all costs associated with the management, removal and clean-up of these contaminated materials.

Clean-up of the Gasworks site for present land use (industrial)

The State Energy Commission of Western Australia has identified that the Gasworks site is heavily contaminated. The proponent has not proposed any significant clean up of the site for industrial purposes. The EPA does not believe that the containment strategy, as proposed by the State Energy Commission of Western Australia, is a walk away solution for rehabilitation of the site for industrial purposes, as it cannot ensure that the contamination would not be a threat to the Swan River in the long term.

The EPA considers that the State Energy Commission of Western Australia should be required to clean up the Gasworks site as soon as possible. The clean up of the site should result in a walk-away solution to the contamination problem, in the context of continued industrial use of the site and ensuring no long term threat to the Swan River.

The proponent has put forward options and costs for site remediation if the site is to be used for a higher land use. Submissions indicate that proper cost benefit analysis has not been carried out and it is open to suggest that the information provided in the PER favours minimal remediation. The EPA believes that the strategy of capping and containment for industrial or any higher land use is not appropriate, as it is not a walk away solution.

The EPA has been advised that bioremediation of similarly contaminated soils and sediments at former gasworks sites in other parts of Australia and overseas may be successful in significantly reducing levels of organic contaminants. Slurry bioreactor trials carried out on samples of contaminated soils from the Gasworks site in 1991 (not reported in the Public Environmental Review) have shown that levels of the more dangerous polynuclear aromatic hydrocarbons (PAHs) could be reduced by 97% on average within 6 weeks. Treatment using large scale enhanced land farming processes were predicted to reduce PAHs in contaminated soils to low levels within 3 months. The Environmental Protection Authority considers that bioremediation, however, may not be an absolute solution to site clean-up, as discussed below (see Recommendation 9).

The EPA considers that a thorough review should be carried out on the costs and practicability of current and recent practises in the treatment of contaminated soils which are similar in nature to the contaminated soils and sediments from the East Perth Gasworks site area. This information should be used to plan and undertake trials within a reasonable time-frame (maximum of three years) to identify the most suitable method of cleaning up the contamination at the Gasworks site to a level appropriate for continued industrial use of the site and which ensures no long term threat to the Swan River from the contaminants.

The EPA considers that specific attention should be given to the further evaluation of bioremediation methods, due to the successful biodegradation demonstrated in trials to date, and the potentially low environmental impacts off-site associated with its implementation; however other technologies should also be thoroughly examined.

The EPA notes that significant levels of contamination occur at depth (up to 13 metres) at the Gasworks site, and considers that further investigations should be carried out into the recovery and treatment of this material.

Recommendation 5

The Environmental Protection Authority recommends that the State Energy Commission of Western Australia should immediately implement research into the decontamination of the Gasworks site, which meets the requirements of the Environmental Protection Authority. This research, which should include trials on bioremediation and other applicable technologies, should be carried out and reported on within three years, with the objective of identifying the most suitable method of reducing the contamination at the Gasworks site to a level which is compatible with industrial use of the site and ensures no long term threat to the Swan River from the contaminants.

Subsequent to the completion and reporting of the trials, the EPA considers that a rehabilitation plan for the Gasworks site should be prepared and implemented by the State Energy Commission of Western Australia according to decisions arrived at in Recommended 5. The major objective of the plan, which should be initiated within three years, should be to reduce the contaminants at the site to a level that is compatible with industrial use of the site and ensures no threat to the Swan River in the long term. The EPA considers that a maximum of a further seven years, after the completion of trials, to achieve the rehabilitation of the gasworks site to this standard, is reasonable.

Recommendation 6

The Environmental Protection Authority recommends that the State Energy Commission of Western Australia ensure that the Gasworks site at East Perth is cleaned up, such that the final level of contamination is appropriate for industrial use of the site and ensures no long term threat to the Swan River, to meet the requirements of the Minister for the Environment on advice of the Environmental Protection Authority.

To demonstrate how this objective would be met, the State Energy Commission of Western Australia should submit a plan giving details to the Minister for the Environment within three years of any approvals given to the proponent under the Environmental Protection Act 1986.

The plan should be developed in consultation with the Environmental Protection Authority and the Swan River Trust, and include, but not necessarily be limited to:

- **the use of results of trials referred to in Recommendation 5;**
- **clean-up of highly contaminated soils within the Gasworks site;**
- **clean-up of contaminated materials which have been removed from the Swan River and the Claisebrook Drain and stored on site;**
- **the environment and human health are protected during and at cessation of clean-up operations; and**
- **the reuse of decontaminated materials at the site where practicable.**

Future land use and rehabilitation of the former Gasworks site

The State Government has plans to redevelop the former Gasworks site for yet to be specified commercial and residential purposes, although the State Energy Commission of Western Australia propose to continue to use the site as a works depot for the immediate future.

The East Perth Redevelopment Authority has submitted that a "Gasworks Park" could be developed over most of the site (following bioremediation of the contaminated soils), and the high ground, immediately east of Trafalgar Road, could be developed for residential uses.

The EPA considers that the State Government should decide whether the former Gasworks site should be used for a higher value land use than the present industrial use.

Should the State Government determine that a higher value land use for the former Gasworks site is required, then the Government should also determine when this should occur, the time frame in which rehabilitation should occur, a source of funding for the work, and who is responsible for carrying the work out.

Recommendation 7

The Environmental Protection Authority recommends that the State Government determines the following aspects relating to the future use of the former Gasworks site:

- **the future land use of the site, other than industrial;**
- **the maximum period of time that the site can continue to be used in its present industrial use;**
- **a suitable time-frame for rehabilitation of the site to its new form of land use;**
- **source of funding for the rehabilitation work, beyond that recommended in this report as necessary for acceptable, on-going industrial use; and**
- **who is responsible for carrying out the rehabilitation work.**

As previously stated, the EPA believes that capping and containment of contaminated materials is not appropriate for a higher value land use at the Gasworks site, as it is not a walk away solution. The EPA considers that, given the nature and extent of the contamination at the Gasworks site, and based on the presumption that many people may be in close proximity to the site following redevelopment of the East Perth area, the contamination should be cleaned up to a level which does not constitute a danger to human health or the environment, and is consistent with the end-use of the site specified by the Government.

Recommendation 8

The Environmental Protection Authority recommends that, in the event that the State Government determines a higher value land use for the former Gasworks site, the party identified by the State Government in Recommendation 7 to carry out the rehabilitation work should ensure that contamination is cleaned up and the site rehabilitated to the requirements of the Minister for the Environment, on advice of the the Environmental Protection Authority.

To demonstrate how this objective would be met, a plan should be submitted giving details to the Minister for the Environment within three months of any approvals given under the Environmental Protection Act 1986 to change the land use of the site.

The plan should be developed in consultation with the Environmental Protection Authority and the Swan River Trust, and include, but not necessarily be limited to:

- **the rehabilitation strategy provides a walk-away solution to the contamination problem;**
- **the final level of contamination is consistent with the future use identified by the State Government;**
- **clean-up of the contamination occurs within a time frame consistent with Recommendation 7;**
- **the environment and human health are protected during and at cessation of clean-up operations; and**
- **the reuse of decontaminated materials at the site where practicable.**

The plan should be implemented and regularly reviewed within time-frames and to standards that meet the requirements of the Environmental Protection Authority, on advice from the Swan River Trust.

Disposal of hazardous wastes

The EPA notes that, regardless of the land use of the former Gasworks site, some of the contaminated material may not be amenable to treatment at a reasonable cost or time frame. The EPA considers that it could be acceptable to dispose of this material in a land-fill site that is approved to receive hazardous waste. However, apart from a designated facility at Mt Walton, no such site presently exists in the State. The EPA considers that it is appropriate for the State Government to arrange for an environmentally acceptable site for the disposal of significant volumes of hazardous waste. This facility could be made available for the disposal of hazardous wastes from other sites.

Recommendation 9

The Environmental Protection Authority recommends that the State Government initiates a process for identifying and setting aside an environmentally acceptable site for the disposal of hazardous wastes. (Such a site could be available for other hazardous wastes of a nature appropriate for secure land fill.)

1. Introduction

The former Gasworks site at East Perth (Figure 1) was used for the production of gas from coal between 1922 and 1971. Since decommissioning of the gas plant in 1971, structures have been progressively demolished, and the nature of operations has changed to a services depot containing offices, laboratories, workshops and stores.

Contamination by coal tars, as a result of past operations, has been known to exist on and around the Gasworks site for some time. The site is regarded as a seriously contaminated industrial site. Late in 1989, the State Energy Commission of Western Australia (SECWA), being the owner and user of the site, commenced an assessment of contamination on site and in the Swan River to formulate plans for management of the contamination. Recently there has been concern in regard to visible migration of tars into one area of Claisebrook Drain. This was temporarily halted with a plug of earth and rock in 1990.

In a separate proposal to this assessment, the East Perth Redevelopment Authority proposes to construct an artificial waterway called the Claisebrook Inlet. The waterway would be the focal point of the town centre of the redeveloped East Perth area, and would provide an aesthetic amenity and direct connection with the Swan River. The waterway would be located at the existing outlet of the Claisebrook Drain, which enters the Swan River adjacent to the southern boundary of the Gasworks site. Construction of the inlet and access channel would involve excavating material from the Claisebrook Drain and the Swan River, parts of which would include contaminated sediments. Movement of contaminants from the Gasworks site could have major deleterious effects on the East Perth Redevelopment Authority's Inlet proposal. The proposed Claisebrook Inlet and the redevelopment of the East Perth area are therefore constrained by the necessity to properly manage the contamination within and around the Gasworks site. Accordingly, the Environmental Protection Authority (EPA) has assessed the environmental impacts and made recommendations to the Minister for the Environment on both proposals at the same time.

In April 1991 the EPA wrote to SECWA seeking a firm public commitment to resolving the contamination at the gasworks site, to achieve a "walk-away" solution. Specifically, SECWA was requested to carry out studies to:

- define the location, extent and level of contamination in the soil, groundwater and surface waters and sediments on and adjacent to the gasworks site as result of the operation of the gasworks;
- compare the contamination with accepted Australian and international standards for the protection of the environment and the clean-up of contaminated sites;
- identify the necessity for remedial works to be undertaken to recover pollutants which have escaped from the gasworks site and affected the surrounding environment and identify appropriate options to clean up the off-site pollution;
- investigate and identify appropriate options to clean up contamination on the site to achieve compliance with appropriate Australian and international standards for the present rezoning, and to ensure that any waste remaining after such clean-up is contained on site; and
- describe in detail the works required to implement the best clean-up option and demonstrate that these works will ensure that waste on the site is contained and would not prevent further pollution occurring off-site.

SECWA referred their proposal to the EPA in July 1991 and the level of assessment was set at Public Environmental Review (PER). Guidelines for the PER were subsequently prepared by the EPA in consultation with other government agencies. The guidelines included the requirements detailed above, and the need for SECWA to address the future alternative land uses of the site, bearing in mind the plans of the State Government to redevelop the site.

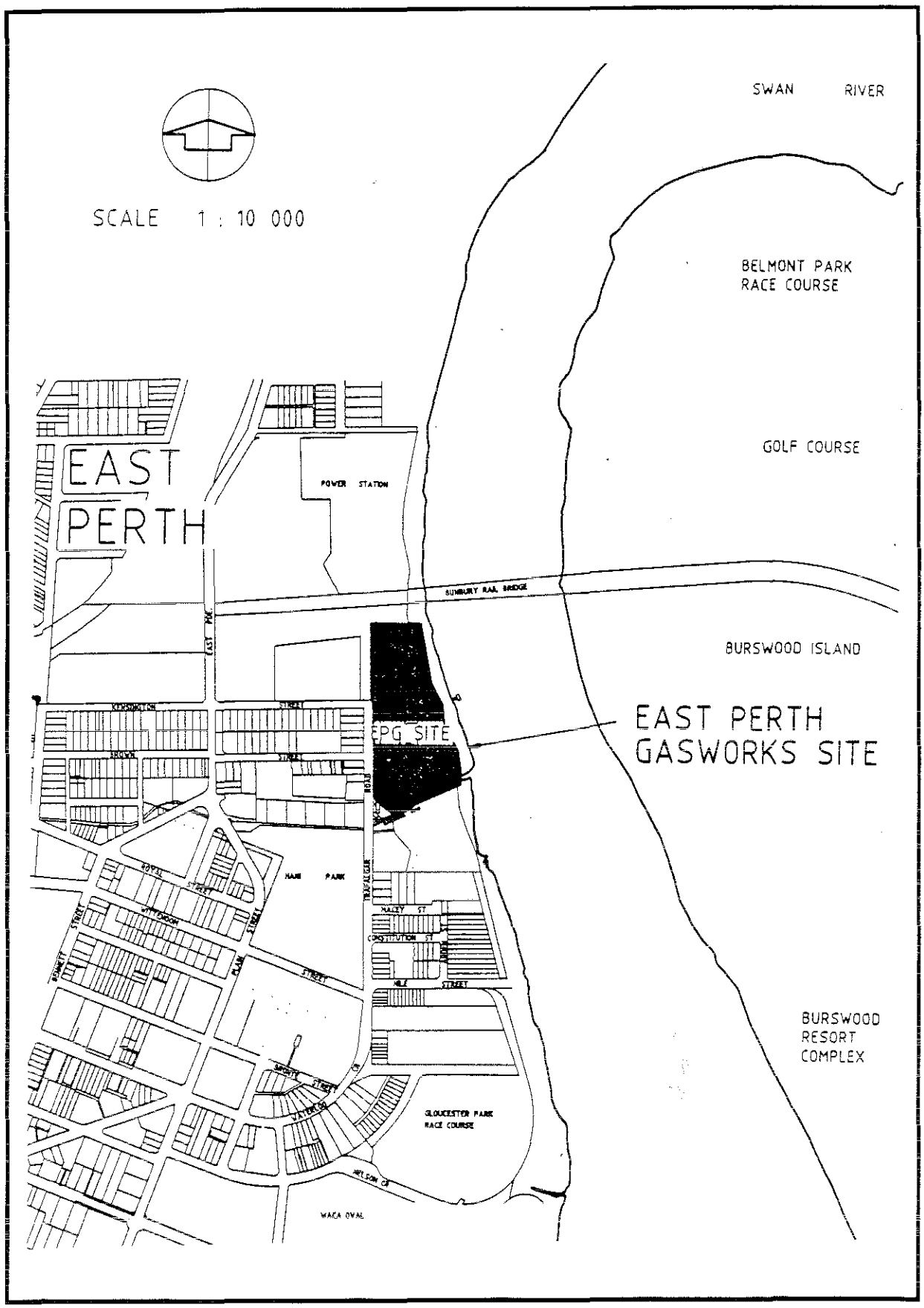


Figure 1: Location of East Perth Gasworks (Source: SECWA's PER).

SECWA has carried out investigations on the contamination at the site and environs since 1985, and has compiled this information into a number of documents which also form part of the PER, namely:

- Investigation of East Perth Gasworks Site Rehabilitation Volumes 1 and 2, December 1990 by Camp Scott Furphy in conjunction with Golder Associates and others;
- Site Remediation Proposals for East Perth Gasworks, January 1992 by Camp Scott Furphy; and
- Environmental Assessment of Polyaromatic Hydrocarbons Contamination of River Sediments Near The East Perth Gasworks, January 1992 by Bowman Bishaw Gorham in association with Camp Scott Furphy.

SECWA has summarised the information in the above reports and proposed a contamination management strategy for the gasworks site and contaminated sediments of the Swan River and the Claisebrook Drain in the PER. The PER was released for an eight week review period on 4 May 1992, with submissions closing on 25 May 1992. Thirty six submissions were received by the EPA.

The EPA has assessed the potential environmental impacts of the proposal, both as described in the Public Environmental Review and from SECWA's responses to issues raised during the public submission period (Appendix 1).

2. Type, extent and impacts of contamination

The environment and previous land use, including factors leading to the present state of the site have been described by SECWA in the PER.

Gasworks site

Soil contamination occurs over most of the Gasworks site to depths reaching approximately 12 metres and well below the water table. It is greatest in locations where the gas manufacturing plant was sited in the past. Some idea of the extent of contamination which exists near the surface of the Gasworks site is shown in Figure 2, which is taken from the report by Camp, Scott and Furphy.

The chief contaminant is coal tar, which is a mixture of many individual organic chemicals. Of major environmental concern are the polynuclear aromatic hydrocarbons (PAHs), phenols and aromatic hydrocarbons. Inorganic chemical residues include ammonia nitrogen, sulphates and heavy metals. The major concern with many of these chemicals is their toxic and carcinogenic properties, which could impact on human health, mainly as a result of contact during uncontrolled excavation activities on site.

An occupational health study of the Gasworks Depot for its current use showed no significant risk to the health of SECWA employees on the site.

Major contamination of the groundwater under the Gasworks site by the more soluble contaminants was shown. Groundwater from the site is generally unsuitable for domestic and general use without treatment. The soluble indicators (phenols, lower PAHs and ammonia nitrogen) of gasworks contamination appear to be localised in areas of high tar levels.

The contaminated groundwater is expected to eventually transport pollutants off-site into the Swan River where further impacts may occur. Significant potential to migrate towards the Swan River was identified in the south-eastern corner of the Gasworks site, adjacent to the proposed Claisebrook Inlet.

Swan River and Claisebrook Drain

Contamination in the Swan River was determined by SECWA by investigating and analysing river water, sediments and bottom dwelling organisms. Sediments in the river were found to be contaminated by tars (measured as PAHs) to at least 0.5 metres over approximately 600m

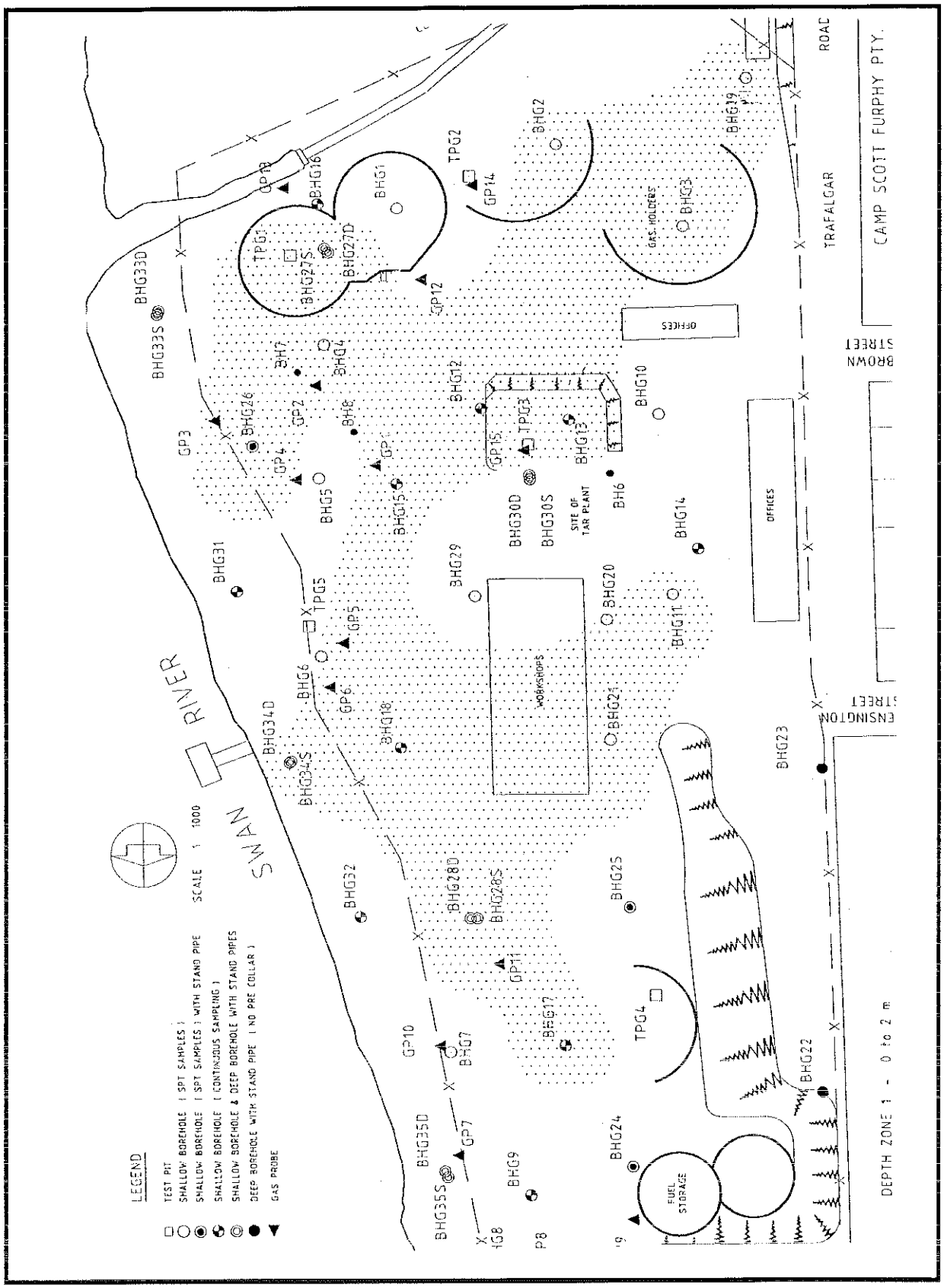
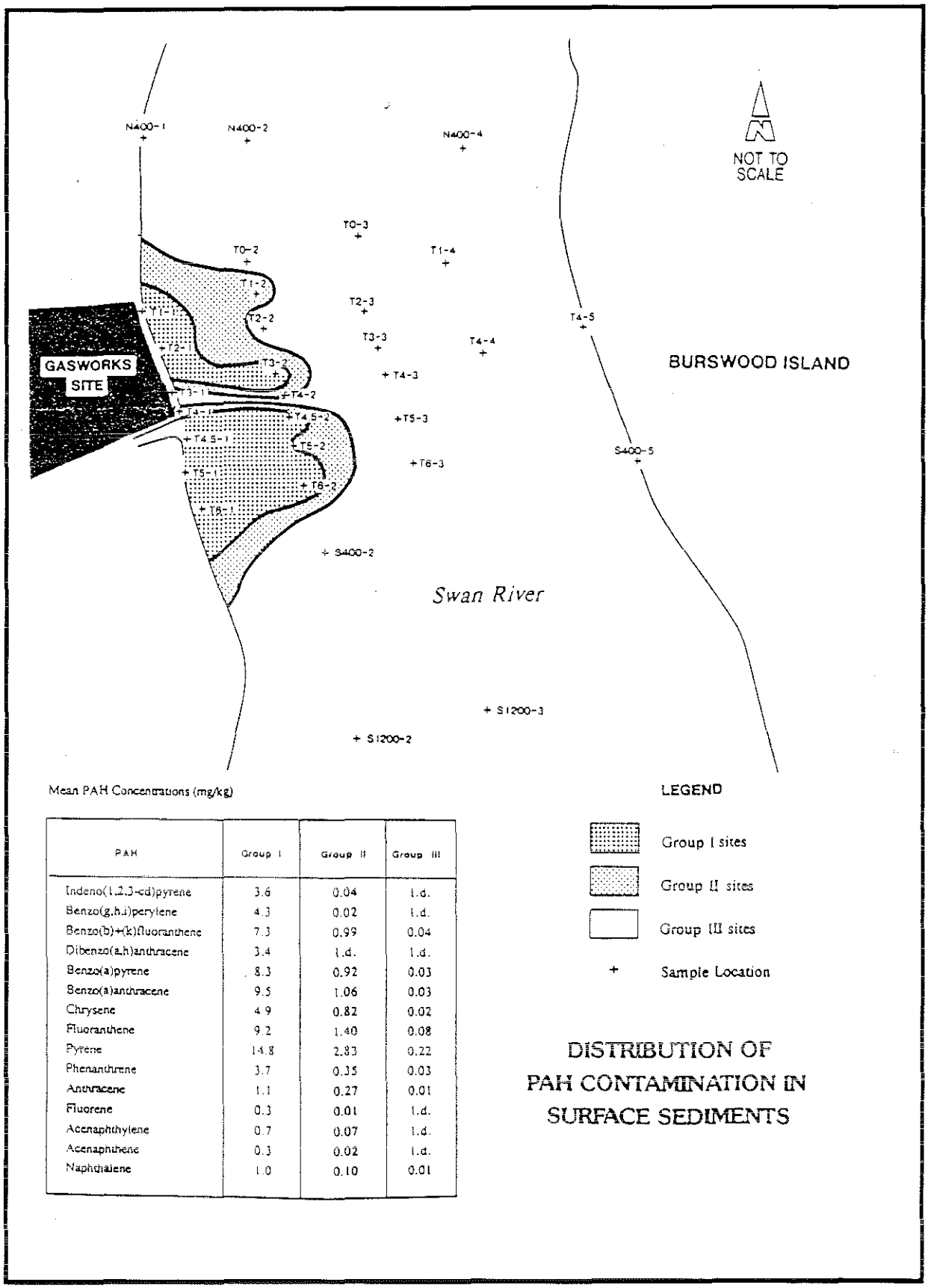


Figure 2: Approximate extent of contaminated soils (0-2 metres) at the former Gasworks site(Source: Volume I, Camp, Scott and Furphy report, 1990).



PAH	Group I	Group II	Group III
Indeno(1,2,3-cd)pyrene	3.6	0.04	l.d.
Benzo(g,h,i)perylene	4.3	0.02	l.d.
Benzo(b)+(k)fluoranthene	7.3	0.99	0.04
Dibenzo(a,h)anthracene	3.4	l.d.	l.d.
Benzo(a)pyrene	8.3	0.92	0.03
Benzo(a)anthracene	9.5	1.06	0.03
Chrysene	4.9	0.82	0.02
Fluoranthene	9.2	1.40	0.08
Pyrene	14.8	2.83	0.22
Phenanthrene	3.7	0.35	0.03
Anthracene	1.1	0.27	0.01
Fluorene	0.3	0.01	l.d.
Acenaphthylene	0.7	0.07	l.d.
Acenaphthene	0.3	0.02	l.d.
Naphthalene	1.0	0.10	0.01

Figure 3: Approximate extent of contaminated sediments in the Swan River (Source: SECWA's PER).

and confined largely to the western areas of the river (refer to Figure 3). No soluble organic contaminants (phenols, hydrocarbons or lower PAHs) were evident, indicating an old depositional pattern.

Analyses of the river sediment organisms suggested a decline in the number of species and the number of organisms. The literature indicates that the levels of PAHs found in these sediments exceeds those shown to cause tumours in fish and general toxicity to biota. Some of the higher PAHs are carcinogenic. Bioaccumulation of PAHs was found in Swan River mussels.

Tars have seeped from the Gasworks site into the lower portion of the Claisebrook Drain in past years. The sediments are now heavily contaminated by tars (shown by high PAH levels). Heavy metals are also present but it is uncertain whether they originated from the Gasworks site. The Claisebrook Drain is considered by SECWA to be the source of contamination found in the Swan River.

3. The proposal

SECWA have proposed a strategy to containment of contamination at the East Perth Gasworks site and adjacent areas of the Swan River and Claisebrook Drain. This strategy is described in detail in the PER.

On-site containment and treatment of contaminants at the Gasworks site

The main features of SECWA's strategy are the construction of a low permeability in-ground barrier wall, an upgradient drainage trench, and a dedicated water treatment plant.

The low permeability in-ground barrier is proposed to be 250m long and 7m deep. It would be installed along the south-east part of the site fronting the Swan River and Claisebrook Drain, to prevent potential off-site migration of underground contamination. To prevent build-up of groundwater against this wall, an upgradient drainage trench would be installed. Water collected in this passive system would be pumped to storage sumps at the extremity of the trench and barrier. The collection rate is estimated at $10m^3$/day. Having passed through contaminated soil strata, this groundwater could be contaminated and would be treated by a dedicated water treatment plant to a quality permitting discharge into the Swan River.

Dredging of contaminated sediments in the Swan River

Contaminated Swan River sediments over an area of approximately 6 hectares to a depth of 600mm would be selectively removed by a cutter dredging technique. The contaminants which are bound to fine silts would be separated and the uncontaminated coarse material returned to the river.

Excavation of contaminated sediments in the Claisebrook Drain

The sediments in the lower portion of the Drain would be excavated to a depth of 600mm and removed. Contaminated sediments would be removed in conjunction with works by the East Perth Redevelopment Authority for the excavation of the Claisebrook Inlet. SECWA considers that any further contamination of the Drain would be prevented by the barrier system mentioned above.

Capping of contaminated soils and materials

An estimated $10,000m^3$ of contaminated soil would be generated from remediation works described in this proposal. Currently there is no suitable hazardous waste landfill disposal facility in Western Australia. Since this soil would be no more contaminated that the soil already under the site, it would be buried on site at a location which would be ultimately covered by the capping system.

Currently SECWA has no firm plans for disposing of the site and no further remediation of the site is proposed. However, SECWA is aware of plans for urban renewal of the East Perth area

by the East Perth Redevelopment Authority. SECWA considers that the majority of the Gasworks site (apart from high ground) is unsuitable for general redevelopment without remediation.

If, in the future, redevelopment of the site occurs for other land uses, SECWA proposes to cover and contain parts of the site where underground contamination levels exceed guideline criteria for a nominated land use. This capping procedure would provide an engineered cover over the present surface and would consist of a clay base, a drainage layer and top soil. Infiltrated rainfall from this cap would be diverted through site stormwater drains to the River.

4. Public consultation and submissions

SECWA consulted with government agencies during the preparation of the PER, including the EPA, the East Perth Redevelopment Authority, the Water Authority of Western Australia, the Swan River Trust, the Health Department, the Perth City Council and Landcorp. The residential population in the general area was not consulted, except via the Public Environmental Review process. The nearest residence to the site is located 300 metres to the south.

The PER was released for an eight week review period on 4 May 1992, with submissions closing on 25 May 1992. Thirty six submissions were received by the EPA (Appendix 2).

Most submissions supported to some extent the proposal to clean up the off-site contamination in the Swan River and the Claisebrook Drain, although concerns were raised about potential impacts of this work on benthic fauna. Concerns were raised about the effects of any dispersion or solubilisation of contaminants by dredging on users of the river in that area. There was general qualified support for the groundwater containment and treatment strategy proposed by SECWA. A number of submissions raised questions of a more technical nature, such as rationalisation for the extent of the barrier wall and the amount of groundwater to be treated. Few submissions regarded SECWA's proposal as a long term solution to the contamination problem at the Gasworks site. Some acknowledged that the level of clean-up would be dictated by the end-use of the site. The EPA received a number of submissions regarding the effectiveness of various clean-up technologies. Particular attention was drawn to the success of bioremediation as a treatment for soils contaminated by gasworks in other parts of Australia and the world.

SECWA's responses to issues raised during the public review is given in Appendix 1.

5. Assessment of proposal by the Environmental Protection Authority

5.1 Clean-up of off-site contamination

SECWA has identified that a significant area of the Swan River and the Claisebrook Drain adjacent to the Gasworks site has been contaminated. The EPA is concerned about the potential for these contaminants to affect both human health and river biota, and has noted a number of important findings which emerged from SECWA's investigations, namely:

- The distribution of the contaminated sediments in the Swan River and the Claisebrook Drain clearly implicates the Gasworks site as the primary source of contamination.
- Previous contamination from the Gasworks site into Claisebrook Drain continues to pollute the Swan River with high levels of naphthalene.

- A literature search has shown that naphthalene concentrations in other parts of the world cause significant mortalities of benthic fauna at levels substantially lower than those measured in the Claisebrook Drain, and only slightly greater than the mean concentration within the contaminated area of the Swan River.
- Surface sediment concentrations of higher molecular weight PAHs in the contaminated parts of the Swan River and the Claisebrook Drain exceed levels in sediments found elsewhere to cause a high incidence of liver tumours in bottom feeding fish.
- Natural breakdown of the high molecular weight contaminants through biological processes is likely to take a considerable time. Dilution throughout the river by dispersion is unlikely, as the area favours deposition of sediments most of the year. .

The EPA has a policy on dredging in the Swan River, as described in EPA Bulletin 575 on the Riverside Gardens dredging and landfill proposal. The EPA believes that its prime objective, in its guardianship of the environment of the Swan River, is to ensure that the river remains "alive and healthy" and that, to the greatest extent possible, its integrity is maintained. In justifying changes to the river's waterways, proponents of dredging proposals must not only satisfy the EPA that they would not cause adverse impacts to the river system, but they must go further and show that the dredging would be either environmentally beneficial to the river, or necessary for the maintenance of existing river activities.

The EPA considers that the contaminated materials in the Swan River and the Claisebrook Drain need to be removed, because their removal would be beneficial to the Swan River.

The EPA considers that the management of the contamination arising from the former Gasworks site is the responsibility of the State Energy Commission of Western Australia. Accordingly, the EPA considers that the State Energy Commission of Western Australia should clean up off-site contamination originating from the Gasworks site.

Recommendation 1

The Environmental Protection Authority recommends that the State Energy Commission of Western Australia should ensure that off-site contamination originating from the former Gasworks site is cleaned up to the requirements of the Minister for the Environment, on advice of the Environmental Protection Authority.

To demonstrate how this objective would be met, the State Energy Commission of Western Australia should submit a plan giving details to the Minister for the Environment within three months of any conditions set on the proponent under the Environmental Protection Act 1986.

The plan should be developed in consultation with the Environmental Protection Authority, the Swan River Trust and the East Perth Redevelopment Authority, and include, but not necessarily be limited to:

- **dredging of about six hectares of the Swan River to remove contaminated sediments;**
- **construction and operation of a separation plant for the removal of contamination from the dredged sediments to a quality permitting the return of the clean component of the sediments to the Swan River;**
- **contingency planning in the event of a release of contaminated material to the environment during dredging or separation of sediments;**
- **excavation and removal of contaminated sediments in the Claisebrook Drain; and**
- **monitoring and reporting of dredging of the Swan River and associated fauna, and the sediment separation system.**

The State Energy Commission of Western Australia should implement and regularly review the plan within time-frames and to standards that meet the requirements of the Environmental Protection Authority, on advice from the Swan River Trust.

As investigations in the Swan River were limited to 0.5 metres, monitoring would be required during the removal stage, to ascertain whether all contaminated sediments had been removed to an acceptable level. Following removal and separation, all contaminated materials should be initially stored in a secure manner on the Gasworks site, pending the outcome of decontamination research trials.

The EPA considers that, subsequent to the removal of contaminants by the separation process and prior to its return to the river, the cleaned sediment material should be monitored to ensure it meets approved criteria . All contaminated materials should be initially stored and contained within the Gasworks site, to await further treatment, pending the outcome of rehabilitation research trials.

5.2 Containment of contamination within the former Gasworks site

The State Energy Commission of Western Australia has identified that soil contamination occurs over most of the Gasworks site to depths reaching approximately 12 metres and well below the water table. Of major environmental concern are the polynuclear aromatic hydrocarbons (PAHs), phenols and aromatic hydrocarbons, many of which have toxic and carcinogenic properties and could impact on human health.

Major contamination of the groundwater under the Gasworks site by the more soluble contaminants has been shown and appears to be localised in areas of high tar levels. Groundwater from the site is generally unsuitable for domestic and general use without treatment. The contaminated groundwater is expected to eventually transport pollutants off-site into the Swan River where further impacts may occur.

The EPA expresses major concern about the presence of these materials close to the Swan River and, in the near future, to large numbers of people once the East Perth area is redeveloped. The EPA considers therefore, as a matter of high priority, that SECWA should initiate works, as soon as possible, to contain this contamination to the Gasworks site and ensure that no further contamination of the Claisebrook Drain and the Swan River occurs.

Recommendation 2

The Environmental Protection Authority recommends that the State Energy Commission of Western Australia ensures that no further off-site impact occurs from the former Gasworks site to the requirements of the Minister for the Environment, on advice of the Environmental Protection Authority.

To demonstrate how this objective would be met, the State Energy Commission of Western Australia should submit a plan giving details to the Minister for the Environment within three months of any conditions set on the proponent under the Environmental Protection Act 1986.

The plan should be developed in consultation with the Environmental Protection Authority, the Swan River Trust, the East Perth Redevelopment Authority, and the Water Authority of Western Australia, and include, but not necessarily be limited to:

- **measures to fully contain contaminated soils, sediments, ground and surface waters on site, including:**
  - **construction of a low permeability in-ground barrier wall to prevent off-site migration of contamination;**

- **construction of an up-gradient drainage trench against the barrier wall to collect contaminated groundwater; and**
- **construction and operation of a dedicated treatment plant to treat this groundwater to a quality permitting discharge to the Swan River;**

- **monitoring and reporting of groundwater outside the site boundaries, the groundwater treatment system, and discharge of water from the site to the Swan River; and**
- **contingency planning if monitoring shows emissions from the site are occurring.**

State Energy Commission of Western Australia should implement and regularly review the plan within time-frames and to standards that meet the requirements of the Environmental Protection Authority, on advice from the Swan River Trust and the Water Authority of Western Australia.

The EPA considers that the impermeable barrier wall, drainage trench and water treatment plant to be constructed by the State Energy Commission of Western Australia should prevent off-site impacts of contamination from occurring in the short term, and should form the basis of the contamination management plan.

The State Energy Commission of Western Australia should be required to monitor and take appropriate action to ensure that ground and surface water quality, and noise, dust and gaseous emissions associated with the works to clean up and contain the contamination, are within standards set by the EPA to protect the environment and public health. These aspects can be controlled through conditions imposed by Works Approval and, subsequently, a Licence, under the Environmental Protection Act.

5.3 Co-ordination of contamination management with construction of the Claisebrook Inlet

The EPA notes the plans by the East Perth Redevelopment Authority to develop the Claisebrook Inlet. The EPA considers that it is important that clean-up of contamination in the Swan River and the Claisebrook Drain and the construction of containment structures by the State Energy Commission of Western Australia should be co-ordinated with the activities of the East Perth Redevelopment Authority.

Recommendation 3

The Environmental Protection Authority recommends that the preparation and implementation of the plans by State Energy Commission of Western Australia identified in Recommendations 1 and 2 should be co-ordinated with those parts of the East Perth Redevelopment Authority's construction programme for the Claisebrook Inlet which are related to the contamination from the gas works site, including the dredging of the entrance channel, the excavation of the lower parts of Claisebrook Drain, the connection of the Inlet with the Swan River and the commissioning of the entrance channel for public use. The objective of this recommendation is to ensure that the clean-up of off-site contamination is completed at the same time or before the completion of the Inlet construction programme, and meets the requirements of the Minister for the Environment, on advice of the Environmental Protection Authority and the Swan River Trust.

The East Perth Redevelopment Authority has given conditional endorsement to the strategy of SECWA to construct the barrier wall along the southern boundary of the gas works site as part of its proposed Contamination Management Strategy. The excavation of the Claisebrook Inlet by the East Perth Redevelopment Authority would involve dewatering which has the potential to draw contaminated groundwater or coal tars from the Gasworks site. The EPA consider that it is important that dewatering for the Inlet does not commence until an approved barrier wall is constructed.

SECWA propose to extend the barrier wall from the southeast corner of the site to the wier along the Claisebrook Drain, about a third of the length of the southern boundary of the Gasworks site. It has been brought to EPA's attention that contamination extends to the extreme southwest of the Gasworks site, where coal tars were detected by drilling near the Claisebrook Drain, at about 2 metres below the surface. The EPA is concerned that in time these coal tars and polluted groundwaters could enter the proposed Inlet and Swan River if the barrier wall was not extended to this area.

Recommendation 4

The Environmental Protection Authority recommends that the State Energy Commission of Western Australia should construct the barrier wall between the Gasworks site and the Claisebrook Inlet to prevent the movement of further contaminants from the Gasworks site. This work should be carried out prior to the start of dewatering for the construction of the Inlet, to the requirements of the Minister for the Environment on the advice of the Environment Protection Authority.

Contaminated materials from previous operations at the Gasworks may have been buried along the foreshore of the Swan River and the Claisebrook Drain, outside the cadastral boundaries of the Gasworks site. The EPA considers that any contaminated materials encountered during the excavation of the Inlet are the responsibility of the State Energy Commission of Western Australia to manage. The EPA believes that the State Energy Commission of Western Australia should be held liable at any time in the future for all costs associated with the management, removal and clean-up of these contaminated materials.

5.4 Clean-up of the former Gasworks site for present use (industrial)

The State Energy Commission of Western Australia has identified that the Gasworks site is heavily contaminated. The proponent has not proposed any significant clean up of the site for industrial purposes. The EPA does not believe that the containment strategy, as proposed by the State Energy Commission of Western Australia, is a walk away solution for rehabilitation of the site for industrial purposes, as it does not ensure that the contamination would not be a threat to the Swan River in the long term.

The EPA considers that the State Energy Commission of Western Australia should be required to clean up the Gasworks site as soon as possible. The clean up of the site should result in a walk-away solution to the contamination problem in the context of continued industrial use of the site and ensuring no long term threat to the Swan River.

The proponent has put forward options and costs for site remediation if the site is to be used for a higher land use. Submissions indicate that proper cost benefit analysis has not been carried out and it is open to suggest that the information provided in the PER favours minimal remediation. The EPA believes that the strategy of capping and containment for industrial or any higher land use is not appropriate, as it is not a walk away solution.

The EPA has been advised that bioremediation of similarly contaminated soils and sediments at former gasworks sites in Australia and overseas may be successful in significantly reducing

levels of PAHs and other organic contaminants. The East Perth Redevelopment Authority commissioned CRA Services Ltd to undertake bioremediation laboratory tests on contaminated soils from the Gasworks site in 1991, and reported the results to EPA as part of their submission on the PER. Results from these trials indicated the following:

- Bioremediation can achieve major reductions in all PAH compounds within reasonable times. For example, slurry bioreactor trials showed that levels of total priority PAHs could be reduced by 97% on average within 6 weeks; the worst result was for benz(gih)perylene which was reduced by 73%.
- Treatment using large scale enhanced land farming processes were predicted to reduce PAHs in contaminated soils to low "parkland" levels (500 mg/kg) within 3 months.

The Environmental Protection Authority considers that bioremediation, however, may not be an absolute solution to site clean-up, as discussed below (see Recommendation 9).

The EPA considers that a thorough review should be carried out on the costs and practicability of current and recent practises in the treatment of contaminated soils which are similar in nature to the contaminated soils and sediments from the East Perth Gasworks site area. This information should be used to plan and undertake trials within a reasonable time-frame (maximum of three years) to identify the most suitable method of cleaning up the contamination at the Gasworks site to a level appropriate for continued industrial use of the site and which ensures no long term threat to the Swan River from the contaminants.

The EPA considers that specific attention should be given to the further evaluation of bioremediation methods, due to the successful biodegradation demonstrated in trials to date, and the potentially low environmental impacts off-site associated with its implementation; however other technologies should also be thoroughly examined.

The EPA notes that significant levels of contamination occur at depth (up to 13 metres) at the Gasworks site, and considers that further investigations should be carried out into the recovery and treatment of this material.

Recommendation 5

The Environmental Protection Authority recommends that the State Energy Commission of Western Australia should immediately implement research into the decontamination of the Gasworks site, which meets the requirements of the Environmental Protection Authority. This research, which should include trials on bioremediation and other applicable technologies, should be carried out and reported on within three years, with the objective of identifying the most suitable method of reducing the contamination at the Gasworks site to a level compatible with industrial use of the site and ensures no long term threat to the Swan River from the contaminants.

Subsequent to the completion and reporting of the trials, the EPA considers that a rehabilitation plan for the Gasworks site should be prepared and implemented by the State Energy Commission of Western Australia according to decisions arrived at in Recommended 5. The major objective of the plan, which should be initiated within three years, should be to reduce the contaminants at the site to a level that is compatible with industrial use of the site and ensures no long term threat to the Swan River. The EPA considers that a maximum of a further seven years, after the completion of trials, to achieve the rehabilitation of the gasworks site, is reasonable.

Recommendation 6

The Environmental Protection Authority recommends that the State Energy Commission of Western Australia ensure that the Gasworks site at East Perth

is cleaned up, such that the final level of contamination is appropriate for industrial use of the site and ensures no long term threat to the Swan River, to meet the requirements of the Minister for the Environment on advice of the Environmental Protection Authority.

To demonstrate how this objective would be met, the State Energy Commission of Western Australia should submit a plan giving details to the Minister for the Environment within three years of any approvals given to the proponent under the Environmental Protection Act 1986.

The plan should be developed in consultation with the Environmental Protection Authority and the Swan River Trust, and include, but not necessarily be limited to:

- **the use of results of trials referred to in Recommendation 5;**
- **clean-up of highly contaminated soils within the Gasworks site;**
- **clean-up of contaminated materials which have been removed from the Swan River and the Claisebrook Drain and stored on site;**
- **the environment and human health are protected during and at cessation of clean-up operations; and**
- **the reuse of decontaminated materials at the site where practicable.**

5.5 Future land use and rehabilitation of the former Gasworks site

The State Government has plans to redevelop the former Gasworks site for yet to be specified commercial and residential purposes, although the State Energy Commission of Western Australia propose to continue to use the site as a works depot for the immediate future.

The East Perth Redevelopment Authority has submitted that a "Gasworks Park" could be developed over most of the site (following bioremediation of the contaminated soils), and the high ground, immediately east of Trafalgar Road, could be developed for residential uses.

The EPA considers that the State Government should decide whether the former Gasworks site should be used for a higher value land use than the present industrial use.

Should the State Government determine that a higher value land use for the former Gasworks site is required, then the Government should also determine when this should occur, the time frame in which rehabilitation should occur, and a source of funding for the work.

Recommendation 7

The Environmental Protection Authority recommends that the State Government determines the following aspects relating to the future use of the former Gasworks site:

- **the future land use of the site, other than industrial;**
- **the maximum period of time that the site can continue to be used in its present industrial use;**
- **a suitable time-frame for rehabilitation of the site to its new form of land use;**
- **source of funding for the rehabilitation work, beyond that recommended in this report as necessary for acceptable, on-going industrial use; and**
- **who is responsible for carrying out the rehabilitation work.**

As previously stated, the EPA believes that capping and containment of contaminated materials is not appropriate for a higher value land use at the Gasworks site, as it is not a walk away solution. The EPA considers that, given the nature and extent of the contamination at the Gasworks site, and based on the presumption that many people may be in close proximity to the site following redevelopment of the East Perth area, the contamination should be cleaned up to a level which does not constitute a danger to human health or the environment, and is consistent with the end-use of the site specified by the Government.

Recommendation 8

The Environmental Protection Authority recommends that, in the event that the State Government determines a higher value land use for the former Gasworks site, the party identified by the State Government in Recommendation 7 to carry out the rehabilitation work should ensure that contamination is cleaned up and the site rehabilitated to the requirements of the Minister for the Environment, on advice of the the Environmental Protection Authority.

To demonstrate how this objective would be met, a plan should be submitted giving details to the Minister for the Environment within three months of any approvals given under the Environmental Protection Act 1986 to change the land use of the site.

The plan should be developed in consultation with the Environmental Protection Authority and the Swan River Trust, and include, but not necessarily be limited to:

- **the rehabilitation strategy provides a walk-away solution to the contamination problem;**
- **the final level of contamination is consistent with the future use identified by the State Government;**
- **clean-up of the contamination occurs within a time frame consistent with Recommendation 7;**
- **the environment and human health are protected during and at cessation of clean-up operations; and**
- **the reuse of decontaminated materials at the site where practicable.**

The plan should be implemented and regularly reviewed within time-frames and to standards that meet the requirements of the Environmental Protection Authority, on advice from the Swan River Trust.

5.6 Disposal of hazardous wastes

The EPA notes that, regardless of the land use of the former Gasworks site, some of the contaminated material may not be amenable to treatment at a reasonable cost or time frame. The EPA considers that it could be acceptable to dispose of this material in a land-fill site that is approved to receive hazardous waste. However, apart from a designated facility at Mt Walton, no such site presently exists in the State. The EPA considers that it is appropriate for the State Government to arrange for an environmentally acceptable site for the disposal of significant volumes of hazardous waste. This facility could be made available for the disposal of hazardous wastes from other sites.

Recommendation 9

The Environmental Protection Authority recommends that the State Government initiates a process for identifying and setting aside an environmentally acceptable site for the disposal of hazardous wastes. (Such a site could be available for other hazardous wastes of a nature appropriate for secure land fill.)

6. Conclusions

The State Energy Commission of Western Australia has identified that the Gasworks site is heavily contaminated. The proposed impermeable barrier wall, drainage trench and water treatment plant may be an effective method of preventing off-site impacts of contamination occurring in the short term. However, whilst the contamination exists on the site, the containment structures and treatment systems may not be adequate and would continue to require monitoring and maintenance for an indefinite period.

The proponent has not proposed any significant clean up of the site for industrial purposes. The EPA does not believe that the containment strategy, as proposed by the State Energy Commission of Western Australia, is a walk away solution for rehabilitation of the site for industrial purposes. The presence of major contamination within the site would remain a threat to the Swan River in the long term.

The proponent has put forward options and costs for site remediation if the site is to be used for a higher land use. Submissions indicate that proper cost benefit analysis has not been carried out and it is open to suggest that the information provided in the PER favours minimal remediation. The EPA believes that the option of capping and containment for industrial or any higher land use is not appropriate, as it is not a walk away solution.

Appendix 1

Response by the State Energy Commission of Western Australia to issues raised in public submissions on the Public Environmental Review.

QUESTIONS ARISING OUT OF SUBMISSIONS ON THE PUBLIC ENVIRONMENTAL REVIEW FOR EAST PERTH GASWORKS SITE

1. *CONTAMINATION DESCRIPTION AND ASSESSMENT*

Gasworks Soil

Question 1.1

What rationale has been used to determine that sufficient sampling and analysis have been conducted to:

(a) Adequately describe and assess the nature and extent of contamination; and

(b) Develop a management strategy?

Answer 1.1

The contamination assessment philosophy of the gasworks site followed closely the guidelines inherent in draft documents for site remediation by NH & MRC and ANZECC which were the precursors to the final document titled 'Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites', January 1992. Additionally, worldwide philosophies specific to gasworks sites were used.

Early investigations by Consultants Sinclair Knight and Partners for Landcorp screened the full USEPA priority pollutants. Further investigations by Camp, Scott and Furphy built on these findings to:

(a) Further assess the presence of specific gasworks contaminants.

(b) Define the extent of contamination using the species of environmental significance.

(c) Judge the local environmental significance of the contamination, and

(d) Assess the possible remedial techniques that could be applied.

The sampling regime that was used concentrated on areas suspected of being contaminated from historical records, and was complemented with sampling locations strategically placed to assess environmental impacts.

This gave sufficient information to screen available techniques on such considerations as cost, applicability, availability and effectiveness to achieve developed criteria of remediation. The management strategy proposed in the PER in the result of this process.

Further, infill sampling and analysis is envisaged as part of the engineering design phase to implement the proposed actions in the strategy.

Question 1.2

The following questions arise in relation to describing the nature and extent of the contamination of the soil at the Gasworks site:

(a) What are the mass estimates of contamination in the soil, groundwater and the river and drain?

(b) Which of the parameters listed in Table 5.5 of the PER were most frequently used to define the area requiring clean-up for residential and commercial uses.

(c) Quality assurance test results quoted in Table 5.9 in the December 1990 Camp, Scott and Furphy report suggest that this data provide only a general indication of contamination levels. How accurate and reproducible are the analyses quoted in the PER?

(d) What are the volume estimates of contaminated soil at the Gasworks, for the various depths and end-use clean-up levels? What degrees of confidence can be attributed to these estimates?

(e) What relevance do geometric or arithmetic means have in describing the levels and distribution of contaminants of the Gasworks site? i.e. would not the use of such numbers lead to a low estimate of the level and extent of the contamination?

(f) What is the approximate volume of fill and area covered by concrete slabs on the site? How much of this fill is contaminated.

(g) What compounds constitute total volatile polynuclear aromatic hydrocarbons (PAHs)? What is the relationship between this parameter and the 16 priority PAHs nominated by the USEPA? i.e. what correlation exists between the two data sets for various conditions? Under what circumstances is it appropriate and inappropriate to use total volatile PAHs in describing the contamination at the Gasworks?

(h) Are the water-insoluble, heavy (and more carcinogenic) PAHs made more mobile by dissolution in other organic liquids? To what extent could this mechanism have affected their spread throughout the Gasworks site?

Answer 1.2

(a) The mass quantities of contaminants on and off site have not been estimated for the following reasons.

(i) There is little point to such an exercise.

(ii) Any reasonably accurate estimate would require highly extensive sampling and testing. Even so, since the measured species reside in complex matrices such as tar, such estimates would have little practical meaning.

(b) In the delineation of contamination boundaries, all the parameters listed in Table 5.5 were used. Any exceedence of a parameter over the values listed designated a point to be within the 'contaminated' zone for that particular land use. The actual parameters which determined such classification for each sampling point and depth are listed in Table 8.1 of Volume 1 of 'Investigation of East Perth Gasworks Site Rehabilitation' CSF (December 1990).

(c) The difference in inter laboratory results shown in Table 5.9 is indicative of the variability of the samples, differences in laboratory procedures, the complex matrices in which the analytes exist and the variability to be expected at the low concentrations of the materials analysed.

The Analytical Reference Laboratory was selected for all the analytical work during the assessment due to past experience, and confidence in its work. Another indication of ARL accuracy and reproducibility is given in Tables 5.7 and 5.8 of volume 1 of 'Investigation of East Perth Gas Works Site Rehabilitation', CSF (December 1990).

ARL estimates its analytical precision for all analytes at ten times detection limits to be 10%; and 20% for PAHs.

(d) The area of the site that is estimated to be contaminated is 3.75ha for both residential and recreational land uses and 2.25ha for commercial/industrial land uses. Thus the volume of soil exceeding clean up criteria to a depth of 2m is 75,000m^3 and 45,000m^3 respectively.

For residential/recreational purposes the volume between 2 and 4 metres is about the same, and about half that amount again below 4 metres. The confidence of estimates at larger depths decreases due to uncertainties of further contamination of soil by attempts at remediation.

For commercial/industrial land uses the volume of soil exceeding criteria between 2 and 4 metres is approximately half that in the surface layer, and approximately equal to the volume to be expected below 4 metres.

These estimates are approximate indicators only. Little confidence can be placed in any such estimates unless very close order sampling and analysis programmes are undertaken.

(e) Large amounts of data are usually summarised by presenting a range and mean of values. The range shows the spread of results i.e. the lowest and the highest. The mean attempts to give the mid point of results. For gaussian distributions the arithmetic mean is appropriate.

Results of surveys of contamination analysis results, however tend to be log normally distributed. Hence the geometric mean is a better indicator of the median value. The significance of a median value is that there is a probability of 0.5 that a sample value will exceed (or be less than) the population median.

Normally the assessment of health risks to any exposed population is based on an average value for each contaminant, where unbiased sampling locations are used, although this will be area dependent. Due to uncertainties involved, the USEPA procedure recommends that exposure concentrations be the upper confidence limit of the arithmetic average.

(f) Historical records indicate that the majority of the low-lying areas of the site were filled in the past as has most of the foreshore in the general area. The volume of such fill on the Gasworks site is unknown. It is estimated that over half the present area of the site is covered by bituminised surface, buildings and paved areas. Underground concrete foundations of older buildings still exist since it was past practice to demolish structures only to one foot below surface level. The volume and condition of such buried structures are unknown.

(g) 'Total volatile PAHs' represents the sum of the following compounds:-

* Naphthalene
* Methyl Naphthalene
  Dimethyl Naphthalenes
  Trimethyl Naphthalenes
* Acenaphthylene
* Acenaphthene
* Fluorene
* Phenanthracene
* Anthracene

The species marked (*) are common to those in the list of 16 priority PAHs.

Fresh coal tar, or tar that has not been extensively dispersed and leached contains high amounts of these volatile compounds, particularly naphthalene. Thus the total volatile PAH analysis is a useful screening tool for identifying such contamination, prior to full analysis. The correlation is subject to the actual sample treatment and is good in ideal circumstances under such conditions.

There is poor correlation under circumstances where the volatile PAHs are depleted and the higher molecular weight (less volatile, and less soluble) PAHs dominate the 16 priority list. This situation was found with PAHs in river sediments. The screening method was ineffective and hence distributions of PAHs in sediments were defined with full analysis techniques.

(h) The higher molecular weight PAHs are intimately associated with a heavy tar matrix in which they would show a preferential solubility. To increase the mobility of these PAHs, one would have to increase the mobility of the tar matrix with an appropriate solvent to the point of fluidity.

There has been no indication of such conditions on the site from the samples taken in the assessment of contamination. High PAH values are associated with locations of tar contamination underground. These positions vary both in depth and areal distribution and there is no defined plume apart from the break through of tar into Claisebrook Drain.

Question 1.3

It is known that some of the contaminants are carcinogenic and there is potential for people to come into contact with them, particularly on the foreshore which is a recreation reserve. The following questions have arisen in regard to contaminant toxicity and carcinogenesis:

(a) How toxic are these contaminants and what are potential routes of exposure and possible synergistic effects under current and future end uses for the Gasworks area?

(b) In the context of encountering these compounds in every day life (e.g. as tars in bitumen and in burnt food), how common are they, and how exposed and at risk is the general population?

(c) Who carried out the risk and hazard assessment? What was the basis for the division of the site into the six areas? Could averaging of the few values on specific PAHs have lead to a conservative and possibly inaccurate calculation of the risks and hazards? What level of confidence can be placed on the results of the study?

Answer 1.3

(a) Chemical contaminants may be divided into two broad groups according to their human health effects. The two groups are contaminants that have carcinogenic effects and those that have non-carcinogenic or systemic effects, which may include effects on specific organs or systems, such as the nervous system.

Chemical toxicity depends on human response to the dose of substances delivered to the critical organs or systems. The data used for estimating these dose response relationships are based on life time animal studies and human occupational or epidemiological studies where excessive cancer incidences associated with gas manufacture have been associated with exposure to a specific chemical.

These date are generally limited to data from animal studies and are extrapolated to predict human health effects by applying safety factors which account for the level of confidence in the available data. Chemicals associated with potential cancer risk to humans include:-

- benzene
- some PAHs
- some heavy metals

The critical toxicity values for non-carcinogens are based on levels of exposure where deleterious effects through life time exposure have been demonstrated.

Acceptable levels of contaminants in the soil have been estimated using risk procedures documented by the US Environment Protection Authority by estimating the level of exposure to humans and the potential impact of this exposure based on known or estimated toxicity.

The details of the methodology for assessing these levels is set out in Volume 1 of the report 'Investigation of East Perth Gasworks Site Rehabilitation', CSF, (December 1990) which was provided for public review during the public review period.

Future human exposure to the more toxic PAHs will be addressed by the interception of contaminated groundwater and capping of areas where high levels of near surface contaminants have been identified.

(b) PAHs are very common in the environment. They exist in petroleum products, cooking oils, smoke from various sources (including cigarettes), municipal wastes, sewage wastes, river sediments, water, air, road tar, used engine oils, coal, soot and generally any organic material that has been modified by heat or partial combustion. Cooked food, particularly that prepared by baking or roasting contains PAHs. The levels in these sources vary and not all the PAHs are necessarily carcinogenic.

The general population is therefore exposed to PAHs daily. The risk depends on the dosage from all those sources of exposure and potency factors for the various species. Such information is not fully available for all the PAHs.

(c) The risk assessment study was undertaken by Camp, Scott and Furphy using USA based toxicologists familiar with these procedures which are commonplace in the United States.

For the purposes of the assessment, the site was divided into six sections since the level of contamination is significantly different across the site. This preliminary stage was to guide the assessment of rehabilitation requirements. It should be remembered that the assessment was applied to the appropriate land use under that consideration of the site in its present form i.e. no rehabilitation to be undertaken. Hence average values of the contaminants found were used in this initial screening stage.

The second part of the study developed contaminant criteria based on a marginal health risk of 1×10^{-6} of contracting cancer (during a lifetime of exposure), or a level of exposure to the non carcinogens considered, on the basis of available data, to result in adverse health effects, also for lifetime exposure. The 1×10^{-6} risk for carcinogenic effects is considered to be conservative. A marginal risk of 1×10^{-5} is, for instance, used to assess WHO drinking water criteria, where the exposed populations are very large compared to the likely exposed population at East Perth. These site specific, risk based criteria are given in Table 5.5 of the PER. It is these criteria that are proposed as the final outcome of any remedial treatment to be undertaken on the site. The procedures used are highly conservative and similar to those used elsewhere in the world.

Question 1.4

What explanation can be given for the uneven growth of the fig trees along the river foreshore?

Answer 1.4

There are many examples of different size trees of the same species growing along the Perth river foreshores. The relative growth rates of the figs adjacent to the East Perth Gasworks site were not investigated in detail. There are many reasons for variable growth rates of trees; seed and seedling viabilities, different soil structure, nutrient levels, competition with adjacent trees, to name a few.

Question 1.5

What is the distance to the nearest residences from the site boundaries?

Answer 1.5

The closest current residence (Macey Street, East Perth) is about 300 metres from the nearest boundary point of the Gasworks site.

Groundwater

Question 1.6

In which bores and pits and at what levels were non-aqueous phase liquids detected? What is their rate and direction of migration?

Answer 1.6

Non aqueous phase liquid was only found in BHG 8. This was a monitoring bore installed by SKP and sampled during the investigations undertaken in 1990. There was no evidence of floating product in adjacent bore BHG 35S. Furthermore there was no evidence of migration of floating product (light non aqueous phase liquid) along the foreshore adjacent to this borehole. Furthermore hydrocarbons and phenols were not detected in the water column adjacent to the site.

Question 1.7

What is the rate of migration of dissolved contaminants in the groundwater? When are these contaminants likely to reach the Swan River or the Claisebrook Drain?

Answer 1.7

Rates of migration of dissolved contaminants are estimated in Section 6.1.5 of the December 1990 Report.

Question 1.8

What is the potential for contaminants found in shallow bores to pollute deeper groundwater, and when is this likely to occur?

Answer 1.8

Contamination by gasworks waste is evident at depths of up to 14 m and at depths up to 6 and 7m at a number of locations on the site. These wastes are likely to contribute to contamination of the groundwater. However, no evidence of contamination was evident in the deeper bores along the river frontage downstream of the contaminated area, namely BHG 33D, BHG 34D and BHG 35D. High levels of phenol contamination were found in groundwater at BHG 27D, however this is in the area of a contaminant source and does not indicate that any contamination is migrating in the groundwater.

Swan River and Claisebrook Drain

Question 1.9

In relation to the type and extent of contamination of the Swan River and the Claisebrook Drain:

(a) Explain in more detail how contaminated sediments were ranked. What is the relevance of these rankings to specific clean-up criteria?

(b) What explanation is given for the erratic profile distribution of contaminants in the Swan River? Since a significant level of Group I contaminants is still present at 0.5 metres, at what depth does this drop to an acceptable level? On what basis is 'acceptable' defined?

(c) What is the nature of the tar layer which was seeping into Claisebrook Drain? Is this still occurring?

Answer 1.9

(a) The data for individual PAH analyses were assembled in descending order of concentrations. The top value was given a rank number of 1, the second highest, 2 and so on. The resultant set of numbers for each location at each analysis depth were summed. The locations were then assembled in descending order of these sums.

This procedure thus arranges the sampling locations into an order of worst to least contaminated areas, taking into account all the PAH species analysed. It allows a definition of the degree of contamination in a spatial sense.

There are no specific clean up criteria for aquatic sediments, thus the normal simple procedure of definition to meet criteria can not be used. The ranking system allows visualisation of areas of contamination to various degrees, and judgements to be made on the extent of clean up.

(b) It is very rare for contamination to be uniform over an extended area. The pattern of contamination observed is thought to be due to deposition of tars from intermittent spillages into Claisebrook Drain over many years in the past. The deposition pattern would be governed by many complex factors such as tidal movements, seasonal river flows salinity, river sedimentation, deposition of aquatic debris, volatilisation and solubilisation.

River sediment sampling and analysis was only conducted to 0.5m depth due to the difficulty of obtaining representative samples from greater depths under water. It is very possible that bands of contamination exist at greater depths.

The question of 'acceptability' of contaminant levels is a matter of value judgement. Very little scientific knowledge exists about the aquatic toxicology of tar bound PAHs. It could be argued that it is best to leave deep sediments undisturbed, rather than put the rest of the environment at risk by deep excavation attempts.

(c) The tar layer found intersecting Claisebrook Drain was an approximately 30cm thick strata of soil and coal tar mixture at a depth of about 2 to 3m below the surface. The seepage was extremely slow, causing a weep only through the bank of the drain. This was contained temporarily by excavating the tar contaminated soil adjacent to the Drain and installation of an earth/rock plug in 1990. The containment strategy proposed in the PER will provide for the permanent interception of this tar seepage.

Question 1.10

It has been pointed out to the EPA that the original alignment of the Claisebrook Drain was further towards the centre of the Gasworks site. Can this be delineated on a map? What significance does this have for the spread of contaminants on the site, particularly groundwater movement and impacts on the Swan River?

Answer 1.10

Historical records are not definite about the original course of Claise Brook. It is known that the Brook was first straightened and canalised (by boarding) in 1920. Best estimates suggest the original alignment was as depicted in the enclosed plan. The date of the plan is not known but is thought to be about 1890 or 1900. Most of the site was originally a river depositional area, progressively reclaimed over the years. This is evident from the borehole stratigraphy.

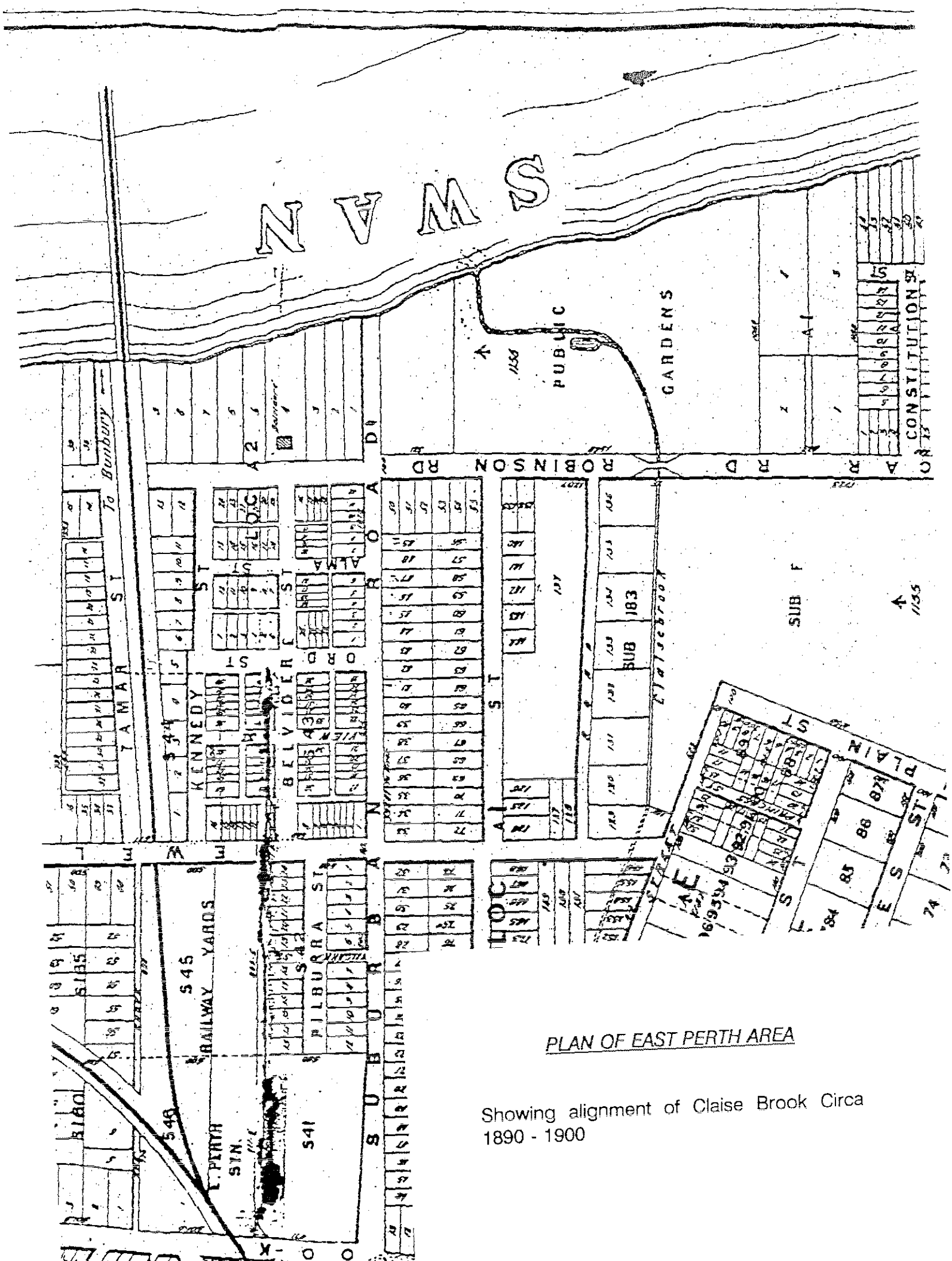
Thus the realignment of Claise Brook, should, in principle, have little bearing on the potential spread of contaminants.

Question 1.11

How likely is it that fish and benthic fauna (other than mussels) in the river and drain that are part of the human food chain would exhibit bio-accumulation of PAHs? What are the implications of this for human health?

Answer 1.11

The fish are migratory and were not assessed as part of the study, not being considered to be an indicator for localised contamination.



PLAN OF EAST PERTH AREA

Showing alignment of Claise Brook Circa 1890 - 1900

Given that there is limited consumption of fish from this section of the Swan River, intake of any contaminant by consumption of fish is likely to be low and not considered to impact human health.

2. *SITE CAPPING AND CONTAINMENT STRATEGY*

Question 2.1

In relation to the proposed management strategy for the contaminated material:

(a) How does it compare with the ANZECC/NH&MRC guidelines issued in January 1992?

(b) To what extent does the strategy propose a final (walk-away) solution to the contamination problem at the East Perth Gasworks site?

(c) At what other places similar to the East Perth Gasworks site has this strategy been adopted? What on-going environmental management problems are associated with this approach? How are these problems managed? How successful is such management?

(d) What parameters were used to determine the 'economic viability' in regard to the final recommended contaminant strategy?

(e) The PER and associated reports identify adverse public perception as one of the reasons why leaving contaminated sediments in the Swan River is considered unacceptable. Why does the same rationale not apply to capping and containing similar material on the Gasworks site?

Answer 2.1

(a) The proposed management strategy is totally consistent with the options given in the ANZECC/NH&MRC guidelines 1992, for site clean-up and management (see section 3.1.8 of that document). The options are listed in preferred order, and such a process has been undertaken in the selection of the SECWA strategy.

(b) The strategy proposes a management scheme rather than a final 'walk-away' solution. Ongoing management of water treatment, maintenance, monitoring and land use restrictions are therefore required.

(c) The rehabilitation of former gasworks sites using a capping and containment strategy has been commonly applied in Australia and worldwide. Some examples are:-

- Little Manly Gasworks Site (Sydney).
- Oyster Cove, North Sydney (plans approved).

- False Creek (Canada) is very similar to the East Perth situation.
- Stroudsburg (USA).

There are a number of other sites referred to in the main report - 'Investigation of the East Perth Gasworks Site' - Volume 1, CSF (December 1990).

The management techniques for this approach include the following:-

- Monitoring of performance of the containment and capping systems, through groundwater bore sampling off-site.
- Restrictions on uncontrolled excavations.
- Identification of service routes.
- Proper design of service ducting and corridors through the contaminated area to service full site development.
- Prevention of groundwater use from the contained site.

These management techniques and others are contained in the main report - 'Investigation of the East Perth Gasworks Site' - Volume 1, CSF (December 1990).

(d) The parameters used by SECWA to determine the best rehabilitation strategy in economic terms was done through consideration of the following items. Consideration was given to a comprehensive remediation programme of the site and the river, rather than an adhoc approach.

- Cost of remedial treatments.
- Effectiveness of treatments against land uses to determine standards of clean-up.
- Availability of waste landfill sites.
- Availability of remediation technologies and techniques in Western Australia.
- Off-site impact.
- Duration of the rehabilitation options.

A broad range of technologies that had demonstrated application to clean-up of gasworks sites was considered in the above review process, including thermal desorption, soil washing and biological treatments.

(e) Public perception was only one of the factors considered in the proposal to dredge contaminants from the river. The others were:

- Potential for adverse ecological effects.
- Largely unknown aquatic toxicology of tars.
- High probability of a successful technical outcome.
- Relatively low costs.

Public perception was also a consideration in the selection of the proposed land site treatment together with other factors similar to the above.

Question 2.2

If the site was capped:

(a) *Would the contaminated soil be separated from the clay by a layer of gravel to prevent transfer of contaminants to the surface?*

(b) *Would the site be registered as contaminated?*

(c) *Would conditions be placed on the titles of the land to prevent inappropriate uses?*

(d) *Would the thickness of capping material be sufficient to prevent vegetation and burrowing animals having access to the contaminated sediments?*

(e) *Would the proposed capping system cover ground water monitored by bore BHG 8 which the PER identifies as being contaminated by high levels of 'oily factions'?*

Answer 2.2

(a) The low permeability capping system proposed would prevent the migration of water-borne contaminants to the surface. Gravel would serve no purpose further to that provided by the generally sandy near surface soil, which will effectively drain below the proposed capping.

(b) There is no procedure in Western Australia to register contaminated land.

(c) SECWA has made the commitment to identify the nature of contamination of the land and the remedial treatment undertaken on the titles of the land. Technically, the proposed containment and capping system should not restrict any land use, provided appropriate management practices are adopted.

(d) The thickness of the capping would prevent vegetation and burrowing organisms from disrupting the integrity of the engineered capping system. The ANZECC Guidelines for assessment and management of contaminated sites, January 1992, states that 2.5m of soil is sufficient for this purpose. In most situations, 500mm of cover gives a high level of protection. Deep trenching for service installation is unlikely to extend below 2m.

(e) BHG8 is not regarded as heavily contaminated. Some contaminants associated with very deep fill material in the general area are evident. The shallow groundwater is not considered to be sufficiently contaminated to warrant interception. Furthermore, there is no evidence of contamination potentially reaching the river from this area of the site. However, the final extent of the slurry wall and interception system is yet to be determined by further considerations of the contamination found and will be detailed in the engineering design stages of the project.

Question 2.3

It appears that the cost estimates for some components of the capping strategy, particularly costs for sand and clay, are far too conservative. If the estimates are significantly low, does this make other remediation strategies more attractive?

Answer 2.3

No.

Question 2.4

What are the individual components of the 10,000m³ of contaminated soil to be capped and contained on site? What are the likely variances of these amounts and why?

Answer 2.4

The estimate of the total volume of excavated contaminated soil to be contained on site under the capping system is based on:

▪ Sediments from river after separation	6,000 m³
▪ Construction of cut-off wall	2,500 m³
▪ Sediments from Claisebrook Drain	1,000 m³
▪ Contingency	500 m³
	10,000 m³

These are nominal values to be refined during the engineering design stages. Variances will arise from considerations of feasibility of sediment separation, excavation techniques employed and gasworks wastes identified during the Claisebrook Inlet construction phases by the East Perth Redevelopment Authority.

Question 2.5

In relation to the cut-off wall design and construction:

(a) *What documentation is there that the contaminants reported at the site would not break down materials used in the cut-off wall at some later stage, leading to a release of contaminants to the environment?*

(b) *What evidence suggests that the cut-off wall as proposed will effectively intercept ground water at this site which consists of unlithified sediments?*

(c) *Why was the cut-off wall limited to a depth of 7 meters?*

(d) *Would the groundwater flow under the cut-off wall if it is not anchored in underlying impervious material?*

(e) *How are slurry walls installed and what prevents the sides of the trenches in unlithified sediments from collapsing?*

(f) *What is meant by a 'hanging wall' design?*

(g) *Bores BHG 28 and BHG 8 both show high levels of contamination. Would the proposed wall be extended to ensure that the ground water affected by them would be retained and collected?*

(h) *What would stop the river from flowing into the interception trench, particularly around the end of the wall during flood conditions?*

(i) *How would SECWA ensure that the river is not further polluted by dewatering during excavation of the cut-off wall?*

Answer 2.5

(a) The primary purposes of the cut-off wall is to prevent excessive inflow of water from the Swan River in addition to the control of the shallow groundwater flow to the interception trench. Note that the interception trench will collect the shallow groundwaters upstream of the cut-off wall.

Final selection of the cut-off wall material will consider, compatibility with aggressive permeates, however, slurry wall construction with use of an appropriate filler generally performs satisfactorily as a barrier for organic wastes.

The material to be used in cut-off walls would be selected on the basis of laboratory tests for compatibility with the pollutants present on site.

(b) Cut-off walls are standard practice in Perth for groundwater control and have been widely used overseas and in Australia for containment of ground contamination. The cut-off wall in conjunction with a groundwater interception trench provides for the interception of shallow groundwater and any floating product moving towards the river and Claisebrook Drain. In this regard the data from the groundwater investigation has indicated that potential groundwater contamination is generally restricted to upper aquifers.

(c) The depth of the cut-off wall at 5m is a nominal depth established from consideration of the hydrogeology of the area. The final depth is to be defined during detailed engineering design.

(d) The cut-off wall and interception trench will be designed to intercept shallow groundwater. Groundwater would bank up against the cut-off wall. It is this increased hydrostatic head which would tend to force water under and around the wall. However, the interception trench would dissipate this hydrostatic head and would in fact cause a decreased hydrostatic pressure to draw contaminated water into the trench. Refer to (b).

(e) Slurry walls are installed by progressively digging a narrow trench to the required depth and back-filling with a slurry of the construction material. Bentonite in the slurry prevents wall collapse during construction. Once in place the slurry material sets to its final form in situ.

(f) A 'hanging wall' design is a cut-off wall, that is not anchored at the bottom to bedrock. That is, it 'hangs' in soil strata extending from the surface to a specified depth.

(g) No volatile PAHs or mono-aromatic hydrocarbons were detected in samples taken from BHG28. Low levels of total hydrocarbons were reported in the shallow bore at this location (0.05mg/l total petroleum hydrocarbons). This is not regarded as warranting containment - see also 2.2(e).

(h) The design of the cut-off wall will recognise the requirement to limit leakage from the river into the trench. The depth of the cut-off wall below the invert of the trench would increase the dynamic loss of water flowing from the river limiting the flow of water from the river into the trench. Further modelling of the proposed cut-off wall/interception trench system will be undertaken during the engineering design to confirm wall depth and the cut-off wall/interception trench layout.

(i) There is no proposed dewatering and nor is it necessary. Refer to (e).

Question 2.6

What contaminants would still be able to migrate off the site after installation of the drainage trench and cut-off wall? e.g. what evidence is there that the containment strategy would intercept non-aqueous liquid phases that are heavier than water? If these materials were not contained on site, where would they go and what would be their environmental impact?

Answer 2.6

The cut-off trench is designed to intercept only shallow groundwater and lighter non aqueous liquid phases. In theory, the heavy non aqueous phase liquids will migrate more or less vertically downward depending on the configuration of soil strata and particularly the nature of the low permeability zones. The rate of vertical migration based on evidence from the 1990 investigations is low. The organic chemicals from areas of deeper contamination will slowly leach into the groundwater. However, it is noted that there is no evidence of hydrocarbon contamination in the deep bores downstream. The off-site environmental impact from this leaching effect would not be evident.

Question 2.7

How much contaminated soil would be located outside the confines of the containment wall and along the foreshore? What remedial treatment would be applied to this contaminated material?

Answer 2.7

Test bores on the foreshore revealed no tar contamination except for the south east corner in the area of known highest site contamination. Also tar was located at depth near the jetty associated with an area of fill. Such contaminations are deep so that users at the foreshore are not exposed. Hence, capping of this area has not been proposed.

Question 2.8

How would SECWA manage odours from soil and sediments during dredging and excavation?

Answer 2.8

There would be no odours from the dredging operation since the tar components are well-leached of the odour producing species.

During soil excavation minimal odours are expected since trenching is in the least contaminated parts of the site. Any odours that do occur would be minimal and would be expected to be present on the immediate site only. However, nearby residents would be informed that transient low level odours may occur and of their sources and significance.

Monitoring of volatile emissions would be undertaken during all excavation works to assess odour in terms of OH&S exposure. Contingency plans would be established to deal with high volatile levels, should they occur.

Question 2.9

What assurances can the proponent provide for the occupational health and safety of workers involved in the future maintenance of below ground services such as sewerage?

Answer 2.9

SECWA maintains that the provision of services in contaminated land must be specially engineered at the time of final capping to suit the intended development of the site. This is standard practice as for example, in the Little Manly Gas Works remediation in NSW. Engineered corridors for services such as sewerage, power, and water reticulation below the clay layer ensures that human contact with contamination does not occur. A buried warning mat over the corridors would alert excavators to the existence of the services and the containment layer. If excavation below the containment is necessary, standard procedures for occupational health and safety of workers would apply.

Question 2.10

How would SECWA ensure that emissions of volatiles from excavation work would not exceed occupational health standards or have an adverse impact on future land users?

Answer 2.10

The levels of volatiles found on site are unlikely to cause exceedence of occupational health and safety standards during the excavation works. Similar experiences on other gasworks sites have been noted. Volatile emissions will be monitored during excavations as part of the project OH&S plan. Future land users will not be effected.

3. *GROUNDWATER CONTROL AND TREATMENT*

Question 3.1

In regard to the design and operation of the groundwater treatment plant:-

(a) The quantity of contaminated groundwater collected (10m³/day) appears low. What assumptions were made to calculate this volume?

(b) Who would be responsible for operating the groundwater treatment plant in the long term, particularly if ownership of the land changes? How would this be controlled in the case of multiple titles and ownership?

(c) How long would collection and treatment of contaminated groundwater continue at the site?

(d) What storage facilities would be provided for treated groundwater to allow for monitoring, prior to release to the river?

(e) Could the proposed treatment plant could be more suitably located, other than on the river flood plain which is part of a public recreational area?

(f) What safeguards would be put in place to protect the river in the event of spillages?

(g) What design criteria and operating procedures would be implemented for the handling and storage of chemicals for the groundwater treatment facility, to ensure that environment and public safety are protected?

(h) What wastes and gaseous emissions would be associated with the treatment plant? Where would any sludges from the water treatment be disposed of?

Answer 3.1

(a) The preliminary estimate of contaminated groundwater to be collected from shallow aquifers (10cu m per day) is based on data collected during the investigation.

This estimate considered the typical groundwater gradients and soil permeability across the full extent of the barrier and seasonal effects. This estimate will be reviewed as part of the engineering design.

(b) Is it SECWA's intention to retain ownership of the land and operate the treatment plant. Should ownership change, operation of the plant and management of the remediation treatment must be vested in the new owner.

(c) The quality of the groundwater collected by the interception system will be monitored and interception will continue until such time as groundwater quality is acceptable for discharge directly to the Swan River. This is considered to be a very long period of time.

(d) The monitoring control systems and any holding tanks that may be required would be established in the design stages of the plant.

(e) The final location of the treatment plant has not been decided. The location will be reviewed during the engineering design and a site selected, preferably at the environmentally most suitable location.

(f) The treatment plant would be enclosed within bunding in accordance with standard practise for chemical handling and storage facilities.

(g) The design and operating procedures for the groundwater treatment facility would be in accordance with regulations and guidelines issued by appropriate authorities with respect to off-site environmental impact and public safety.

(h) The groundwater intercepted is likely to contain low levels of light aromatic hydrocarbons (benzene, toluene, ethylbenzene and xylene), semi volatile PAHs, phenol and ammonia nitrogen. The light aromatic hydrocarbons and ammonia are likely to strip off during treatment and would be vented to atmosphere or if necessary, flared or passed through activated carbon cylinders. Given the anticipated low rate of groundwater interception, venting without treatment is likely to be satisfactory. The design of the treatment plant will review the required efficiencies for stripping of volatiles in the groundwater and the impact of resulting emissions.

Pre-treatment may be required for collection of lighter non-aqueous hydrocarbons in an interceptor. Interceptor waste (hydrocarbons) could be collected routinely by an oil recycler or a waste collection service.

There are a number of process options for treatment of phenol and the polyaromatic hydrocarbons based on biodegradation, oxidation to carbon dioxide, or destruction by a peroxide/UV process. Production of sludges is not likely for these options. An interim stage of treatment by activated carbon absorption may be necessary to achieve the required discharge limits and disposal of the spent carbon would be necessary.

Question 3.2

The treatment proposed for the small quantity of groundwater being collected seems excessive. Other waste water treatment options (such as UV/ozone) may also be more cost effective, especially considering the cost of the treatment chemicals and the need to replace activated carbon. Please comment on this and on the disposal of activated carbon.

Answer 3.2

The proposed treatment option employing chemical oxidation and activated carbon treatment is one of a number of options which may be used for treatment of the water to a standard acceptable for discharge to the river. Other treatment options such as UV/peroxide systems will be evaluated during the engineering design and the best cost option chosen.

Activated carbon could be disposed of to cement kilns or electric power plants and possibly even landfill.

Question 3.3

What is the probability of insoluble organics migrating to or precipitating out in the drainage trench? What sort of problems could this create in terms of recovery of such material? Could it prevent the more soluble contaminants from being recovered by blocking the system? How could it be determined that the drain was not blocked?

Answer 3.3

There is no evidence of a light non aqueous phase in bores other than the BHG8. However, lighter non aqueous phase hydrocarbons could migrate to the trench because of the induced groundwater gradient back to the trench. Heavy hydrocarbons will be intercepted by the trench along the mouth of the Claisebrook Drain where past seepage was evident. The rate of seepage is, however, low and blockage of the trench is unlikely. Provisions will, however be provided for monitoring of the drain performance.

Question 3.4

Would developments in the vicinity of the drainage trench, such as the proposed capping, affect the groundwater level in the drainage trench? Could any resultant drop in groundwater level decrease the effectiveness of the drain in capturing contaminants in the groundwater?

Answer 3.4

Developments in the vicinity of the drainage trench, unless requiring extensive deep foundation work are unlikely to effect the groundwater levels. The concept of the interception trench is to collect all groundwater to a depth of approximately 7m below the existing ground surface. The seasonal fluctuation in the groundwater level has been catered for in this design concept.

Question 3.5

What is the nature of the mixing zone in the Swan River for the disposal of the treated groundwater? Would it flow up stream or down stream? How rapidly would contaminants be mixed through the water column of the river?

Answer 3.5

The mixing zone necessary to achieve the minimal dilution of discharge from the plant is only likely to extend a number of metres upstream or downstream of the discharge point, depending on the direction of movement of the river as only minimal dilution (1:10) of the treated groundwater has been adopted. This would be reviewed during detailed design, based on the configuration of the discharge and other factors.

The river is tidal at East Perth, and has large flow rates downstream during wet winter months.

Question 3.6

What would be done to prevent the abstraction of ground water by future users of the site for reticulating gardens?

Answer 3.6

The capping system could incorporate a mesh warning layer to warn of uncontrolled excavations. This is a similar process to the warning tapes used over buried gas mains and power cables. Additionally, land title caveats or selected land use would preclude the abstraction of groundwater on the site. Water reticulation can be provided from off-site bores.

4. *DREDGING*

Question 4.1

Would all the contaminated sediments be removed? How would SECWA know how much contamination was left?

Answer 4.1

Contaminated sediments would be removed to a degree found feasible by pilot studies to be undertaken in design stages from the area delineated in Figures 5.5, 5.6 and 5.7 of the PER. The degree of contaminations left would be assessed from post operations sampling and analysis as stated on page 6-21 of the PER.

Question 4.2

Some submissions questioned the suitability of conventional dredging equipment to remove this type of pollution. How would SECWA ensure that the equipment employed is adequate? Based on present knowledge from sampling in the river, would a cutter be required for dredging of the contaminated sediments?

Answer 4.2

The dredging and separation techniques will be pilot tested to establish all the necessary engineering and operational parameters prior to the full-scale dredging operation. Furthermore, the dredging operation will be trialled on an uncontaminated portion of the river to assess a variety of necessary operations, e.g. release and containment of particulates and of course will include testing of the suitability of the dredging equipment.

Question 4.3

With regard to dredging operations:

(a) What would be done to avoid dredged material from the first cut (0.3m) being returned to the river until the deeper (0.6m) cut takes place?

(b) Would analytical checks be carried out on coarse materials prior to their return to the river?

(c) How could the development of 'holes' in the river bed from dredging be prevented?

(d) How would SECWA ensure that potentially contaminated fines, suspended during the dredging, would be retained?

(e) Under what flow conditions would the river be dredged?

(f) How long would the dredging and separation of the sediments take?

Answer 4.3

(a)& (b) The logistics and final program for the dredging of material, the effectiveness of the separating technology, development of analytical and quality control procedures and the necessary materials handling will be developed in an engineering phase. This will progress from laboratory trials through to field trials and finally be scaled-up to the actual full-scale operation.

(c) The actual method of dredging the material will be developed concurrently with the investigation programme. Clean sediment will be returned to the river thus minimising any depressions caused by the dredging operation.

(d) Suction dredging should capture most of the finally suspended sediments. A curtain wall around dredging operations may be installed should it be found necessary after evaluation of this need from the dredging trials mentioned in Answer 4.2.

(e) The necessity for dredging under particular flow conditions will be investigated during the dredging trials and associated investigations. In particular, the mobilisation of and release of sediment nutrients will be investigated. Preference would be for dredging under quiescent summer conditions for ease of manoeuvring the dredge, however the operation could be undertaken under winter river flow conditions. This decision will be made in conjunction with the Swan River Trust after review of the findings of investigative programmes.

(f) SECWA proposes to undertake a number of trials to confirm the requirements for dredging and separation of the recovered sediments and an estimate of the time required for dredging and treatment of sediments will be available after completion of these trials.

Question 4.4

How does this dredging project comply with the EPA's stated position on dredging in the Swan River as outlined in Bulletin 575?

Answer 4.4

The EPA Bulletin 575, August 1991, is an assessment report and recommendations for a project by the City of Bayswater titled 'Riverside Gardens (West) dredging and landfill, King William Street, Bayswater'. In this report the EPA recommends against dredging the Swan River to obtain 90,000m³ of soil to be used as fill in the further redevelopment of the public open space which exists on the former Bayswater Rubbish Tip site. The reasons given, if they may be taken to reflect the EPA's position on dredging, are two fold.

(a) A principle that the River should not be used as a quarry for development material.

(b) With regard to ecological impacts, a lack of demonstration that the dredging would be beneficial to the section of the Swan River.

In the first instance, SECWA's proposed dredging of the river is for the purposes of removing contaminant materials and not providing fill material. Any 'clean' material separated from dredged sediments would be replaced.

Secondly, any dredging operation causes a local ecological disruption. This is unavoidable if contaminants are to be removed, but benthic fauna and flora are likely to re-establish themselves in the future. The dredging operating was proposed on the principle that it is better to cause a minor disruption (in ecological time) rather than have persistent contaminants of possible detrimental ecological impact.

The Bulletin also makes reference to EPA 1986 guidelines for dredging, used for assessment purposes by the Swan River Trust as a policy instrument. It is stated there, that there are two acceptable reasons for dredging; maintenance and development purposes. Neither of these reasons are strictly applicable to the SECWA proposal. River clean-up, however, could possibly be classified as a maintenance procedure.

Question 4.5

What would be the Swan River Trust's role in the river clean-up?

Answer 4.5

SECWA intends to liaise with the Swan River Trust at every stage of the river clean-up operation. This will include preliminary design, pilot studies, actual operations and the final validation and monitoring phases.

Question 4.6

How would SECWA ensure the safety of people using the river during dredging operations, such as those fishing, prawning, crabbing or digging for bait and worms in this area of the river?

Answer 4.6

The levels of tar contamination in the river sediments are generally low. Long term contact with tars is necessary for health effects to occur, and transient contact, such as occasional digging for worms is unlikely to cause a public health problem. Public access to the dredging operation itself, will be restricted for safety reasons.

Following clean-up of the river sediments, tar contamination will be reduced to minimal levels.

5. *SEPARATION PLANT*

Question 5.1

With regard to the design and operation of the separation plant:

(a) What tests and assumptions have been made to determine the feasibility of separating contaminated material for the sediments?

(b) How efficient is the separation plant likely to be?

(c) How would SECWA ensure that capacities of the separation plant matches that of the dredge used?

(d) What contingency plans will be developed in case of emergencies?

Answer 5.1

(a)& (b) SECWA will undertake further sampling to determine the likely distribution of contaminants within the river sediment. Various separation treatments will be trialled to determine the efficiency of treatment. These types of plants are commonly used in the mineral/mining industry but in the reverse mode to what is intended here. Generally, the coarse material is retained and the fines are discarded. The effectiveness of this separation depends purely on the number of stages and design of the plant, and is generally very efficient. The actual efficiencies of the equipment used for the clean-up of the river will be determined in the pilot testing program and equipment performance requirements will be specified for the works to be undertaken.

(c) The sizing of the separation plant will be determined following the review of the findings and the dredging trials and the engineering design. SECWA will engage engineers who are experienced in this area.

(d) A work plan will be developed to direct the dredging and will provide procedures for dealing with emergency situations identified following further consideration of the preferred dredging methodology.

Validation procedures will also be established to monitor the performance of dredging, and procedures will be established for any reworking as a result of unsuccessful or insufficient separation of contaminated sediments from the dredging operations.

Question 5.2

Water separated from the sediments would probably contain some fine particulate material. How would this water be treated prior to its return to the river?

Answer 5.2

Fine particulate material will be removed from the water/sediments by a suitable treatment. There are many technologies which are appropriate, ranging from settling in tanks or earthen settling dams, centrifuges or other specialised equipment.

The pilot investigations will also examine flotation and cycloning as options for separating of fine contaminants from the water.

The final methodology to be adopted is to be selected after consideration of technical and cost issues.

Question 5.3

How would the liquid which comes from the land-filled sediments be managed?

Answer 5.3

The water recovered during the dredging operation would be treated as discussed in 5.2. The only treatment required is separation of particulates from the water recovered during dredging and separation processes. Should dewatering of sludges be necessary, requirements for further water treatment will be determined in the pilot studies mentioned in 5.1.

6. *MONITORING*

Question 6.1

How and how often would PAHs, heavy metals and nutrient levels in treated sediments and water be monitored prior to their return to the river?

Answer 6.1

The laboratory and field trials proposed would determine the performance of a range of separation treatments with respect to removal of PAH, heavy metals and nutrients.

The details of monitoring will be established in the engineering design stages after the test programme. The programme will indicate the quantities of material that will be separated and the necessary handling requirements. They will also give correlations between contaminational levels to be expected in the return sediment with the level of such species as PAHs, heavy metals and nutrients.

The exact validation and analytical procedures would be established together with surrogate operation/performance monitoring techniques. If a non-batch procedure is to be entertained, the operations would be subject to routine analyses and spot checks would be made with full analysis of the above species monitored.

Question 6.2

How would SECWA monitor volatiles emitted during soil excavation?

Answer 6.2

SECWA would monitor volatile emissions under a health and safety plan for the soil excavation by analysis of air samples using suitable volatile organic compound (VOC) monitoring equipment and/or personal monitoring.

Question 6.3

How would recolonisation of the dredged area by benthic fauna and flora be monitored after the dredging has been completed?

Answer 6.3

The recolonisation of benthic fauna and flora would be monitored several years after the dredging operation by a similar technique employed for the assessment stage (see CSF Report).

Question 6.4

Would monitoring of the riverbed include upstream sites to allow for transport of materials by tidal movement

Answer 6.4

In the PER, SECWA has made the commitment to post-dredging sampling and analysis of sediments to establish the overall effectiveness of the operation and changes in downstream conditions. Should the dredging operation be conducted at times other than winter full flow conditions, sediments upstream will also be tested.

7. *CRITERIA*

Question 7.1

How do the criteria for soil, groundwater and sediment contamination used in the PER compare with the criteria recently published by ANZECC/NH&MRC? On what basis does SECWA consider the degree of site remediation required for recreational and residential land uses are identical (as stated in section 3.4 of the PER)?

Answer 7.1

The Gasworks site assessment against criteria developed for that purpose, was conducted well before the publication and availability of the ANZECC/NH&MRC, January 1992 Guidelines. This document stresses that the criteria shown 'should be seen as guidance values only and site specific factors will influence their use'.

A similar philosophy was advocated in precursor drafts of the document, and used in developing site specific criteria for the Gasworks site.

The clean-up requirement for various land uses are detailed in Table 5.5 of the PER. Different criteria are given for residential, recreational and industrial/ commercial land uses. The strategy of this PER is one of containment and capping and the degree of this treatment required to meet these criteria falls into two distinct groups i.e.

- industrial/commercial and
- recreational/residential

The details of development of the criteria and the considerations of the required strategy are given in the main reports - 'Investigation of East Perth Gas Works Site Rehabilitation' - Volumes 1 and 2, CSF (December 1990).

Question 7.2

Water quality criteria used in Table 5.3 appear to be based on draft criteria for marine environments, not low energy estuarine or freshwater environments which would require stricter criteria. What criteria and procedures would be used to determine the quality of water returned to the river?

Answer 7.2

The water quality criteria appropriate for setting discharge limits will need to be reviewed in view of the release of a draft set of Australian Water Quality Guidelines by ANZECC in January 1992. These draft ANZECC guidelines set receiving water quality and the discharge limits would be proposed on the basis of achieving the appropriate guideline levels beyond an agreed mixing zone. In the case of benzene and PAHs which are listed in Table 2.1 of the ANZECC guidelines, the same receiving water concentrations are set for fresh and marine water. Water quality criteria are also established in the WAEPA, Bulletin 103.

Routine monitoring of the effluent from the groundwater treatment plant would be undertaken to verify plant performance in meeting the appropriate quality requirements, allowing for a 1:10 dilution in the river.

Discharge of water recovered from dredging and separation of particulates would be free of sediment material and equivalent to river water quality.

Question 7.3

Table 5.4 shows detection levels for copper, chromium, cadmium, lead, arsenic, mercury and cyanide much higher than the recommended criteria. Please explain.

Answer 7.3

The water quality criteria (WQC) for marine and estuarine waters (WA EPA Bulletin 103) were derived from toxicity data to ensure the protection of the quality of the aquatic environment and the constituents of the designated water use. For some criteria the levels set are below current analytical levels of detection. This was recognised by the 1990 Working Group which reviewed Bulletin 103.

It should be noted that a 'criterion' is not a 'standard'.

AA methods were considered to be the most reliable analytical technique for the assessment in 1990. Lower detection limits for the metals listed can now be achieved by ICP methods, but are still above the WQC for chromium and copper. The limit of detection of total cyanide in water is still above the WQC (10 µg/l).

Question 7.4

How credible are derived sediment criteria quoted in Table 5.6 of the PER, when some of the levels are two to three times levels at which PAHs have been directly linked with toxicity to marine biota?

Answer 7.4

There are no established criteria for sediments. The criteria quoted in Table 5.6 are the results of an attempt to derive a guideline for assessment purposes. It is freely admitted in the PER and background reports that such criteria are not perfect, but they illustrate a logical approach to the problem. The derived criteria were included in the PER to stimulate an appreciation of the problem and possibly be of guidance to assessment authorities.

Question 7.5

Would sludges from the water treatment meet USEPA-TCLP criteria prior to their disposal?

Answer 7.5

We do not see the relevance of this question. The only liquid waste from the entire remediation strategy are water streams, either treated groundwater complying to the standards set out in WAEPA Bulletin 103, or river water returned after removal of sediments. There are no hazardous liquid wastes under the meaning of the USEPA TCLP envisaged anywhere in the project.

8. *ALTERNATIVE SITE CLEAN-UP AND DISPOSAL OPTIONS*

Question 8.1

Costs provided in Table 12.2 in the December 1990 report by Camp, Scott and

Question 8.2

Why was the work documented in the CRA Services report on bioremediation (dated 5 December 1991) not considered in the PER? What implications does this work have regarding the costs, efficiencies and practicabilities of biodegradation of contaminated soils and sediments at the Gasworks site?

Answer 8.2

The work documented in the CRA report was undertaken by the East Perth Redevelopment Authority on samples taken from the Gasworks site due to its interest in the site. The report was not provided to SECWA until May 1992, well after SECWA's PER was released for public comment.

The report details the results of laboratory scale studies of bio remediation trials on contaminated soil from the site. A land-farming approach simulation showed typical decay rates of PAHs levelling off before total destruction. Such results are typical of other trials around the world on gasworks contaminants and are well documented in the literature. The CRA report does not add any specific extra knowledge about the technique which remains in the category of having an uncertain outcome.

Question 8.3

The EPA have been advised that soil washing costs for a similar sized project elsewhere would be in the vicinity of $30/tonne. What is the basis for SECWA's cost estimate of $144/tonne?

Answer 8.3

Soil washing technology is somewhat of a misnomer in that the process actually relies on hydraulic separation of fine soil size fractions from coarse sand. The principle also relies on the premise that contaminants adhere preferentially to the fine particles.

It is possible that low costs may be quoted for operations conceived to apply to soils being low in fines and rich in gravel sized material. They may possibly apply only to the separation operation only, disregarding capitalisation and further material handling costs. The nature of the soil on the East Perth Gasworks site is not in this category.

Costs for soil washing will largely depend on the nature of the contaminants and natural materials on site and in turn on the requirements for set up of the soil washing plant. The costs may therefore be highly variable from one situation to the next. The natural materials at the East Perth Gasworks site consist of gravels, clayey sands and sandy clays. In this regard, the efficiency of washing would need to be established for the full range of soil types before costs can be assigned noting that a soil washing process will be directed to separation of the clay (less than 62 micron fraction) from coarser fractions.

SECWA's estimate is based on costs from reputable companies with experience of clean-up trials and operations in the USA, Netherlands and Germany. Apart from the Bayside project in Melbourne there have been no applications or demonstrations of the technique in Australia.

Question 8.4

On what basis is the capital cost of a thermal desorption plant deemed 'uncompetitive'? Are there other contaminated sites in Australia where such costs could be shared? What would be the likely operating cost of a thermal desorption unit?

Answer 8.4

The cost of thermal desorption are stated in the main report - in particular, the Scheiden Netherlands experience should be considered where a clean-up was started in 1986 with a 20t/hour plant and was still operating in 1988. The projected cost of such treatment in 1986 was $100/tonne. Applying such costs to the East Perth Gasworks site, treatment of soil to 2.5m depth would require $15m, to 5m depth $30m, assuming the same areal extent of contaminant and more again for treatment of all contaminated soil to a depth of 12m. The cost of excavation and water treatment are not included and would be a significant addition.

This type of plant, including site dewatering does not exist in Australia and capitalisation of a 20 t/hr plant would be estimated at $15m to $20m. A plant of this capacity would take over a year to treat contaminated soil to a depth of 2.5m.

Thermal desorption (high temperature) is being used predominantly in Europe for treatment of soils contaminated with gasworks wastes and high efficiencies of treatment have been demonstrated. However the costs for establishing a high temperature thermal desorption plant locally may be of the order to $15m to $20m and it is not considered appropriate to pursue this option for the East Perth site.

It is worthwhile to note that the European thermal desorption technology has been developed for the treatment of heavy hydrocarbons including PAHs and relies on a two stage rotary kiln with second stage kiln temperatures of around 700° C. This technology is not comparable with low temperature thermal desorption processes being developed in the US for treatment of light hydrocarbons where kiln temperatures are typically around 200° C.

Question 8.5

What consideration has been given to using various remediation methods for different types and extent of contamination? e.g. would the areas high in total petroleum hydrocarbons be amenable to pump and treat remediation methods?

Answer 8.5

Various remediation treatments appropriate to gasworks sites and specific to the conditions existing at East Perth have been considered by consultants expert in this field. The considerations are detailed in the main report 'Investigation of East Perth Gasworks Site Rehabilitation Report', CSF (December 1990).

Pump and treat remediation technology is normally applied to petroleum hydrocarbons of a mobile nature, and in sufficient quantity to permit substantial removal by pumping. Residual hydrocarbons invariably remain underground. Final treatment is usually attempted by such means as injection of bacterial cultures, oxygen and nutrients.

Such contamination conditions do not exist at East Perth, and are rare on Gasworks sites. There has never been, to our knowledge, a successful demonstration of an in situ bioremediation of gasworks contaminants.

Question 8.6

Could the contaminated soil be removed and utilised beneficially, e.g. as a base for asphalt covered car parking ares, burnt as a fuel source or stabilised using cement?

Answer 8.5

This suggestion is consistent with past use of coal tars for road surfacing in Perth. However, there are some envisaged difficulties as follows:

- Cost of excavation, treatments and refill of the site.
- The effectiveness of total removal.
- Public acceptance.
- A large quantity of soil involved which would provide logistical problems with transport, storage and use for road surfacing.
- Removal process would dilute soil essentially to give (mildly) contaminated material.
- Such a process would be perceived to transport the problem from one area to another.

To utilise contaminant tars as a fuel would require their total separation from the soil matrix. It is doubtful if this could be achieved by any practical technique.

Even so, the combustion characteristics of coal tar are largely unknown. They are after all, the residuals from a combustion process. The quantities that would be theoretically extractable would be too small to have significant fuel value.

Stabilisation with cement is usually applied to inorganic contaminants and is not applicable to organic gasworks contaminants. Soluble organics are cement setting retardants.

Question 8.7

In the event that a clean-up of the contamination was required, would a cut-off wall and interception trench be necessary? In this situation, would bores at the centres of the principal sources of pollution be more effective in controlling and recovering residual contaminants?

Answer 8.7

A 'clean-up' of site soil contamination in the sense of decreasing the contamination levels to predetermined specified levels could be envisaged to be undertaken in one of two ways:-

(a) Excavation of all contamination above that level and removal off site for further treatment.

(b) Treatment of contaminated soil on site.

For both these options the following operations are necessary:-

- Installation of a barrier to prevent river water flooding the site.

- Lowering of the groundwater table by suitably positioned production bores to prevent escape of contaminated water created by excavations.

- Treatment of large quantities of groundwater prior to discharge into the river.

- Excavation of contaminated soil by a suitable method. Dry excavation is unlikely to be achievable due to the massive dewatering which would be required. Underwater excavation would tend to spread the pockets of contamination and would require greater ultimate groundwater treatment and dewatering of the soil.

  Underwater excavation to depths of 14 metres will require an estimated 200,000m^3 of soil to be handled.

- A suitable logistics plan is necessary for an operation of such magnitude. Off site nearby land may be required for soil handling and treatment.

- In the case of option (a), a suitable site for further treatment would need to be procured and established. Contaminated material would need to be transported to the site. Clean fill would be required to replace the material removed.

- A suitable process for treating the contaminated soil would be required. Such processes have already been discussed.

- Contaminated groundwater would remain in situ. This would require treatment prior to further development of the land.

- Remediation of river sediments would need to be co-ordinated with such a scheme.

The costs of such a strategy cannot be costed with any degree of certainty but are certain to be extremely high. It is also not possible to predict with any high degree of certainty whether a successful outcome would result.

Question 8.8

In relation to the costs and benefits of different options for clean-up for the site, what consideration has SECWA given to:

(a) On-going operating and monitoring costs?

(b) Differences in public perception of the value of the area?

Answer 8.8

(a) Operating and maintenance costs (including monitoring) are a consideration in any project or endeavour. Options are normally compared using a nett present value concept which includes both capital and operating costs.

In principle an option which successfully destroys all contamination from the site would be expected to have no ongoing operational and maintenance costs. Such an option, however has not been identified, and those considered have uncertain outcomes and costs. Total costs are estimated to be very high.

The selection option of containment has quantifiable O&M costs, being:

- Operation of water treatment plant.
- Maintenance of slurry wall.
- Monitoring of wall effectiveness and integrity.

These costs are low.

(b) It is very often impossible to place a monetary value on public perceptions, since they vary considerably across community groups and are subject to change after consideration of specific circumstances.

There will always be a section of the community opposed to any proposed option for remediation of the site. Such options must be considered for their universality and tempered with other considerations of technical feasibility, costs, applicability and effectiveness of outcome.

Question 8.9

Why was the timing of the remediation given as a major factor in the consideration of clean-up options, when SECWA does not have any specific plans to move off the site?

Answer 8.9

As stated in the PER and associated reports, SECWA is very much aware of longer term plans for redevelopment of the East Perth area. The East Perth Redevelopment Authority (EPRA) already has current plans for the creation of a Claisebrook Inlet, adjoining the gasworks site, and a definite schedule for their implementation. SECWA has liaised closely with EPRA in its assessment stages of the site.

The proposed strategy is one that has a well defined schedule and outcome. Other 'clean-up' options have uncertain time scales, outcomes and associated costs.

Appendix 2

List of people and organisations who made submissions.

Individual submissions:

Statewide Network of Action Groups
Australian Anglers Association
Royal Australian Chemical Institute
Perth City Greens
Swan River Action Group
Swan Waste Action Group
Conservation Council of Western Australia Inc.
MacMahon Remedial Technologies
Bergmann Australia
Girl Guides Association
M Hipkins.
P Molloy
S Linton

Form Letters:

K Fisher
R K Goves - Jacka
S Jennings
G Capes
J Duggie
A & M Thomson
A Harris
B Masters
J Kitchins
D Cunningham
J Read
B Fremlin
D James

Government agencies:

Swan River Trust:
Health Department of Western Australia
South Australian Waste Management Commission
Water Authority of Western Australia
Environment Protection Authority of New South Wales
Chemistry Centre - Department of Minerals and Energy
Geological Survey Division - Department of Minerals and Energy
East Perth Redevelopment Authority
City of Perth
Department of Planning and Urban Development