NSW Environment Protection Authority

Orica Botany Mercury Independent Review: Stage 1 - Data and Information Collection and Review

CDM Smith

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6 February 2014

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This report was written and published by CDM Smith. The NSW Environment Protection Authority contracted CDM Smith as independent consultants to undertake Stage One of the Orica Mercury Independent Review.

The views in this report do not necessarily reflect the views of the EPA and the NSW Government.

Executive Summary

Orica (formerly ICI Australia) has operated a chemicals manufacturing facility at the Botany Industrial Park in Matraville (the 'site') since 1942. Between 1945 and 2002, the Former Chlor-Alkali Plant (FCAP) operated onsite, and used a mercury cell technology to produce chlorine, hydrogen and caustic soda from brine (salt water). The historic use of mercury at the FCAP has resulted in soil and groundwater contamination both onsite and offsite, and contamination of sediments in the Penrhyn estuary, which received waste effluent and sludges from the FCAP via a stormwater channel in the 1940's and 1950's.

In response to concerns raised in 2012 and 2013 by community members and representatives, the NSW Environment Protection Authority (EPA) has been directed by the NSW Minister for the Environment to undertake an independent review of the environmental and health impacts from historic mercury emissions from Orica's FCAP at Matraville. CDM Smith was selected through a public tendering process to complete Stage 1, comprising data and information collection and review. The tender process was overseen by the Steering Panel.

CDM Smith's team, comprising local and international experts, received (from both the EPA and Orica) and reviewed an extensive quantity of documentation, and also conducted community consultation with the local residents and businesses surrounding the site. The results of this review, with respect to the concerns and questions raised are as follows:

FCAP Mercury Usage & Mass balance

CDM Smith developed a detailed mercury mass balance for the FCAP over the life of its operation, and it is estimated that Orica-ICI purchased a total of approximately 950 tonnes of mercury during the life of the FCAP. This estimate is partly based on records showing actual quantities of mercury purchased in the 1980's and 1990's, which were located in a data room at the Orica Botany offices, where CDM Smith was granted access to review confidential documents. This number is considerably lower than what has been previously estimated or suggested by community members or representatives. However it should be noted that previous estimates of historic mercury usage at the site, by others, were based entirely on assumptions and not on the site specific data that was available for review by CDM Smith.

CDM Smith's assessment of the available data indicates that at least 50% of the mercury used can be accounted for with a high degree of certainty. When using less conservative values for reported mercury concentrations (e.g. higher mercury concentrations and higher annual mass of wastes produced and stored onsite in drums) in our mass balance model, this figure increases substantially, and approximately 95% of the mercury used can be accounted for. The large range of possible values in the mass balance model is due to uncertainty in the historic measurement of mercury concentrations in waste streams, based on measurement accuracy and variability of the waste streams, and a number of potential areas within the FCAP where mercury could accumulate and escape measurement. The mercury accountability of the Botany plant appears to have been consistent and comparable with that of Chlor-Alkali plants internationally.

Unauthorised or Illegal Disposal of Waste Offsite

CDM Smith did not identify any evidence of potential or actual unauthorised or illegal offsite dumping of mercury waste originating from the FCAP. The documents reviewed also show a consistent timeline of plant operations, and mercury usage rates and waste streams. It is also apparent that the opportunity for Orica/ICI to undertake onsite disposal of excess Chlor-Alkali

wastes existed, with what appear to be onsite ponds which are visible in aerial photographs from the 1950's. Furthermore, there does not appear to have been any incentive for Orica/ICI to have undertaken any unauthorised or illegal dumping of wastes offsite. It is noted that on one occasion an attempted theft of mercury from the FCAP by a former employee was reported. The number of other potential thefts of mercury from the site (if any) is unknown, but expected to be low.

Offsite Air Emissions

Preliminary air emissions modelling undertaken by CDM Smith indicated that historic mercury concentrations in air may have exceeded current international standards for long term exposure within close proximity (<500m) of the FCAP. More detailed modelling incorporating meteorological data, and simulating mercury deposition and decay processes was not within the scope of the Stage 1 review. The existing air dispersion model developed by CDM Smith should be refined and expanded as part of the next stage of environmental works (Stage 2 works) to better define the areas and distances over which mercury accumulation and deposition may have occurred.

Offsite Soil Contamination

Based on CDM Smith's review of available data, the risk of significant offsite soil contamination being present in surrounding residential areas, public parks and reserves as a result of FCAP operations appears to be low.

The previously nominated study area, a 1.25km radius surrounding the FCAP, is considered conservative and was based on assumptions of much greater mercury consumption and emissions from the plant. Preliminary air emissions modelling results suggest that this figure should be closer to a 0.5km radius surrounding the FCAP.

Due to the absence of definitive data on offsite mercury concentrations, and significant concerns amongst local residents regarding potential mercury contamination in soil, a program of offsite environmental testing/sampling is considered necessary to adequately address these concerns.

Offsite Groundwater Contamination

Sampling for mercury in groundwater has been completed extensively over the past 5 to 6 years at, and surrounding the FCAP. Geochemical modelling was undertaken in 2008, followed by development of a groundwater fate and transport model in 2010. The groundwater plume, and fate and transport of mercury to potential receptors, are well identified and continue to be updated with every groundwater monitoring round where mercury is sampled.

Ongoing groundwater sampling for mercury is recommended to continue as per the existing groundwater management plan on a yearly basis. Should the groundwater monitoring results depart from the conceptual model, further geochemical modelling would need to be undertaken to assess the significance.

Penrhyn Estuary

Previous sampling undertaken in 2004 showed mercury concentrations in fish in Penrhyn Estuary to be below the Maximum Permitted Concentration (MPC) set by the National Health and Medical Research Council (NHMPC). Discharges of mercury have been significantly reduced, by virtue of closure of the FCAP, and diversion and remediation of high mercury concentrations along Springvale Drain. Furthermore, it is expected that new sediments deposited in the estuary will contain much lower levels of mercury, and these would be expected to be acting as a natural

capping layer for the contaminated sediments deposited historically, thereby improving water quality and limiting further bioaccumulation in fish tissue.

To enable to complete a robust and scientifically defensible Health Risk Assessment for Public Health Concerns (Stage 3), additional sampling in Penrhyn Estuary is considered to be necessary as fish that is positioned in the middle of the marine food chain has not been investigated yet.

Recommendations

Proposed actions for Stage 2 – Environmental Testing Regime are summarised (in chronological order) below:

- A detailed review of available historical aerial photographs is recommended;
- It is recommended that refining the preliminary air model developed by CDM Smith be completed with actual meteorological data, to provide a better understanding of how the fugitive and stack emissions for mercury could have been dispersed during plant operations. Furthermore, the AERMOD modelling system should be refined to include deposition and decay. The results of the modelling should be taken into account before finalising the Stage 2 soil sampling locations;
- Offsite sampling (Stage 2) within residential areas, and local parks and reserves (both surface and shallow soil sampling) is considered necessary to effectively alleviate the concerns raised in the community, and definitively evaluate the current potential exposure to the community from historical mercury releases. Prior to the start of the Stage 2 fieldworks, a document should be prepared by the Consultant for Stage 2, that sets out the seven-step Data Quality Objective (DQO) process as presented in the the NSW DEC (2006) Guidelines for the NSW Site Auditor Scheme (2nd edition);
- Additional biota (fish) sampling is recommended to complete the existing biota dataset; and
- The Stage 3 – Health Risk Assessment for Public Health Concerns should be undertaken once the results from Stage 2 are available.

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Section 1 Site Background and Community Concerns

Orica (formerly ICI Australia) has operated a chemicals manufacturing facility at the Botany Industrial Park in Matraville since 1942. In 1945 the former Orica / ICI Chlor-Alkali Plant (FCAP) was commissioned until its closure in 2002. In the plant, elemental mercury cell technology (electrolysis) was used to produce chlorine, hydrogen and caustic soda from brine (salt water). The use of mercury, which was recirculated in the FACP, resulted in soil and groundwater contamination both onsite and offsite. Sediments in the Penrhyn estuary were contaminated as it received effluent and sludges from the FCAP through a stormwater channel. This has been addressed in several environmental assessments.

In response to concerns raised in 2012 by community members and representatives, the EPA has been directed by the NSW Minister for the Environment to undertake an independent review of the environmental and health impacts from historic mercury emissions from Orica's FCAP at Matraville.

The Botany Mercury Independent Review Steering Panel (Steering Panel) has been established to provide an opportunity for community involvement and to provide expert advice to inform and oversee the independent review. The purpose of the review is to determine if there is a significant public health risk and the level of such health risk to the community associated with mercury release during the operation of Orica's FCAP at Matraville from 1945 until 2002.

CDM Smith considers that the review will require the following number of stages:

- Stage 1 – Data and Information Collection and Review;
- Stage 2 – Environmental Testing Regime;
- Stage 3 – Health Risk Assessment for Public Health Concerns; and
- Stage 4 – Health Risk Assessment for Individuals.

CDM Smith was selected by the Steering Panel to conduct Stage 1 of the review, evaluate the results of investigations done to date and provide recommendations and communicate the findings to the community.

CDM Smith's primary focus in Stage 1 was historical mercury releases to the environment as a result of FCAP operations. Releases such as effluent, air-emissions and waste handling practices were evaluated.

The initial study area included the FCAP and all residents and commercial properties within a 1.25km radius around the centre point of the FCAP, as this was a study area used in historical public documents and used as a starting point (however it was considered conservative).

Remedial action is ongoing at the site to clean up contaminated soil, and to prevent any further impacts on groundwater. The works must be completed by the end of 2014.

Section 2 Community Consultation

2.1 Community Engagement Process

At the commencement of the project, the NSW EPA requested that additional community consultation be included in the scope of the Independent Review, and a Community Consultation and Engagement Plan was prepared. CDM Smith prepared a memo (**Appendix B**) and presentation for the EPA and Steering Panel. The Amended NEPM, Schedule B8 "Guideline on Community Engagement and Risk Communication" was adopted as the most appropriate guideline for the consultation process.

At the inception meeting with the Steering Panel, the community consultation process was presented and discussed. It was agreed that the process would include:

- Provision of a questionnaire to the community soliciting feedback and information;
- Organising two open-house sessions to meet community members face to face and listen to their concerns; and
- Engage with the community via newsletters and individual confidential interviews.

In June/July 2013 the EPA requested community input and the submissions received (a total of five responses) were provided to CDM Smith for review as part of this project. However, a deeper understanding of community concerns was needed to enable the Independent Review to focus on addressing specific questions and concerns raised by community members, and also define further investigation and/or environmental testing aimed at assessing risks to the community from historical operations at the FCAP.

All responses were used to help CDM Smith better understand the community and their concerns and to structure the information provided in Stage 1, and to identify potential data gaps to be addressed in Stage 2.

All submissions received from the community will remain the confidential property of CDM Smith and will not be provided to any third parties, including Orica and the NSW EPA.

The community Steering Panel members (see **Section 3.1.1**) also used their media channels to reach out to the broader community, further raising awareness regarding the Independent Review, and seeking additional community input into the process.

Local General Practitioners and schools within the Study area were also informed.

2.2 Questionnaire

As part of the community engagement process a questionnaire and newsletter was delivered to 4,500 homes and businesses located within a 1.25km radius from the FCAP site, covering portions of the suburbs of Pagewood, Matraville and Hillsdale, in the Botany area in the first week of October 2013. The questionnaire included 23 set questions where the residents were encouraged to circle 'yes' or 'no'. The questions presented included the length of time the respondent had lived within Botany, if the respondent was aware of environmental investigations conducted, if the respondent was aware of the EPA Independent Review, how the respondent would like to be kept informed, if the respondent believed their property requires testing for mercury contamination and further questions relating to the respondents' level of understanding of potential impacts from

mercury contamination and knowledge of Orica/ICI activities. A copy of the questionnaire is provided in **Appendix D**.

Respondents were asked to provide contact details however they were also advised that they may submit the response anonymously. Respondents were asked to return the questionnaire before 15th October 2013 by using the reply-paid self-addressed envelope enclosed or to email or phone through responses. Reponses to questionnaires are anonymised summarised below in **Section 2.2** and in **Appendix E**.

A total of 155 submissions were received from the 4,500 residents and businesses that CDM Smith contacted in the Botany area. In **Appendix E** CDM Smith has anonymised and tabulated all responses. Approximately 10 respondents who provided personal and/or privacy related information were contacted by CDM Smith staff to seek permission to include the information in the report. In all cases the respondent gave his or her permission to include this information in the report.

Almost half (48%) of the submissions received were from residents who have lived in the region for more than 20 years. The majority of respondents (94%) had not previously worked at the FCAP. Four respondents noted that they had worked at the Orica plant. Subsequently these people were individually approached by CDM Smith staff and some of them were interviewed (see **Section 2.3.1**).

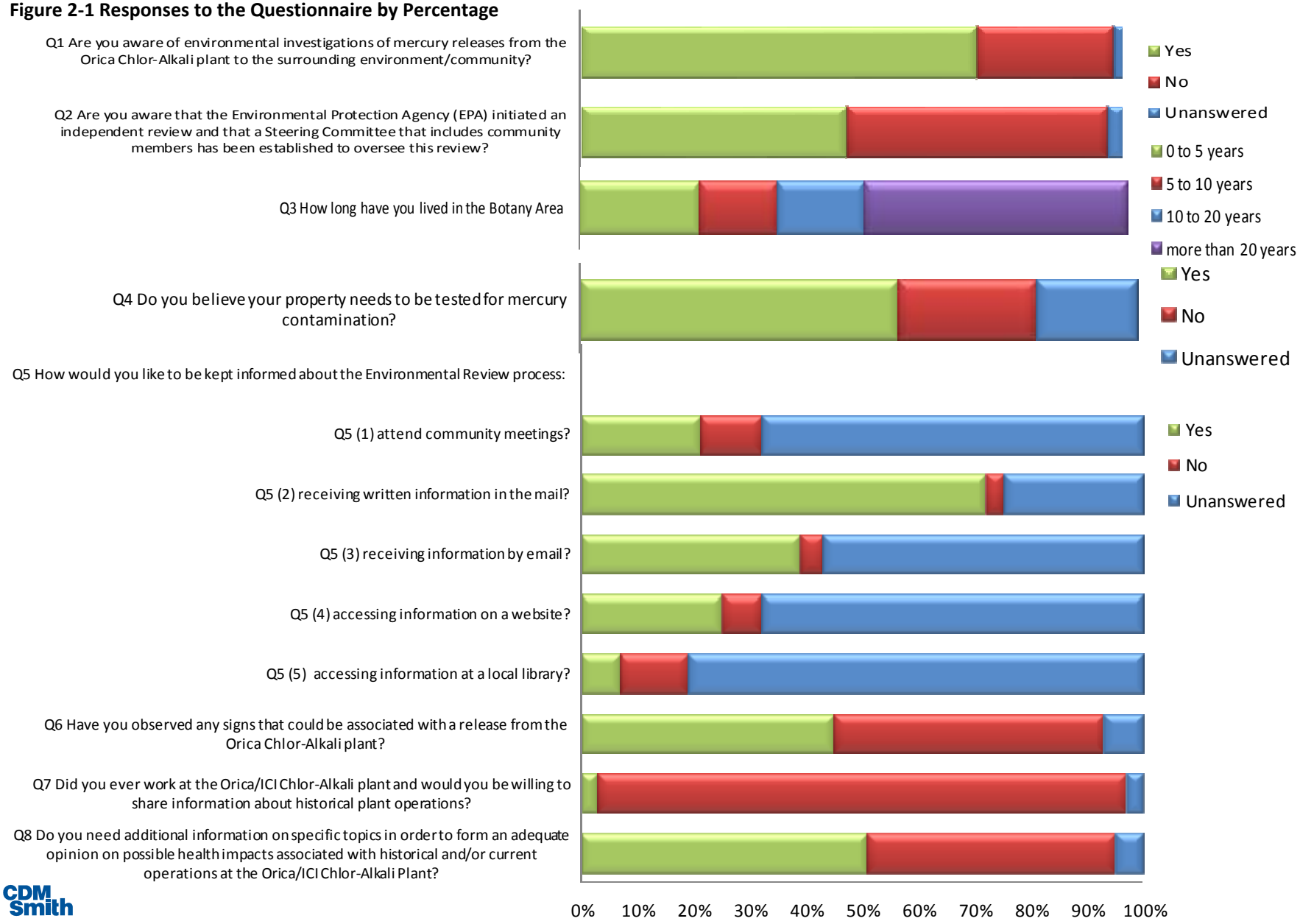
When asked if the respondent was aware that environmental investigations into mercury releases from the FCAP had been conducted, the majority of respondents (73%) answered yes, and only half (49%) of respondents were aware that the EPA had initiated an independent review, and that a Steering Panel which includes community members had been established to oversee the independent review. When asked if the respondent required additional information on specific topics in order to form an opinion on possible health impacts associated with historical and/or current operations at the FCAP Orica/ICI Chlor-Alkali Plant, 51% indicated yes and 44% indicated no. A further five % left the question unanswered.

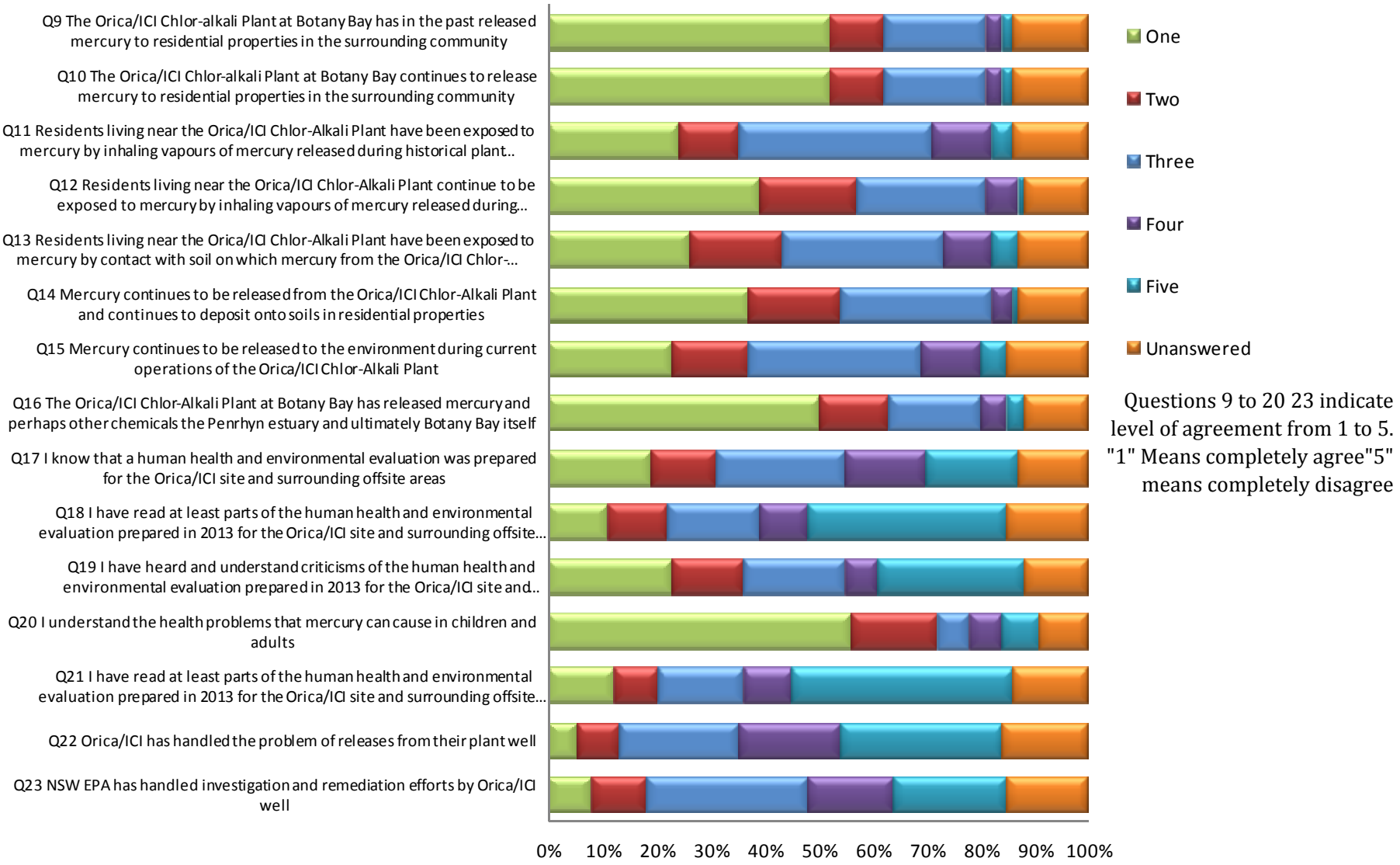
More than half (57%) of the respondents believed that their property requires testing for mercury contamination, however almost a quarter (18%) of respondents were unsure if their property requires testing, leaving the question unanswered, and a number of respondents also provided comments alongside the question stating that they were unsure of how to respond. When asked if the respondent had observed any sign that could be associated with a chemical release from the Orica Chlor-Alkali Plant, the responses were split with almost half responding with a yes (45%) and half (48%) with a no; seven % did not answer the question.

Respondents were asked how they would like to be kept informed about the environmental review process. Receiving written information in the mail generated the highest yes response (72%), followed by email (39%) and accessing information from a website (25%). Receiving information by attending community meetings and through a local library received the lowest yes response within 21% and seven % answering yes respectively.

For Questions 9 to 23, which were introduced to better understand the community attitudes as well as specific concerns and information, respondents were asked to indicate a level of agreement from one to five with one indicating completely agree, and five indicating completely disagree. Question 9, 10, 12, 14, 16 and 20 were predominately responded to with a one, or completely agree. Questions 11, 13, 15, 17 and 23 with a three and questions 18, 19, 21 and 22 were predominately responded to with a five, completely disagree. Around 15% of respondents did not answer questions 9 to 23.

Figure 2-1 Responses to the Questionnaire by Percentage





Questions 9 to 20 23 indicate level of agreement from 1 to 5. "1" Means completely agree"5" means completely disagree

2.3 Open Houses – Walk in Session

CDM Smith arranged and attended (Loek Munnichs and Andrew Kita) the following two open house / walk in sessions:

- Tuesday 8th October between 7pm-9pm at the Hillsdale Community Hall on Bunnerong Road; and
- Wednesday 9th October between 1pm-3pm at the Matraville Youth and Cultural Hall (Corner Knowles Avenue and Pozieres Avenue).

Three individuals and one couple attended the 8th October open house session. Concerns about black dust that comes down almost daily (even when there is no rain fall) were expressed and people asked questions about whether or not groundwater within the residential area had been investigated.

One resident had questions about the "Davies report" (which is part of the package of documents provided by EPA for review). This resident was very concerned about rumoured historic illegal offsite dumping activities, and stated that he knew previous employees and family members that worked at Orica who could confirm this. CDM Smith requested to meet/interview these persons anonymously, however the resident was not able or willing to arrange this. No further information in relation to these claims was provided to CDM Smith, and in view of this, these claims remain unsubstantiated.

One local resident expressed concerns regarding potential health impacts for a parent which had worked a few decades on a site near the FCAP. The parent is not reported to be experiencing any health issues. The resident was simply enquiring as to whether she should be concerned.

Three individuals attended the 9th October open house session. Two of them represented a larger group of people (chair of the Matraville Precinct and a representative for the Hillsdale-Eastgarden Residents Action Group). The following information was shared with CDM Smith at the meeting:

- The community's view is that Orica only focuses its efforts on addressing the onsite contamination;
- The NSW Department of Planning has a Risk Assessment Study for the Botany/Randwick Industrial Complex and Port undertaken in 1983, and a public sanitised version of this document was released in 1985. This document was never made public (*note that CDM Smith requested (under the GIPA Act) both documents from the Department of Planning and Infrastructure. The 1985 document was provided to CDM Smith. The 1983 document was not found in the Departments archives. The assessment was undertaken in response to concerns by local councils and community groups as a result of the intensification of potential hazardous installations within the area. The report describes the overall risks qualifications and implications on nearby residential land uses as a consequence of major accidents such as explosions or fires within the study area. CDM Smith considers this report not relevant for the independent mercury review*; and
- At a community meeting approximately 9-12 months ago, an Orica employee was reported to have stated that the Malabar headland was previously used as a primary disposal location for waste soil and sludge, and that this was approved by the authorities at the time.

2.3.1 Interviews with Individuals

2.3.1.1 Hg Recoveries – Community Expert

On 29 October, CDM Smith employees, Loek Munnichs and Andrew Kita, conducted a telephone conference with an employee from Hg Recoveries Pty Ltd who is an expert who had publicised concerns of mercury impact to the Botany Community. The following information was shared:

- Hg Recoveries stated it is his view that the Australian guidance in relation to mercury contamination and health-based investigation levels is not in line with global best practice, and the, in 2013 amended 1999 NEPM guidelines are not conservative enough;
- Hg Recoveries related that historically mercury was purchased by ICI from a firm called Peacocks. Also large amounts of mercury are believed to have been provided (at no cost) to Orica by the navy, from stockpiles used on warships. It was considered likely that Orica did not have to pay for mercury up until the 1960s;
- At the Malabar Rifle range, high methane levels were measured but soil gas samples were not analysed for mercury;
- At Pioneers Park, elevated levels (2 mg/kg) of mercury were reportedly detected with an XRF (CDM Smith: XRF devices are a field screening tool, and measurements are influenced by aspects like grain size, moisture, etc.); and
- The employee indicated that he had estimated that the total loss of mercury during the lifespan of the FCAP to be in the order of 6,000 to 9,000 tonnes.

2.3.1.2 Former Orica Employee 1 (FOE1)

On 9 October 2013 CDM Smith personnel, Loek Munnichs and Andrew Kita, interviewed a former ICI employee (FOE1).

FOE1 worked on the Botany site for ICI from 1966 to 1990 as a maintenance electrician. When FOE1 joined ICI he was only 20 years old and was by far their youngest electrician (age gap of 20 years with his peers). He therefore could be one of the last individuals alive that worked at the FCAP prior to 1970.

In the interview the following relevant information was shared:

- Prior to 1971 FOE1 believed the surface was unsealed (at two of the three cell banks) directly under the mercury cells. He recalls that concreting of the floors occurred in approximately 1971, and spilled mercury was subsequently recovered from that time via a network of floor drains;
- FOE1 mentioned that mercury was being brought to Site on an approximately monthly basis, with quantities averaging approximately 1 tonne/month;
- Estimated dimensions of the 80 cells were 30m long and 0.6-0.7m wide;
- An approximate 0.5cm thick layer of mercury was used as the cathode;
- It was a normal occurrence for some mercury to spill out of the cells onto the sand surface underneath the cells;
- It took a few minutes to less than half an hour for the elemental mercury to seep into the sand;

- Some staff tried to take mercury home as it was very expensive. There was an employee that reportedly filled up his bicycle with mercury resulting in his bike being too heavy to pick up when it fell on the ground while passing security at the gate, and he was caught;
- The mercury was imported from Japan around that time;
- FOE1 did not observe or was not aware any offsite dumping of wastes from the ICI plant;
- Mercury wastes, amongst others, were reportedly washed into stormwater drains and hosed down, ending up in the Bay;
- Asbestos was reportedly used with putty to seal the chlorine cells. This material was reportedly dumped onsite;
- Beside goggles (to protect the eyes from the chlorine gas) no other protective measures were required to work at the FCAP at the site;
- When FOE1 left ICI he was not asked to sign a confidentiality agreement;
- FOE1 had no objections to being mentioned in our report (note: CDM Smith chose to keep all submissions confidential); and
- FOE1 indicated he will try to get us in contact with other former employees (if still alive).

2.3.1.3 Former Orica Employee 2 (FOE2)

On 28 October 2013 CDM Smith employee, Loek Munnichs, had a phone conversation with FOE2. The following information was shared:

- FOE2 worked at the Orica/ICI site between 1991 – 2009 as an electrical engineer;
- The decision to closing the FCAP in 2002 appeared to FOE2 to be a rushed decision by upper management;
- To FOE2 it is well known and a regular occurrence that mercury was released to the site's drainage system. CDM Smith note that it is unclear if this refers to the sewer or stormwater; and
- Orica reportedly has a map that shows all the locations with elevated mercury levels on it. The employee (probably from Botany Industrial Park) that provides excavation permits holds this information (Note: CDM Smith has not yet been able to locate a copy of this map).

2.3.1.4 Former Orica Employee 3 (FOE3)

On 19 and 20 November 2013 CDM Smith employee, Loek Munnichs, had email correspondence with former ICI employee, FOE3. The following information was shared;

- FOE3 worked at the ICI site between 1954 – 1964 as a scientific instrument maker, and lived with his parents in an ICI supplied house on Denison Street, Matraville, opposite the main gate;
- The mercury used at the site arrived on the back of a truck from Sydney port in hundreds of 4 inch diameter x 9 inch long sealed pipe sections with a concave welded cap at one end and another convex cap at the other, with a welded thread and plug to contain the mercury. The mercury was imported from Italy and other places, approximately 2-3 times a year;

- The trucks used to transport mercury from Sydney port had flatbed trays with no sides, and the pipe sections were loosely stacked and not crated. The flat bed was only partially covered for shipment to prevent overloading, necessitating several trips from the Port to complete the freight shipment;
- Within the FCAP, there were concrete floors under the cells. These were very pitted with the metal (stones in concrete) exposed by 30-40%, and mercury and caustic spillages were observed everywhere;
- Concrete drains ran from the chlorine plant to the chinese gardens (near the water treatment plant). The water treatment plant was the lowest part of the site. The effluent was treated and pumped up hill to the sewer connection near the solid caustic plant and bowling greens, where it was discharged into the sewer system. There was a building (size of a garage) between the ponds and the rail line at the end of the street between the ponds and the plant buildings. This is the position of the original water treatment zig zag mixing plant for pH control of liquids, which FOE3 maintained the instrumentation of. This building would have been the lowest part of the plant, and at a lower elevation than the ponds, so liquid from the ponds could gravity feed to the treatment system, and then sewer (or other places prior to the sewer connection being installed);
- FOE3 never witnessed offsite dumping of mercury sludges from the chlorine plant (FCAP);
- During FOE3's time working at ICI, mercury was only used at the chlorine plant;
- The mercury cells, which were approximately 50 m wide and 50 m long, were complete with hundreds of adjustable carbon electrodes. There were pressure excursions which were probably caused by a spark between the electrode and the mercury, which was maintained as a fixed mercury level in the bottom of the cell, while carbon electrodes were manually adjustable for depth. Most days there were incidents where the cell bank back pressures would blow caustic soda and mercury onto the ground;
- Mercury was observed everywhere on the ground in this restricted area, and sometimes also observed to be flowing down the gutters towards the chinese gardens; and
- On one occasion, mercury was stolen from the site by an employee using his bicycle.

2.3.2 Community Presentation

At the time of writing this report the community presentation is planned to be delivered on 12 February 2014.

2.4 Areas of Community Concern

As part of the questionnaire, respondents were also asked to provide any other information, ask questions, or provide criticism. A list of the key issues identified through this process is provided in **Table 2-1** below. This table also contains previously raised concerns (submissions following the EPA request for information) and concerns provided in the request for tender documentation.

Table 2-1 Summary of Key Concerns, Comments or Criticisms Identified Through Submissions

Issue	Response CDM Smith
	Previously raised questions and concerns
What criteria should be used in the assessment of risk from mercury contamination from Orica's former Chlor-Alkali Plant?	In **Section 7** CDM Smith has answered this question. Primarily CDM Smith will refer to State and Federal Guidelines for NSW and Australia. Where no criteria were available CDM Smith has referred to US EPA guidance.
Is the presence of mercury above pre-habitation background levels an indicator that further sampling and analysis are required to establish actual contamination levels?	Even in the absence of the former Chlor-Alkali plant, the post industrial development levels of mercury in air, soil, water and fish would be expected to increase above background levels simply due to the increased burning of coal globally, and other globally sourced deposition. This makes it very important that CDM Smith has adequate and appropriate background data for any local area sampling that is conducted.
What is the risk, and possible short- and long-term impacts, on human health and the environment from Orica's FCAP, associated with mercury emissions from 1945 until the plant closed in 2002, outside the boundary of the site in the ambient air, soils, groundwater and surface water?	To answer these question CDM Smith has separated it into two sub-questions: ▪ What are the health effects of mercury exposure? These were addressed in the fact sheet provided by the South Eastern Sydney Public Health Unit (see **Appendix F**) or download it from this location: http://www.seslhd.health.nsw.gov.au/Public_Health/resources/Mercury_Exposure_and_Health_Factsheet_07 ▪ What were the mercury emissions and associated exposures associate with this plant. This is detailed in **Section 6.4**. Figure 6-7 of this report shows that the main exposure routes to mercury occur via inhalation, dermal (skin) contact and ingestion of surface soils, home grown produce and fish. Note that any fish will add to the total exposure, not just the fish caught from Penrhyn Estuary.
What is the risk to human health and the environment outside the boundary of the site from mercury contamination currently in soils inside the site?	Currently the contaminated soils on the site are being remediated by excavation, within an enclosed air-controlled building. The remaining contamination present under the FCAP (Block G) will be encapsulated as the result of the construction of a purpose built cut-off wall and vapour barrier to isolate onsite mercury from surrounding groundwater and to prevent mercury vapour egress. Other onsite contaminated soils are mostly covered by concrete pavements. Therefore the potential for exposure and distribution of mercury contaminated dust (see also **Section 6.4**), resulting in adverse health risks is considered to be minimal. There is not much data available on mercury levels in surface soils across Southlands, except for the sediments and soils in/near Springvale Drain (Note that this drain has been remediated). In the Phase 1 (1990 Woodward Clyde) and Phase 2 (1996 Woodward Clyde) assessments, samples were collected and mercury was commonly detected at concentrations below 10 mg/kg. This is below the NEPM Human Health Investigation Level for residential land use (HIL A).
Have previous reports adequately identified the level of risk of mercury contamination outside the boundary of the site? What was the nature and findings of previous contamination testing in air, soils, groundwater and surface water	Historical reports have not addressed risk levels outside the boundary of the Orica site. Note that in the 2008 and 2013 Human Health and Ecological Risk Assessment (HHERA), the biota and sediment data was not included in the revised risk assessment, as Penrhyn Estuary was no longer considered accessible to the public. However it is covered in the previous 2005 Consolidated Human Health Risk Assessment.
What types of sampling should be performed? Groundwater monitoring of existing bores in the upstream residential area.	In **Section 9.2** CDM Smith has identified additional data that needs to be collected in the Orica Botany Independent Mercury Review, Stage 2 – Environmental Testing Regime.

Issue	Response CDM Smith
What methodologies should be used for sampling?	As above
Where should sampling be conducted?	In **Section 10 C**DM Smith has summarised where additional testing is considered necessary.
Should air quality be measured in people's homes? If so which homes? Should concerned community members be offered testing?	Again, please refer to see **Section 10**.
What is the appropriate season to perform monitoring for gaseous mercury emissions?	Air monitoring is best done to account for seasonal variations. However, there is data to suggest that mercury vaporisation rates are higher when there is direct sunlight.
Should roadside drains be tested for elemental and gaseous mercury?	No. At this point in time CDM Smith do not see any reason why this should be done. Most sewer and roadside drains are situated above groundwater level and therefore ingress of contaminated groundwater into drains is not considered likely. However to alleviate concerns drains can be tested for gaseous mercury when ambient air samples will be collected using a gaseous mercury analyser (e.g. Lumex Model 915+)
What is the risk from anode sludge dump sites? Are there anode sludge dumps at: ▪ Anderson Street and surrounding area including the abandoned block of overgrown land at the back of a school ▪ Heffron Park ▪ Franklin Street / Wassell Street ▪ Anderson Street	During our review of EPA's and Orica's files CDM Smith has not found any evidence regarding illegal dumping of mercury waste. Also, none of the former employees interviewed had any knowledge of such activities. Additionally, the local residents that CDM Smith has been in contact with have not been able to provide us with any information to assess in this regard. For the parks and streets mentioned, CDM Smith requested additional information from Councils. From Randwick Council CDM Smith received, and subsequently reviewed, a 2004 Phase 1 report for Heffron Park. CDM Smith has summarised the content in document 175 in **Appendix G**. The report concludes that historical filling or earthworks at the site is unlikely to have previously occurred. Randwick Council also provided us with a summary report of Phase 1 studies on all their historical landfill sites. This included sites located within the entire Local Government Area. No figure with a location of the Parks was provided with the report. At Pioneer Park, it was recommended that groundwater and surface water investigations be undertaken. CDM Smith has not received any additional information for the other identified parks. A comprehensive review of historical aerial photographs is required. This needs to be undertaken as part of the Stage 2 - Environmental Testing Regime. In **Section 10.1.2** CDM Smith has discussed the need to conduct some testing within a number of Parks to alleviate community concerns. The nominated Parks have been selected based only on their proximity to the FCAP, or as a result of community concerns which have been raised about the potential for elevated mercury concentrations to exist.
Should Port Botany shore line, Penrhyn Estuary and the delta fan that enters the estuary be tested? Should the fishing ban in Penrhyn Estuary continue? If so why?	In **Section 7.1.3 and 7.1.5** CDM Smith has discussed the Penrhyn Estuary and the need for additional testing. More information regarding the recent publications on the fishing ban can be found in this document: http://www.epa.nsw.gov.au/resources/oricabotanycttee/130669spupdateaug.pdf

Issue	Response CDM Smith
What is the risk of mercury contamination associated with the use of Malabar Headland as a waste site?	The central area of Malabar headland was used for waste disposal from approximately 1968 to 1988. As part of an ongoing site clean-up and remediation program by the Commonwealth Government, soil, groundwater and surface water from the site has been extensively tested. Mercury has not been found at levels that would be considered harmful to human health or the environment. The EPA undertook its own independent sampling of stormwater at the site in February 2013 and the results showed that there were no elevated levels of mercury (source: EPA 2013/0211, April 2013). There is no immediate reason for CDM Smith to conclude, based on the reported information, that there are any potential risks associated with mercury at Malabar Headland. Please note that CDM Smith has not received nor reviewed any soil/groundwater assessments undertaken at this former waste disposal site.
What is the risk from other potential sources of mercury in the area? i.e.: ▪ Mercury from Bunnerong Power Station; ▪ Ash from the power station used as fill across the Port Botany area; and ▪ Any other potential sources of mercury.	Bunnerong Power Station is a coal fired station. In Orica's files CDM Smith locate an internal ICI report "The Mercury Burden": ▪ Mercury content in black coal is reported to range from 0.015 - 0.40 ppm in Australia, and 0.015 - 0.34 in NSW. ▪ On the Botany-ICI site 85,000 tonne / year of coal is burnt (not the Bunnerong Power Station). The coal is usually from the western district in NSW and its mercury content ranges from 0.015 to 0.07 ppm. ▪ The conventional wisdom is that 10% of the mercury remains in the ash and the ash is 10% of the total coal, such that the ash should roughly have the same content as the original coal. This is very different from the concentrations of mercury measured in the boiler ash as presented in the 1990 Phase 1 report (20ppm in ash found at Southlands and 8ppm in ash directly from Orica's onsite boiler). ▪ The emission of mercury from this onsite source would be approximately 1.28 - 5.95 kg/year. ▪ If the coal had 8 to 20 ppm Mercury (as measured in the Phase 1) the total output from the onsite boiler would be 1,700 kg/year of which some 1,500 kg/year would be liberated to the atmosphere. In order to assess mercury content in boiler ash from Bunnerong power station which is known to be present on Southlands, and elsewhere in the study area, CDM Smith recommends additional sampling to address this question. In **Section 6.1** CDM Smith has included other mercury sources within the immediate area of the FCAP site.
Confidential representations made to the review by community stakeholders, including former and current workers, to present information and knowledge of Orica work practices and health status.	This has been undertaken by CDM Smith. CDM Smith refer to **Section 2.3.1**
What does the groundwater monitoring associated with the groundwater treatment plant tell us about mercury contamination of groundwater?	CDM Smith has not reviewed the data from the groundwater treatment plant as this is beyond our Scope. However CDM Smith did review the data on mercury contamination in groundwater, and this has been summarised in **Section 6.2.5**.
Questionnaire	
Concerned that residents may be impacted by mercury poisoning.	This is the main driver for the Independent Review. CDM Smith recommends reading the Conceptual Site Model and Exposure Summary in **Section 6.4**, and mercury factsheet provided by the South Eastern Sydney Public Health Unit (see **Appendix F**)

Issue	Response CDM Smith
Comments on a lack of community understanding on the health effects associated with mercury exposure.	See our response above.
Requests for direction on where historical records associated with mercury contamination can be found.	The NSW EPA holds substantial historical records on this issue. These are within the public domain. The NSW EPA should be contacted if individuals wish to review their records on this issue. Orica provided CDM Smith access to their historical files as part of this review. This has been discussed in **Section 3.3.4.**
Requests for details regarding monitoring and review programs implemented by the EPA in the Botany Bay area.	Information on this can be found on the NSW EPA website: http://www.epa.nsw.gov.au/Oricabotanycttee/indrevoricabotany.htm
Concern about risks to pregnant women, fetuses and children.	Pregnant women, fetuses and children are the most sensitive group amongst humans to mercury exposure. The South Eastern Sydney Public Health Unit has produced the following fact sheet (see also **Appendix F**) http://www.seslhd.health.nsw.gov.au/Public_Health/resources/Mercury_Exposure_and_Health_Factsheet_07May2013.pdf This concern can only be addressed by conducting a full Human Health Risk Assessment. The need for such an assessment shall be reviewed and discussed once the results of Stage 2 of the Independent Review - Environmental Testing Regime are available.
Lack of investigation into mercury contamination or health effect by an independent body.	The NSW EPA commissioned an Independent Review to address community concerns
Comments of foul smelling fumes and observing smoke release from the Orica site.	CDM Smith acknowledge that residents have concerns about stack releases. During our review of the EPA files CDM Smith has found numerous complaints made to the Pollution Line regarding smelling fumes and stack releases at the Botany Industrial Park site (occupied by Orica, Huntsman and Quenos). Addressing these concerns was beyond our scope of work.
Observations of flames and loud explosions from the Orica site.	See above.

Issue	Response CDM Smith
Concerns about contamination to groundwater and the use of borewater.	There is a groundwater restriction zone on part of the study area. Using bore water for personal use such as watering (vegetable) gardens, filling up pools or for washing cars is not allowed within this restriction zone. http://www.water.nsw.gov.au/Water-Management/Water-quality/Groundwater/Botany-Sands-Aquifer/default.aspx Regarding mercury CDM Smith has no reason to expect significant groundwater contamination within the residential areas surrounding the FCAP. Groundwater concentrations in monitoring wells down-gradient of the FCAP are impacted, but the levels of impact are relatively low. Furthermore groundwater flow is toward Botany Bay. As can be seen in **Figure 6-7** CDM Smith has concluded that the exposure pathway via groundwater is incomplete meaning that there are no risks for residents related to mercury contamination in the groundwater. Note that the groundwater on the site and it surroundings is contaminated with chlorinated organic compounds. These groundwater contaminants are considered to be much more significant, and are being addressed by Orica and the EPA.
Concerns about contamination from consuming vegetables grown in potentially contaminated soil.	CDM Smith has made recommendations to collect soil samples within the residential area adjacent to the former Chlor Alkali Plant. Please refer to **Section 10.1.1.**
Response that this is the first time the respondent has heard about the mercury release from the Orica/ICI.	In response to concerns raised by community representatives the EPA has been directed by the NSW Minister for the Environment to undertake this independent review. This direction came in early 2013, since the EPA engaged with the community in relation to the mercury issue. For an overview of the community engagement activities CDM Smith refer to this publically available document: http://www.epa.nsw.gov.au/resources/oricabotanycttee/130669spupdateaug.pdf. Minutes of the Steering Panel meetings can be located here: http://www.epa.nsw.gov.au/Oricabotanycttee/indrevsteerpanelmeetings.htm Note that since the early 1990's, there is a Groundwater Community Liaison Committee (CLC) where all environmental issues related to Orica are being discussed in a public forum. Information can be found on this website: http://www.oricabotanytransformation.com/?page=32

Section 3 Scope, Objectives and Methodology

3.1 Scope and Objectives

3.1.1 Objectives

The following five objectives were identified for the project:

- Determine if there is a significant public health risk and the level of such health risk to the community associated with mercury release;
- Determine if there are any sources of community exposure to mercury that are not currently being managed and controlled;
- Ascertain if there are communities and/or individuals at risk;
- In so doing, assist in reassuring the community that appropriate actions are, or have been taken, through current and legacy projects managed by Orica and regulated by the EPA at the Matraville site; and
- Determine exposure pathways and possible sources not being currently identified and/or managed.

To be able to realise these objectives, CDM Smith identified the following critical success factors to be achieved during the project. These factors included:

- *Establish a strong working relationship with the Panel*;
- *Demonstrate transparency and independence to the affected community;*
    - CDM Smith employed a transparent and open-minded approach to the work that demonstrated that our work was comprehensive, scientifically defensible, and unmarred by any conflict of interest. In order to establish transparency and trust, CDM Smith worked closely both with members of the Panel and with the community. Stage 1 works were carried out without bias;
- *Develop a comprehensive review report that is accepted as technically excellent and unbiased by the Committee and the community, that incorporates communities' concerns in its approach and directly answers as many of the questions raised by the community as possible;*
    - The Stage 1 review effort was based on the extensive list of questions listed in the request for tender, plus any others raised during our Stage 1 work. Careful and direct consideration was given to each issue;
- *Provide recommendations for additional characterisation of the Site and/or surrounding environs for Stage 2 of the effort; and*
    - At the start of the project CDM Smith anticipate that some questions raised by concerned citizens and other stakeholders will not be fully answered by review of current data. The review has identified data gaps and CDM Smith provided recommendations for gathering additional information.

3.1.2 Scope

The Independent Review Stage 1 - Data and Information Collection and Review included the following scope:

- Undertake a comprehensive independent review and analysis of the available data on the emission and distribution of mercury or mercury contaminated material, addressing all the Community Concerns for Consideration, and including an analysis of the extent and limitations of the data and information available;
- Seek other information (e.g. confidential submissions from members of the public) that may be available about potential community exposure to mercury originating from the former Chlor-Alkali Plant;
- Determine what further information (e.g. environmental sampling) is needed to assess the potential health risks to the community that are attributable to mercury emissions from the former plant;
- Determine the appropriate criteria for risk assessment and environmental testing types, methodologies and locations to assist in determining the health risk including any seasonal variation, staged testing regime and appropriate quality assurance requirements for the Orica Botany Mercury Independent Review Stage 2 - Environmental Testing Regime. This regime must identify any significant sources of mercury exposure which may cause possible short- and long-term impacts on the health of the local community from;
    - mercury within the ambient air;
    - mercury contamination in soils at the site;
    - mercury in soils outside the boundary of the site;
    - mercury in groundwater; and
- Provide an Independent Review Report with recommendations concerning all above mentioned tasks.

To enable to address the above mentioned scope CDM Smith provided a team of suitable experts to perform this Orica Botany Mercury Independent Review Stage 1 - Data and Information Collection and Review, including:

- Review and Analysis of Available Data (see **Section 4**), Addressing Community Concerns for Consideration (**Section 2.4**) and Data Gap Analysis (**Section 8**). This included a Conceptual Site Model (**Section 6**);
- Set up, provision and management of a confidential method for community members to relay any concerns (**Section 2.1**);
- Provision of an Independent Review Report with conclusions and recommendations concerning all above mentioned tasks;
- Meetings and Liaison:
    - An inception meeting with the EPA and the steering panel to discuss project scope, methodologies and timeline was held on 12 August 2013;

- Mid contract discussions with the EPA to discuss progress and findings (10 October 2013 and 8 November);
- A summary of the report and recommendations was given as a presentation to the Committee (21 November 2013);
- A summary of the report and recommendations should be given as a presentation to a community information meeting (Provisional: 12 February 2014);
- Communications with NSW EPA/ others as necessary throughout the project;

- Stage 2 Environmental Testing Regime, Sampling, Analysis and Quality Plan (**Section 10**) containing;
  - Determination of further assessment needed to determine health risks attributable to mercury emissions from the former plant; and
  - Determination of criteria for risk assessment (**Section 7**), including testing, methodologies and locations to assist in determining health risk.

3.2 Methodology

At CDM Smith our approach is to **listen**, **think** and **deliver**.

3.2.1 Listen

Community members and others have information, questions, and concerns about the operations of the former Chlor-Alkali plant, facility waste management, releases of mercury, and possible risks to the greater environment and public health. Our listening and information-gathering was iterative. CDM Smith has listened to members of the Panel, members of the community, current and former employees, and other stakeholders such as the EPA. CDM Smith listened carefully, respectfully and with no bias to people's concerns and relevant information. And, of course, CDM Smith read all of the relevant background documents, and conduct research in the relevant scientific literature.

In addition to this CDM Smith setup a confidential email address for online submissions where community members were able to post information confidentially.

3.2.2 Think

CDM Smith has considered (think) and discussed what CDM Smith has heard, read, and learned. Our ability to do so was based on the individuals in the project team (Section 3.3.5). Our team has particular expertise in mercury toxicology, chemical fate and transport, exposure assessment, hydro-geochemistry and health risk assessment.

3.2.3 Deliver

Our main deliverable is the thorough report in hand. The report provides summaries of all the files reviewed, mercury mass balance (estimate), technical information and interpretation in terms of public health and environmental impacts, data gaps and a sampling and analysis plan for Stage 2. The report contains an executive summary accessible to lay readers; a detailed main report; and several technical appendices.

3.3 Stakeholders

3.3.1 Botany Mercury Independent Review Steering Panel

The Botany Mercury Independent Review Steering Panel has been established to provide an opportunity for community involvement, and to provide expert advice to inform and oversee the Review. The steering panel includes representatives from the EPA, NSW Ministry of Health, Office of Environment and Heritage, City of Botany Bay and Randwick Councils, an independent health expert and community members. The Steering Panel will inform and oversee the independent review. The EPA will, after seeking advice from the Panel, select suitable independent experts to conduct the review; the steering panel will evaluate the results of the investigation and its recommendations and communicate the findings to the community. If in the course of the review, it is established that other hazardous substances need to be investigated, the steering panel will provide recommendations on future investigations that may be required. The Steering Panel is the only body that received the draft report before it was finalised.

3.3.2 Community

In previous community presentations a 1.25km radius around the FCAP was introduced as the initial study area. As it was CDM Smiths opinion that this radius was conservative (based on similar sites internationally), CDM Smith adopted this area as being the initial study area (see **Appendix H**). CDM Smith engaged with residents and businesses within this area.

As mentioned above, two members of the local community were part of the Panel and they represented the interests of the local community.

3.3.3 NSW EPA

The NSW EPA is leading the review and chairs the Steering Panel.

3.3.4 Orica

Orica is the owner of the land where the former Chlor-Alkali plant was situated. Orica understands the importance of the review and has agreed to provide sufficient funds for completion of the review.

3.3.5 CDM Smith

It is understood that EPA received approximately 18 tender submissions. CDM Smith was one of three parties who were shortlisted and invited to present their tender and approach to the Steering Panel on 25 July 2013. On 3 September 2013 the contract between the EPA and CDM Smith was signed (agreement number EPA- 29-2013).

CDM Smith combined a team of national and international experts. The overall qualifications of the team exceeded the minimum qualification for accreditation under the NSW Contaminated Land Auditor Scheme under the *Contaminated Land Management Act 1997.*

The team included four technical staff from Australia and additional support staff in our Sydney Office; and three key CDM Smith US-based staff, who provided technical review and advice (remotely), utilising their related Superfund and major-project experience and specialities associated with the project disciplines such as toxicology, risk assessment, site characterisation, fate and transport and community consultation.

Below, in **Table 3-1** the team members, their qualifications and main contributions to the project are summarised. Each team member provided input to the report.

Table 3-1 Review Team Individual Qualifications

Name	Degree	Years of experience	Current Job Title	Key Project Role
Andrew Kita	BEng. Geological Engineering	16	General Manager – Contaminated Land	▪ Project Director ▪ Review-team ▪ Community Consultation ▪ Report Compilation
Loek Munnichs	BEng. Environmental Technology BEng. Chemical Technology	15	Senior Environmental Scientist – Team leader Contaminated Land Sydney	▪ Project Manager ▪ Review-team ▪ Community Consultation ▪ Mass Balance ▪ Report Compilation
Katarina David	PhD candidate in Groundwater, University of NSW, current Master of Science in Hydrogeology and Groundwater Management BSc. Hons, Graduate Engineer of Geology, Major in Engineering Geology and Hydrogeology	16	Principal Hydrogeologist – Team leader Groundwater	▪ Hydrogeological ▪ Review-team ▪ Conceptual Site Model
Dr. James Lavelle	B.S. University of California, Santa Barbara, CA, USA M.S. Thomas Jefferson University, Philadelphia, PA, USA Ph.D., University of Oregon, Eugene, OR, USA	35	Associate, Senior Toxicologist	▪ Technical Lead ▪ Risk Assessor ▪ Air Dispersion Modeller ▪ Peer Review
Dr. Laura Green	B.A., Chemistry, Wellesley College, Wellesley, MA, USA Ph.D., Nutrition & Food Science, MIT, Cambridge, MA, USA Board certification, American Board of Toxicology (D.A.B.T.)	35	Vice President for Environmental Health & Toxicology	▪ Toxicologist ▪ Technical Reviewer
Ernest Ashley	M.S. - Civil Engineering, Hazardous Materials Management, Tufts University, USA B.A. - Geology, University of Colorado, USA	30	Vice President – Geology (C.P.G., LEP, LSP, CHMM) Remediation Engineer and Science Discipline Leader	▪ Toxicologist
Michael Nicholls	BEnv. Science	15	Associate, Environment - Remediation	▪ Team Coordinator ▪ Review

On 14th June 2013 CDM Smith provided the NSW EPA with a tender document Orica Botany Mercury Independent Review: Stage 1 – Data and Information Collection and Review, project number SCL130051.001". This document should be read in conjunction with the report in hand.

Section 4 Summary of Historical Reports and Data

4.1 Approach to gather information

The NSW EPA provided us with their internal files (174 in total) on the former Chlor-Alkali Plant.

Also, as described in **Section 2.2** CDM Smith requested information from concerned community members and former employees, and undertook a comprehensive community consultation program covering 4,500 residents and local businesses within a 1.25km radius of the site. Considerable relevant and useful information was provided by and on behalf of concerned residents, that has been incorporated into this review.

Orica informed the EPA that they extracted and collated hard copies of all their internal files relating to mercury and the FCAP (dating back to the early 1940s), and that these were available for the independent reviewer within a data room onsite.

4.2 Summary of the available information

Most of the EPA files were hard copy documents dating back to the early 1990s. A complete list of all the files received from the EPA is included in **Appendix I**. Files received related to:

- Environmental Protection, Compliance & Regulation – Licence 2148 - Premises - 500755a46 Scheduled premises - ICI Australia Operations Pty Ltd - 16-20 Beauchamp Rd – Matraville premises (Hardcopies);
- Hard copies of studies undertaken by the State Pollution Control Commission (SPCC);
- Hard copies of the Stage 1-Stage 2-Stage 3 Environmental Surveys undertaken by ICI;
- Notes of numerous complaints made to the Pollution Line including information on how the complaint was addressed;
- Electronic documents, mainly site assessment reports undertaken by Orica;
- Human Health Risk Assessments undertaken by Orica (electronic);
- Published scientific articles on mercury (electronic); and
- Public submissions (electronic).

A review of documentation and communications relating to the current remediation efforts on the FCAP site was not part of the scope of this independent review.

The dedicated CDM Smith team (see **Section 3.3.5**) reviewed all these files and provided a summary of each relevant file. Note that science articles/publications and public submissions were reviewed but in most cases not summarised. Our summaries are provided in **Appendix G**.

During the review, attention was focused on available (analytical) data (both onsite and offsite) in relation to mercury impacts on the local environment, waste handling practices and dumpsites.

Information gathered from EPA files has been used throughout the report. The document number refers to the first column in **Appendix G**.

4.3 Information gathered from other parties

4.3.1 Orica

As part of the Independent Mercury Review, CDM Smith requested additional documents from Orica that were not held by NSW EPA, and also presented a list of questions for Orica to answer if possible. A list of the questions is presented in **Appendix C**.

In response to the questions asked, Orica provided CDM Smith with access to an onsite data room, containing an estimated 12,000 pages of documents relating to the FCAP, the historical use of mercury, and disposal of mercury containing waste streams from the site. The documents included the following, amongst other records:

- Internal and external reports;
- Meeting memos and minutes;
- Corporate strategy and action plans;
- Letters to and from various statutory authorities;
- Research papers on mercury toxicity and sources;
- Mercury accountability and the performance of international Chlor-Alkali plants;
- Studies on reduction of mercury in waste streams;
- Waste treatment methods;
- Contracts with waste disposal contractors and facilities;
- Waste transport dockets;
- Notes on capital expenditure for plant upgrades;
- Design drawings and specifications;
- Waste immobilisation and disposal licences;
- Data collected from testing of mercury concentrations in various media; and
- Records of mercury consumption and importation.

CDM Smith senior staff spent almost two weeks reviewing documentation in the data room and summarising key information for inclusion in this report. This was in addition to the extensive review of documentation held by NSW EPA, community feedback, and documentation provided by other sources. Orica also made available key staff, which had knowledge of existing environmental remediation and monitoring programs, and historic activities associated with the FCAP, to provide answers to any additional questions raised during the review of data held by Orica. Where answers to the initial questions raised could not be located within the documents in the data room, CDM Smith requested (in person or via email) that Orica attempt to source additional information (ie. aerial photographs, design drawings, etc) or employees who had knowledge in relation to a

particular matter. No requests were refused. CDM Smith recorded notes regarding any further information requested, provided or interviews undertaken with Orica staff.

It should be noted that Orica did not supervise CDM Smith's review of documents held onsite, or request any details of what notes were being recorded, and were very helpful and co-operative throughout the review process.

The review of historical records held by Orica onsite, which dated back to the 1940's, indicated that Orica (then ICI) became aware of potential issues surrounding mercury toxicity in the 1970's, and commenced a program of mercury reduction in the wastes generated by the FCAP. Documents from the 1970's indicate that from approximately 1973, two technical staff were employed almost full time to deal with the challenge of reducing mercury content in effluent disposed offsite to the Malabar treatment plant.

Documents were also sighted which related to capital expenditure and plant modifications which were implemented to achieve this. Installation of a sludge filter in late 1974, and a retort in 1972 dramatically reduced mercury consumption in the FCAP (refer to Section 5.1), and the concentrations of mercury in effluent sent to the Malabar plant, and sludge sent to landfill (refer to Section 5.2 and **Appendix P**). Mercury consumption, as a measure of kg mercury consumed per tonne equivalent of chlorine, was in the order of 2-4 times lower while the mercury retort was in operation.

Orica also later established a committee referred to as the 'Mercury Taskforce' which appeared to contain approximately 15-20 Orica senior and technical staff (based on records and memos sighted). The Mercury Taskforce was commissioned with addressing a number of items, including developing a mercury mass balance for the Botany site, and assessing the performance (input/output mass balance) of the Botany FCAP against similar operations internationally, developing a strategy and action plan for dealing with mercury accountability and waste management/disposal.

Overall, the documents indicated significant focus by Orica/ICI management since at least the early 1970's onwards, in relation to addressing the issues surrounding mercury consumption, accountability and discharge to waste streams, appropriate disposal of solid wastes to landfill, and subsequent need for environmental investigations and remediation programs to address issues as they were identified.

In **Appendix M** CDM Smith has summarised the documentation that CDM Smith reviewed in Orica's data room.

4.3.2 Work Cover

A Dangerous Goods Search of the Stored Chemical Information Data Base (SCID) and the microfiche records held by NSW WorkCover for 16-20 Beauchamp Road Matraville 2036 (Orica, ICI, Quenos) was requested by CDM Smith.

The following information was provided:

- 11 files were available on the address. All these files were searched by WorkCover for any relevant information on mercury; and
- A licence request for a 500L capacity storage for mercury was the only relevant documentation that was identified in the SCID.

4.3.3 Councils

CDM Smith requested historical data from both Randwick and Botany Council on the Parks identified by the community as potential anode sludge dumping sites. From Randwick Council CDM Smith received two documents; a Phase 1 Environmental Site Assessment (ESA) from 2004 for Heffron Park and a summary report of Phase 1 ESA studies on all their historical landfill sites within the entire Local Government Area.

Section 5 Mercury Mass Balance Calculation – FCAP

To alleviate concerns amongst residents regarding potential illegal off site dumping of mercury waste and sludges, CDM prepared a mercury mass balance over the entire life span of the plant. The mass balance was undertaken to calculate the percentage difference between the mercury that was purchased (total mass 'in') and the mercury that was accounted for in various waste streams, products produced and other losses in the plant (total mass 'out'). In the ideal situation the mass in and the mass out are the same, resulting in a zero percent difference (ie. 100% of mercury accounted for). However it should be noted that it is essentially impossible to achieve a fully closed mass balance, as some assumptions had to be made in the calculations, especially for the period prior to the early 1970s.

Appendix N contains a detailed process flow arrangement plan for the FCAP. In order to understand the mass balance calculations, it is important to understand the manufacturing process of a typical ChlorAlkali Plant. Chlorine and caustic soda are manufactured using an electrolysis process to separate sodium and chlorine (gas) from a brine (ie. saltwater) solution. Sodium is very unstable and reacts quickly with water to create hydrogen gas, which then reacts with chlorine. To prevent the hydrogen from reacting with chlorine, the former ChlorAlkali Plant separated the production of chlorine and hydrogen into two steps. The chlorine and sodium were formed in the electrolytic cell. While the chlorine bubbled off, the sodium formed an amalgam with the mercury that flowed as a thin film at the base of the electrolytic cell, into another vessel. Water was then added to the other vessel to react with the sodium to form sodium hydroxide (caustic soda) and hydrogen. The mercury was then cooled and recirculated.

This section summarises the most important information regarding the mass balance. A detailed calculation can be found in **Appendix P.**

In order to prepare the mercury mass balance, CDM Smith has identified the following timeline for plant alterations and modifications.

Table 5-1 Timeline - Former Chlor-Alkali Plant Botany

Year	Event
1945	The original cell room (H-cell, 24 cells, 10.2 m^2 cathode area) was built in 1945. There are conflicting statements as to whether H Bank had a concrete floor when first built or whether the floor was added when the MK1 cells were added.
1947	ICI monitored mercury levels in the cell rooms and offices since 1947
1954	A second cell room was added in 1954 (MK-1 cell, 28 cells, 12.5 m^2 cathode area)
1958	Prior to 1958, (document 70 and various anecdotal sources) the Orica plant was not connected to sewer and all effluent and sludges went to the Springvale Drain also known as the 'stormwater drain' or the 'Botany Bay effluent'. Some other plants on the site were connected to the noxious effluent which was believed to flow to settling and/or evaporation ponds. An onsite waste water treatment plant was commissioned. Note that the shoreline has changed and that a Caltex carpark is now situated at the historic Springvale Drain outlet. However, the drain itself is present at its historical location.
1965	A third cell room was built in 1965 (B-cell, 28 cells, 20.8 m^2 cathode area). This was an open cell room.
1970	Pollution Control Act
1970	ICI become aware of the mercury toxicity issue.
1972	In June/July 1972, the mercury retort was commissioned.

Year	Event
1974	In June/September 1974, a sludge filter was installed to remove mercury contaminated sludges from the aqueous waste stream. The filter cake was retorted, stored onsite awaiting mercury recovery in Japan or immobilised in waste blocks.
1978	Mercury removed from the End Box vents on the cells using carbon filters. Prior to 1978 this was vented to ambient cell room air.
1979	NSW State Pollution Control Commission (SPCC, replaced in 1991 by the NSW EPA)
1979	Prior to 1979, the hydrogen waste that was vented to the atmosphere but was not treated to remove mercury prior to discharge. Around 1978-79, two absorbers (sulphur impregnated carbon) were installed to treat the hydrogen waste. Mercury from the filter sludges was recovered in the retort and later immobilised in waste blocks.
1983	Commissioning of the End Box venting system in early 1983.
1986	In September 1986, the retort was taken out of production. Sludges were stored on site up to 1991, when sludge was immobilised in brine blocks.
1990	Start of the aqueous abatement program.
1990	Solidification Plant was built to chemically fix brine sludge into solid blocks for offsite disposal.
1998	H and MK1 cells are decommissioned.
1999	The Protection of the Environment Operations Act 1997 (POEO Act) commenced operation in NSW on 1 July 1999.
2002	The Chlor-Alkali Plant was taken out of production and replaced by a Chlor-Alkali Plant using non mercury technology.
2006/2007	The former Chlor-Alkali Plant was decommissioned.

During the review of documents held by NSW EPA and Orica, and information provided by others, CDM Smith gathered a substantial amount of data relating to the FCAP. CDM Smith has used the data obtained from different sources, and from different timeframes to form an independent opinion on the mercury demand and waste streams at the FCAP. It should be noted that a closed mass balance cannot be achieved. There was no reliable data available for the period prior to the 1970s. Also plant upgrades, described above, had a significant impact on the mercury demand and losses.

5.1 Mercury Demand ('IN')

In the documentation provided by the NSW EPA, CDM Smith did not find any information regarding the mercury demand for the FCAP. However, documents held by Orica contained valuable data regarding the mercury demand. CDM Smith also used available information and experiences from other Chlor Alkali Plants around the world for comparison, for the period where no relevant data for the Orica/ICI plant was available (prior to the 1970s).

Table 5-2 contains a summary of the estimates of mercury used in the FCAP at Botany. It should be noted that these numbers are CDM Smith's best estimates, and are considered indicative of the magnitude of mercury demand for the periods shown. These numbers are considered realistic estimates, which are defensible based on the data obtained and reviewed.

Table 5-2 Mercury Demand FCAP Orica/ICI - Botany (estimate only)

Period	Total years	Mercury demand (tonnes/yr)	Total (tonnes)
1945-1954	10	5.32	53.2
1955-1965	11	11.83	130.1
1966-1974 [1)]	9	22.67	204.0
1975-1986 [2)]	12	11.75	141.0
1987-1998 [3)]	12	32.74	392.9
1999-2002	4	8.76	35.6
Lifetime of the FCAP	**58**		**957**

1) 1974 start of retorting (mercury recovery process) and installation of the sludge filter.
2) 1986 end of retorting process.
3) 1998 decommissioning H and MK1 cells.

5.2 Mercury Losses ('OUT')

Appendix P should be read in conjunction with this section to provide a complete understanding of CDM Smith's calculations of the mercury losses in the plant. In Appendix P we have identified the following main sources of mercury losses:

- Effluent (waste water from the plant) to sewer (Malabar treatment plant) resulting in a total of 29.8 tonnes of mercury discharge over the lifespan of the FCAP.
- Stormwater drain discharges into Springvale Drain that discharges into Penrhyn Estuary. The total amount of mercury losses via the Springvale drain is not yet known and it is our opinion that it will always be an unknown factor.
- Mercury loss via product (Chlorine, Caustic Soda and Hydrogen gas) resulting in a total of 11.2 tonnes of mercury losses in the product stream over the lifespan of the FCAP.
- Mercury losses to air can be identified as fugitive emissions via cell room atmosphere (through the roof and open walls in the plant) and mercury via the hydrogen waste venting stack resulting in between 33.5 – 62.4 tonnes and 28.7 – 34.8 tonnes respectively for these two sources over the lifespan of the plant.
- Mercury losses to soil and groundwater have been calculated to be approximately 12 tonnes and 0.15 tonnes respectively. Approximately nine (9) tonnes have been recoverd so far during the remediation works currently undertaken by Orica at the FCAP site.
- Mercury losses via waste and sludges can be considered as the biggest contributor to total mercury losses.
    - Prior to 1958, sludges went to onsite settling/evaporation ponds before potentially being released to Springvale Drain;
    - In the period 1958 – 1974 (after installation of the mercury effluent filters) all sludges went to Malabar Headland Sewer Treatment Plant (STP);
    - A mercury retort, to recover mercury, was constructed in approximately 1974 and it operated up to September 1986. During this period solid mercury wastes were retorted onsite. This excludes brine sludge which was disposed of to licensed landfill, and for iodised carbon which was stored in drums onsite. Retorting was discontinued because it became increasingly difficult to meet modern operating standards with the existing aging equipment. This was due mostly to leakages, damaged floors and

blockages resulting in unacceptable mercury emissions to air being observed. The retort was not replaced as is was deemed economically not viable;

- From 1986, waste was stored onsite and was subsequently disposed offsite to the SITA landfill at Kemps Creek during the demolition works of the building completed in 2006; and

- In Appendix P we have calculated that over the lifespan of the plant a total of 342 tonnes of mercury waste was disposed of to onsite evaporation ponds, discharged to Botany Bay via Springvale Drain, the Malabar Headland STP via sewer, or transported overseas or to landfill for treatment and/or disposal. Appendix P differentiates between these different disposal routes.

- Mercury losses during plant demolotion (mercury accumulated in the building materials during the FCAP lifespan) were calculated to be between 10.3 – 27.3 tonnes.

Table 5-3 below summarises the mercury losses during the lifespan of the FCAP.

Table 5-3 Mercury Mass Balance Lifespan Botany FCAP (Estimate)

Mercury stream	In (tonnes)	Out (tonnes)
Total mercury demand ('IN')	957	
Mercury losses ('OUT')		
▪ Effluent		29.8
▪ Stormwater		unknown
▪ Product		11.2
▪ Air		62.2 – 97.3
▪ Soil		12
▪ Waste		324
▪ Groundwater		0.6
▪ Building Materials		10.3-27.3
Total calculated mercury losses		**450.1 – 502.2**
Mass of mercury unaccounted for		**454.8 – 506.9** [1)]
Mass Balance (mercury unaccounted for)		**48% – 53%** [2)]
Mass Balance (mercury accounted for)		**47% – 52%** [2)]

1) The calculated value of unaccounted mercury should be interpreted as being an upper end value (ie. maximum).
2) When using less conservative data for the concentration mercury in various sources (especially for waste) the mercury mass balance closes to greater than 95% of mercury being accounted for, or between 0-5% of mercury that is unaccounted for.

It can be concluded that approximately 50% (between 48% – 53%) of the total mass (ie. quantity) of mercury that was used in the FCAP over its lifespan cannot be reliably accounted for.

The calculated value for unaccounted mercury over the lifespan of the FCAP is considered to be a conservative value, and should be interpreted as being an upper bound value (ie. maximum percentage). Therefore the calculated percentage for accounted mercury losses should also be viewed as a lower bound (ie. minimum percentage). It should be noted that there are substantial uncertainties within the estimates, which are discussed below:

- Samples were collected and analysed by different staff, and the laboratory and analytical methods used changed during the lifespan of the FCAP. All of these factors contribute to a certain level of uncertainty as they would affect the concentrations measured in the waste streams, and hence the estimates of total mercury masses;

- Drummed wastes were only rarely sampled for mercury. The mercury contents presented in Table 5.7 in Appendix P are based on assumptions made and reported by Orica engineers at the time. In reality the mercury concentrations in these wastes would have likely been highly variable; and

- In November 1989, Orica calculated that accumulation of mercury in solid waste streams was as high as 12.85 tonnes Mercury/year. Assuming this number, rather than the conservative values used in the mass balance model, an additional 123 tonnes of mercury would be accounted for (400 tonnes opposed to 277 tonnes). Substantial variations were also recorded for mercury content in the brine waste blocks. Assuming that the mercury content in the waste blocks was not a consistent 1,000 ppm as conservatively assumed, but as high as 5,917 ppm (as reported by Orica in 1993), the amount of mercury losses via the brine waste stream would increase from 65 to 384 tonnes. When CDM Smith uses these numbers in the mass balance calculations, the percentage of unaccounted mercury reduces to between 0 – 5%, with almost all mercury accounted for.

5.3 Mercury Balance Calculated by Orica in 1991

In 1991 (Orica FCAP data room folder - volume 1,) a mass balance was undertaken for the FCAP (internal report, dated October 1992). It was concluded by Orica at the time that 38% of the mercury used at the FCAP could not be accounted for. More details are provided in Appendix P.

5.4 International Chlor Alkali Plants

In the files held by Orica, an internal document was located, dated 1 October 1992, in which theFCAP at Botany was compared to 62 European Chlor-Alkali Plants, all of which were using similar mercury cell technology. The Orica FCAP at Botany was ranked 17th when compared to the 62 European plants based on calculated mercury accountability. In the same document, the following information was provided for the 62 European Chlor-Alkali Plants:

- For 1989, the average percentage of mercury that could be accounted for within those 62 CAPs was 45% (the lowest being 4% and the highest was 98 %). This means that 45% of the mercury mass 'in' was accounted for in the waste streams (mercury 'out');

- For 1988 for all 62 plants the lowest mercury percentage that could be accounted for was 3% and 97 % was the highest. For that year the Botany plant had a closure percentage of 60% (60% of the total mercury mass 'in' could be accounted for in the waste streams (mercury 'out'));

- For 1987, the average percentage of mercury that could be accounted for was 46% (between 3 - 91 % mercury accounted for). The Botany plant had a closure percentage of 62% for that year; and

- For 1986, the average closure percentage was 50% (between 8 - 99 % Mercury accounted for).

The following was noted at the end of the report:

"*The only idea that has not been fully explored is the possibility of mercury escaping through the cell room effluent drains and pits into the soil. However, the possibility of 9,000 kg/year of mercury escaping into the soil is somewhat unrealistic".*

5.5 Data Gaps

In historic reports there was evidence of onsite sludge ponds and lagoons. Prior to 1958 sludges were potentially directed to settling ponds and/or evaporation ponds where the mercury in the sludge was likely to have been immobilised with sulphide into highly insoluble mercury sulphide.

On the 1955 aerial photo (**Appendix J**), ponds were visible east to the area where the treatment plant was built in 1958. On the 1966 aerial photo, the ponds were no longer visible and the area appeared to be filled in and levelled. This area is presently primarily used for storage (e.g. HCB containers). In order to effectively close this data gap, it is recommended that these areas of potential historic sludge disposal be assessed for mercury and mercury sulphides.

5.6 Conclusions and Recommendations

- During our review of files held by NSW EPA and Orica, and information obtained from the community consultation program, CDM Smith did not identify any evidence that unauthorised or illegal offsite dumping had occurred;
- Our assessment of the available data indicates that at least 50% of the mercury used can be accounted for with a high degree of certainty. When using less conservative values for reported mercury concentrations in our mass balance model, this figure increases substantially, and approximately 95% of the mercury used can be accounted for. The large range of possible values in the mass balance model is due to uncertainty in the historic measurement of mercury concentrations in waste streams, based on measurement accuracy and variability of the waste streams, and a number of potential areas within the FCAP where mercury could accumulate and escape measurement. The mercury accountability of the Botany plant appears to have been consistent and comparable with that of Chlor-Alkali plants internationally; and
- CDM Smith recommends that site specific data (e.g. fugitive and stack emission rates) used to calculate the mass balance, is used when assessing potential health risks to residents.

Section 6 Conceptual Site Model

The community surrounding the FCAP plant has expressed concerns about potential health risks posed by the former Orica ICI Plant. The plant operated from 1942 until 2002 manufacturing chlorine and caustic using the mercury cell process. Activities at the plant and/and related releases from the plant may have increased the potential risk of adverse health affects for people in the vicinity to the plant.

Health hazards associated with environmental chemicals is due to both the toxicity of a chemical and the amount of that chemical taken into the body. Both aspects of hazard are important; if either is missing, no hazard exists. For example, if a highly toxic chemical is present in groundwater, but groundwater is not used for any purpose, the chemical does not represent a hazard to human health except with regard to volatile substances in groundwater, which may result in exposures through off-gassing.

Mercury is present in the environment in several forms, and these different forms may represent hazard in different ways. Metallic (liquid) mercury can evaporate and mainly represents a hazard through inhalation of mercury vapour. Methyl-mercury accumulates in fish and represents a hazard through eating contaminated seafood.

The Conceptual Site Model is a means of representing what CDM Smith know about releases of toxic substances and movement of these chemicals in the environment to locations where they can have potential adverse effects on human and/or environmental health. A Conceptual Exposure Model (CEM) (Section 5.4) is also presented to show and explain how people may take chemicals into their body.

Based on review of available documents the CSM for the former Orica ICI Plant includes the following:

- The plant operated for approximately 60 years;
- The plant used mercury and brine and manufactured chlorine, hydrogen and caustic soda);
- Releases to the environment included or could include;
    - Fugitive and stack emissions;
    - Discharge to sewers, storm drains and/or surface waters;
    - Disposal of brine sludge, brine blocks, etc;
    - Leaks of brine, mercury or manufactured products;
    - Direct discharge of brine, mercury or manufactured products;
    - Movement of mercury released to the environment involved or could have involved;
    - Transport in wind;
    - Deposition of contaminants from air to soil;
    - Uptake from soil into home-grown produce;
    - Leaching from soil to groundwater;

  - Runoff from soil to stormwater conveyances;
  - Deposition from surface water to sediments;
  - Uptake from sediments and surface water into biota;
- Locations where offsite contact may occur;
  - Residential areas;
  - Parks and other recreational areas;
  - Schools; and
  - Clamming and fishing areas.

As described above, health risk is dependent on toxicity and the amount of exposure to a chemical. For the FCAP, mercury and other chemicals were released to the environment; the levels of these chemicals where people contact contamination will determine if a hazard to human health existed or exists.

Such exposure levels are determined by a variety of processes. Local area weather conditions will have a fundamental influence on ambient air concentrations in residential areas and the potential for deposition of chemicals in these areas. Once on the ground, soil chemistry will determine the forms of mercury (and perhaps other chemicals) present in soil. The amount of precipitation, along with soil chemistry, will determine the movement of chemicals vertically to groundwater. Once in groundwater, direction and velocity of flow will determine if and where impacted groundwater might human health or environmental receptors. All of these transport mechanisms may have been or may continue to be important in determining levels of exposure for community residents. Understanding the transport of mercury and other chemicals in the environment will be necessary to reconstruct exposures to residents that may have occurred in the past, and, in so doing, assess the risk of health impacts.

6.1 Sources and Releases

Sources and releases can be divided into categories. Primary sources are industrial processes themselves and wastes produced by these processes. Secondary sources are disposal or dumping locations, or environmental media (e.g. soil) that may release contaminants to other media (air, groundwater, surface water, sediment, home-grown produce). These source categories are discussed separately below.

6.1.1 Primary sources

The FCAP which used the mercury cell process for the manufacture of chlorine, hydrogen, and sodium hydroxide (caustic soda) solution is the ultimate source of mercury release. The FCAP operated in the period from 1945 until 2002 when it was replaced with a membrane cell process that does not require mercury.

Four areas associated within the FCAP previously identified as source of mercury are:

- Block G – Cell Block;
- Block L – Chlorine Liquefaction and Chlorine Storage Area;
- Block M – Hydrogen and Brine Treatment Area; and

- Block A – Caustic Soda Filtration and Storage.

Block G has been decommissioned and demolished, while blocks A, M and L have infrastructure present and are currently operational. Block G was comprised of three cell rooms, the brine treatment plant (which included two clari-flocculator settling tanks and an underground brine saturation tank) and a sulphuric acid storage tank (which was located in the north western corner of the Cell Block) As shown in **Figure 6-1**, an acid loading bay and strong and weak sulphuric acid storage tanks are currently located on the south eastern corner of Block M.

Figure 6-1 Historically-Identified Sources of Mercury (Map Source: Department of Land and Property Information).

6.1.2 Secondary sources

Several secondary sources of mercury are identified in previous investigations and current literature review:

- Discharge of mercury to air from coal fired boilers;
- Ground cover across the site with furnace ash (potentially from Bunnerong Power Station and/or the boiler on the ICI-site);
- Contaminated waste paper storage (associated with paper manufacturing) and disposal on bare ground;
- Discharge of paper waste slurry into the pits and ponds; and
- Leaking of effluent carried by stormwater pipe and Springvale Drain.

In 1965, two coal fired boilers were constructed to replace the existing equipment. In 1977, a gas fired boiler was constructed. Burning of wastes containing inorganic mercury and the burning of fossil fuels, particularly coal, is known to produce mercury emissions. Worldwide, coal burning and combustion of other fossil fuels is estimated to contribute up to 60% of the total annual amount that is contributed to the atmosphere from anthropogenic sources (Sain et al, 2007). At

Orica, furnace ash from boilers (and possibly other industries) were used extensively as fill material in the northern half of FCAP site and in Southlands with depth extending up to 3-5m bgl in some locations.

Within the Southlands area, the Australian Paper Manufacturers owned the land prior to 1980s. APM stored the waste paper, and discharged paper waste slurry into some of the ponds and pits that existed on site as a result of peat and sand extraction. In the manufacturing process of paper, the mercury based fungicides were believed to have been used (AGEE Woodward Clyde, 1990). Ponds and excavations at former Block 1 at Southlands were continuously filled with ash, with paper waste disposal during the period from 1969-1978.

In the period prior to 1958, effluent was disposed of via stormwater pipe directly into the Springvale Drain. The drain also existed between the FCAP site to Southlands along the northern boundary of Southlands. In addition, the discharge also occurred directly onto the ground near effluent treatment plant adjacent to Southlands area. In 1989, a video camera survey of the stormwater pipe revealed seepages. In 1993, a mapping survey of drain was undertaken and it showed the seepages in the Southlands area.

6.2 Hydrogeological Information

6.2.1 Regional Geology

The Botany Basin extends over an area of approximately 80 square kilometres south of the City of Sydney and it includes two large tidal bays; Botany Bay and Bate Bay. Botany Bay has natural water depth that is generally less than 5 m but locally it has been increased by dredging to 20 mbsl. (Albani & Rickwood, 1998).

Regionally, three main geology units are identified (in descending order):

- Quarternary sediments;
- Tertiary Wianamatta Group; and
- Tertiary Hawkesbury Sandstone.

The deposition of Quarternary sediments began within estuarine environment (Mulholland, 1942), followed by fine grained alluvial clay and silt sediments in the deeply incised paleochannels and finally aeolian sand deposition (Hatley, 2004). The upper portion of the sedimentary sequence is characterised by peat lenses which developed in lagoonal areas. Most of the Project site is covered with Botany sands which comprise uniformly graded (well-sorted), clean, poorly cemented, fine to medium grained, quartz sands laid down in a aeolian and littoral dune and beach settings. Thin discontinuous lenses of peat, poorly cemented ferruginous sands and organic clay also occur through the units (WRC, 1986) with the exception of silty sands present in previously dredged areas of Penrhyn Estuary.

The Botany sands unit varies from 0 m to 30 m thickness, with an average thickness of 15 m. Bish et al., (2000) note that the top of this unit is *"…. marked by an erosional discontinuity of intermittently cemented (and very hard) sandy material forming a horizon called 'Waterloo Rock' or 'coffee rock'"*.

Tertiary Wianamatta and Hawkesbury Group sedimentary rocks form the basement of the Botany Basin (Albani and Rickwood, 1998; Griffin, 1963). Wianamatta Group sediments outcrop to the north of study area and comprise interbedded shales and sandstones of the Ashfield Shale

Formation overlying medium to coarse grained quartz sandstones of the Hawkesbury Group. Hawkesbury Sandstone bedrock contours across the study area indicate that the bedrock is elevated and forms the ridge at the southern end with a dip to the northwest and southwest.

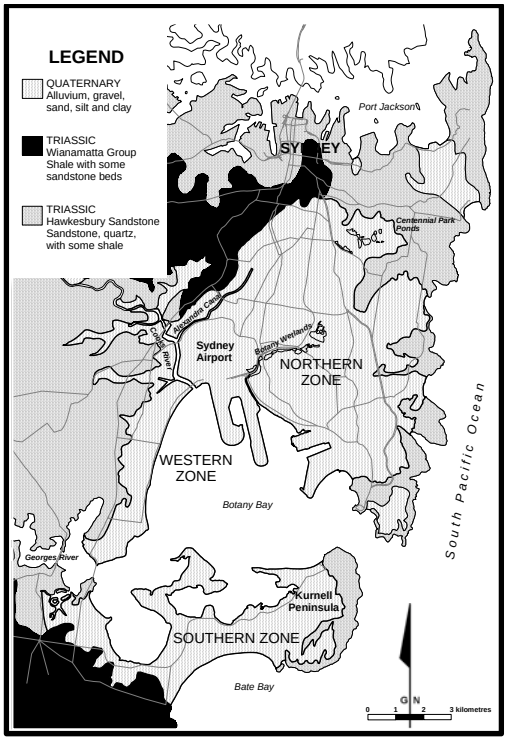


Figure 6-2 Regional Geology Map (After DME, 1983)

6.2.1.1 Geology of the FCAP and Southlands area

The drilling program undertaken within the FCAP area indicates the following lithology:

- 0-1mbgl topsoil/fill;
- 1-19mbgl sand medium to coarse grained interlayered with occasional , thin peat and clay bands; and
- 19-21 mbgl clay and peat;.

The shallow sand layer underneath the FCAP area locally contains peat bands. URS (2006) reported a band of peat in borehole WG32 at approximately 3 m, whilst in WG60 (located on the downgradient boundary of Block L), a 0.5 m thick band was encountered at 3.25 m. At the north eastern end of Block G a peat layer was encountered at 2 m below ground. It appears that the identified peat, clayey peat, clayey sand layers (lenses) are not continuous but laterally thin out. The lateral extent of these layers may range from less than 50 m up to 500 m.

Within the deeper layer at former Solvents Plant (immediately north of Block L) a clay layer was encountered at 14 m depth (unpublished data from drilling in 2005). This organic rich, commonly clayey layer has been identified in most drill holes across the study area at a depth ranging from 19-21 m and appears to be relatively continuous across the wider Botany area.

Below the FCAP area, the depth to bedrock (based on borehole logs) has been determined as relatively shallow between 17 and 26 m below ground. The depth to bedrock increases to the south and west of the FCAP area.

Downgradient of the FCAP area, the presence of peat lenses within the sand layer becomes prominent and the depth to continuous clay layer/weathered sandstone occurs at depths ranging from 16.5 -21 m. Several peat layers were reported to exist at about 15 m depth in the Southland area.

Geology logs from the drilling program within the study area (AGEE and Woodward Clyde, 1990) identified no obvious lateral correlation of the peat or clay units. Geophysical downhole logging undertaken in onsite and offsite wells in 2007 (URS, 2007) confirmed that no extensive clay layers are present across this area. As more data was collected over time, it allowed for the local geology and hydrogeology model to be refined.

6.2.2 Groundwater System

Two primary groundwater systems can be differentiated within the Botany Basin, the bedrock formation and the unconsolidated sediments. Both are described below.

The unconsolidated, poorly cemented sands beds represent the major aquifer in terms of permeability and yield and this unit will be further discussed in this report. The saturated thickness of sand in the study area averages 15 m and ranges up to 30 m. The unconsolidated sand aquifer is generally unconfined, becoming both semi-confined and unconfined closer to Botany Bay, where discontinuous bands and lenses of clay, silt, peat or Waterloo Rock (coffee rock) occur. Jankowski and Beck (1998) reference a pumping test undertaken at David Phillips Field by Webb and Watson (1979) which demonstrated the existence of three separate hydrostratigraphic units within the Botany sand aquifer, namely a water table (unconfined) to 7.7 m, underlain by two semi-confined units at 7.7 – 17 m and 17 – 30 m, each being separated by peaty clay layers.

Locally, this subdivision correlates well with stratigraphic division by AGEE and Woodward-Clyde (1990) and the groundwater system is described as comprising of the following hydrostratigraphic units:

- Shallow upper zone with medium to high porosity sands and few discontinuous peat and silt layers;
- Intermediate unit with lower porosity sands and thin, discontinuous peat and peaty clay and sand layers; and
- Deep basal zone of clayey sands, peaty clay, clay and sandy clays with discontinuous layers of gravel and peat. Clays are present at depths of 15-20 mbgl define the base of this unit, although across FCAP, bedrock is also encountered at some locations at these depths.

No laterally continuous confining units have been identified that separate the shallow from intermediate and the deeper unit.

The comprehensive historical and current monitoring network comprises bores which have been divided into a shallow, intermediate, and deep with screens across shallow (~5-9 mbgl), intermediate (~8-12 mbgl), and deeper (~15-20 mbgl) based on the hydro stratigraphic units as described above.

6.2.3 Aquifer Characteristics

Regionally the Botany aquifer has variable permeability with discrete high yielding zones. No groundwater abstraction is permitted under the Water Management Act (2000) and Water sharing plan for Botany aquifer. However, previous records indicate yields up to 35 l/s from large diameter bores, with up to 1 l/s from spearpoints (WRC, 1986).

Across the study area hydraulic testing was undertaken in 1996 during groundwater program (Woodward-Clyde, 1996), and the results indicate lognormal distribution of hydraulic conductivity. Shallow and intermediate units have higher conductivity in the range from 20 to 30 m/day (lognormal mean 17.6 to 23.3 m/day), while deeper unit has lower hydraulic conductivity of logmean 1.1 m/day. Laboratory measurements of permeability indicate values of 12 to 29 m/day (Merrick, 1994b) while permeability data from pumping tests in the shallow and intermediate units ranged from 20-85 m/day.

Extensive cone penetrometer testing (CPT) during Stage 2 (Woodward-Clyde, 1996) indicated that the porosity of Botany aquifer was in the range from 0.3 to 0.37 (with intermediate unit having the lowest porosity) and specific yield from 0.2 to 0.28.

Historically, groundwater levels and flow direction in the period from 1940s to 1980s reflect the abstraction of groundwater in the area. Following the 1980s with the reduction in pumping (as a result of change in water quality), the groundwater contours return to pre 1950s configurations. Groundwater levels in the shallow unconfined hydrostratigraphic unit range from 6 m AHD at the FCAP to 0 m AHD at the Botany Bay. In the deep unit the potentiometric heads are generally between 4 and 1 m AHD. The overall groundwater flow direction is similar in shallow, intermediate and deep hydrostratigraphic unit; from the northeast to southwest towards the Botany Bay. Across the Project area Woodward-Clyde (1996) report that the groundwater gradient in the shallow hydrostatigraphic unit to be 1:250 m/m, and somewhat flatter in the deep hydrostatigraphic unit at 1:350 m/m. This is consistent with regional hydraulic gradients with an average of 1:120 m/m (AGEE and Woodward Clyde, 1990).

The groundwater velocity calculated based on the gradients in the range from 70-80 m/year in the shallow hydrostratigraphic units and 3-4 m/year in the deep hydrostratigraphic unit. URS (2006) reports velocities in the range from 80 to 260 m/year.

In the Southland, the main topographic feature is the Springvale drain, which is 1-2 m deep and drains part of the catchment with water flow into the Penrhyn Estuary. In the Southland area the drain invert was historically below the groundwater level, therefore resulting in groundwater discharge into the drain. The groundwater discharge to Springvale drain has been estimated based on the flow rate recorded at the weir (Woodward-Clyde, 1996) in the range from 40 m^3/day to 140 m^3/day. This drain was remediated in 1999.

The vertical groundwater gradients at the FCAP area (density corrected) are downward between the intermediate and deep part of the hydrostratigraphic unit, with a subtle change to upward gradients between the intermediate and shallow (URS, 2008). Downgradient of the FCAP and close to the Penrhyn Estuary the groundwater gradients are downward between the intermediate and deep part of the hydrostratigraphic unit, but variable between the shallow and intermediate. The groundwater discharge at Botany Bay is influenced by the difference between the density in fresh and saline water and the presence of saltwater interface (Woodward-Clyde, 1996).

Recharge to the Botany aquifer is primarily through direct rainfall infiltration with minor contributions attributable to lateral inflow into the Botany Basin. Recharge is greatest in undeveloped areas such as golf courses and parks, wetland and ponds. Recharge from these sources has been estimated at between 6% over estuarine sediments to 37% over sandy sediments (Merrick, 1994).

Main discharge from the study area is via pumping from first and second containment lines, evaporation and lateral outflow to the Botany Bay.

6.2.4 Source of mercury in groundwater

Sources of mercury in groundwater and related contamination within the FCAP area are as follows:

- The largest volume of mercury was used on Block G where the floor was not sealed for a number of years allowing elemental mercury to enter soil and potentially impact groundwater;
- Brine sludge stored in Clariflocculator Settling Tanks 1 and 2(Block G) is reported to have contained a concentration of mercury of approximately 1,000 mg/kg (URS,2006);
- Block L had boiler house which was either coal or oil fired. The ash material from the BIP boiler house and potentially also from the Bunnerong Power Station (which reportedly contained mercury) was later used as fill material in Southlands area;
- Within Block L the removal of chlorine storage tank left an area which was filled with mercury contaminated demolition wastes (labelled Depot 60). URS (2006) reports that analytical results obtained from Orica indicate that the mercury concentrations within the this backfilled waste material varied from 1.45 mg/kg to 4,300 mg/kg ;
- Block M has potential soil and groundwater contamination with mercury impurity in hydrogeon compression unit. In the south eastern corner of Block M, a potential for mercury and chloride (saline) contamination existed from the brine tanks operated on unsealed ground until 1972. Where significant quantities of mercury are present, these may behave similar to DNAPL and sink which may result in contamination of deeper groundwater; and
- Block A received caustic soda including mercury derived from the Chlor-Alkali process. URS (2006) reports that although transport and storage of the materials is unclear, the anecdotal information suggests that there may have been some loss of mercury-contaminated caustic soda. The mercury from this source is expected to occur in dissolved state.

Investigations off site during the Stage 2 investigation (Woodward Clyde, 1996) indicated that the fill materials on Southlands (Orica land, located at McPherson Street) contained elevated concentrations of mercury. The concentrations of mercury in surface soils ranged from <0.1 mg/kg to 70.5 mg/kg. The source of this contamination has been attributed to contaminated fill materials from paper mill and boiler ash from boiler house.

In the Springvale Drain, the concentrations of mercury in surface sediments ranged from 15 mg/kg to 220 mg/kg, (Woodward Clyde, 1996) with the concentrations higher in shallow sediments. The source of this mercury was not identified, however, it was concluded that the concentrations of mercury present in sediments could not arise from groundwater contamination.

6.2.5 Groundwater quality

Background pH values of groundwater in the Botany Sand Aquifer indicate that groundwater is slightly acidic (pH values of 5 to 6). At the FCAP area low pH values (< 3) generally occur in shallow groundwater in the former Brine Treatment Area and to the west of the Chlorine Liquefaction and Chlorine Storage Area, and are consistent with the storage of sulphuric acid (H_2SO_4). On the other hand, high pH values (pH of 9 and above) were historically present over the northern part of Block G and over Block A and associated with the use of caustic soda at the FCAP.

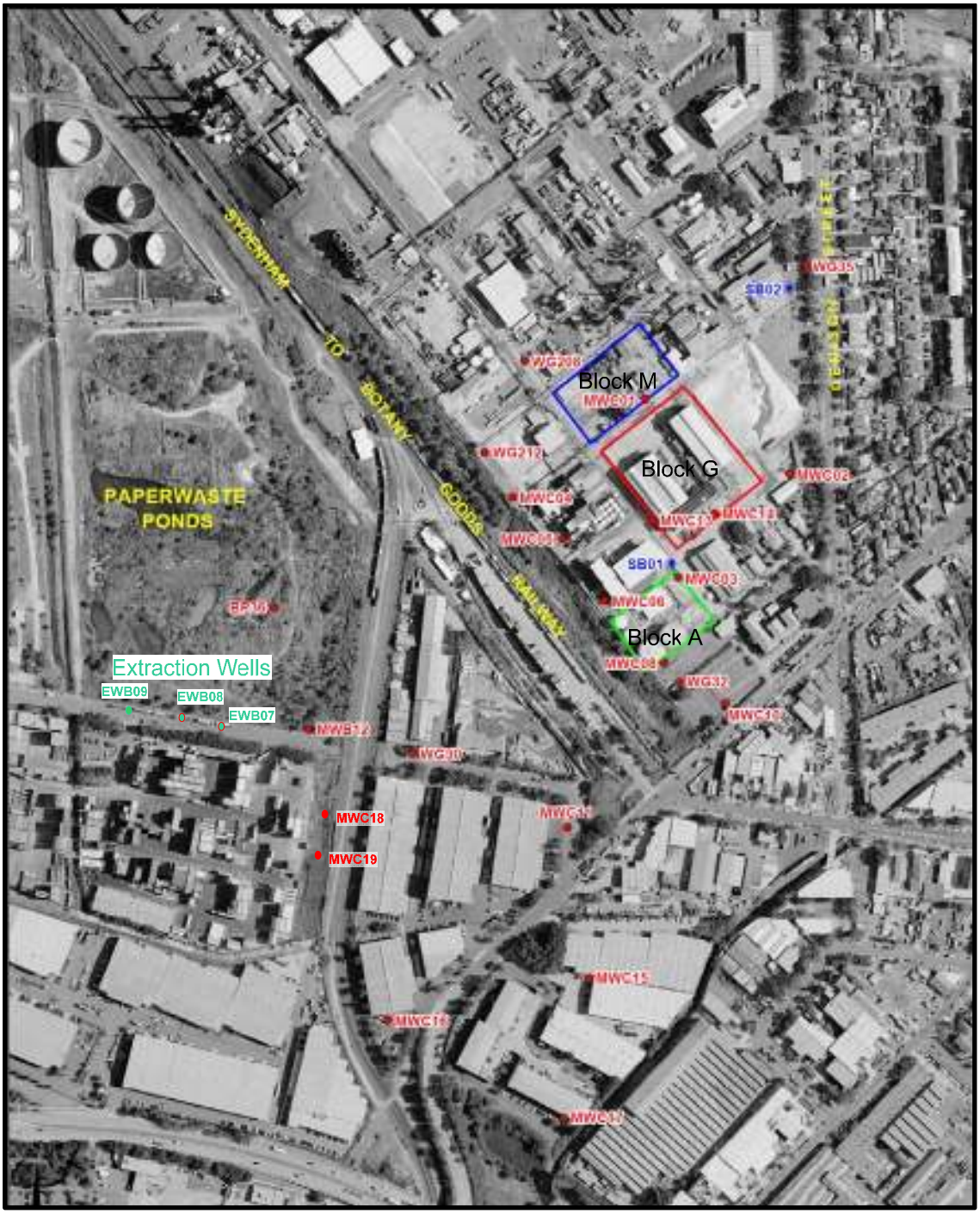


Figure 6-3 Location of Sampled Groundwater Wells Within the FCAP area, Southlands and Offsite

The highest EC values across the study area typically occur in the vicinity of the Block G (**Figure 6-3**), consistent with the storage of salt and brine sludge and the manufacture of chlorine. Additional sources of salt have been suggested such as leaching of saline water from peat beds and seawater intrusion. This is likely to occur as noted by Johnson (1981) based on the presence of Calcium (Ca), sulphate (SO_4) and ferrous/ferric iron (Fe) concentrations, and decrease in alkalinity in groundwater samples. At the same time, it is noted that the stockpile leachate was mostly Na and Cl dominated. Leaching of iron sulphide minerals in the peat could account for acidity, high Fe and SO_4 concentrations in groundwater.

Redox values measured at all depths indicate mildly to strongly reducing conditions on site and DO concentrations indicate anaerobic conditions. Based on the redox indicators (URS, 2008) the reducing conditions were delineated upgradient, within the source area, downgradient and laterally. The intermediate and deep unit were found to be relatively disconnected from the upper shallow unit. Redox reactions are chemical reactions where the oxidation state of the atom changes. Oxidation means loss of electron and reduction means gain of electrons. Mercury occurs in three oxidation states and mercury species vary in their solubility, complexion and microbial processes. Therefore redox reactions have great influence on concentration and mobility of mercury in groundwater. For example, the redox state can result in release or absorption of compound onto certain metal which can increase or decrease its concentration in groundwater respectively.

Groundwater sampling over the period from 1996 to 2013 of shallow, intermediate and deep wells installed within the FCAP area and downgradient in the Southlands indicates the following:

- Shallow groundwater unit was found to be strongly alkaline groundwater within the FCAP and downgradient at Southlands. Elsewhere the pH was slightly acidic. Over time, pH has decreased across the FCAP area but shallow groundwater is still strongly alkaline downgradient in the Southlands. Salinity is high in the FCAP area (Block G) area and in the well in Southlands;
- Intermediate unit had historically strongly alkaline groundwater in the Block A, Block G and Southlands area, while elsewhere the conditions were strongly acidic. In 2013, the alkaline groundwater in the FCAP area is found only to the south of Block A and offsite in the Southlands. Highest salinity concentrations are historically detected in the FCAP area (up to 92mS/cm) and in the well located in the Southlands. The salinity has significantly decreased in 2013. However, the plume covers the same area; and
- Deep unit exhibits acidic groundwater condition within the FCAP area and elsewhere offsite. High salinity conditions are present within the FCAP area and the well and downstream in Southlands. There is minor change over time in salinity and acidity of groundwater in this unit.

The study in 2008 (URS) found that the groundwater in the shallow unit is typically Ca-Na and HCO_3, Cl, HCO_3-SO_4 and Cl-SO_4 and Na-Cl dominated, while the groundwater in the intermediate and deep units is mostly dominated by Na and Cl.

6.2.5.1 Mercury

The plume delineated by AGEE & Woodward Clyde in 1990 was centred over the FCAP area, extending to the northwest along the dip of the sedimentary strata. The wells sampled and reported in the AGEE & Woodward Clyde (1990) investigation were generally less than 10 m in depth and therefore, only screened in shallow groundwater. No deep groundwater sampling was undertaken for mercury.

The AGEE & Woodward Clyde (1990) investigation delineated a high salinity groundwater plume (12,000 µS/cm) centred on the former Block G. The presence of this plume meant that the dominant species for mercury complexation is likely to be chloride- and hydroxide complexes such as $HgCl_2$ (mercury (II) chloride) and $Hg(OH)_2$ (mercury (II) hydroxide). The presence of this plume may have had implications for the dissolution and transport of mercury in groundwater around the site, causing higher mercury mobility where high salinity was delineated.

In 2006, URS sampled most of the existing wells and found that the concentrations of total mercury were not present at concentrations above the LOR (0.0001 mg/L) in all monitoring wells

sampled with the exception of three wells. The concentration in monitoring well WG32 was 5.67 mg/L, significantly greater than the previous sampling event in 1990, when the concentration was 0.003 mg/L. Twelve new groundwater locations were selected within the FCAP and off site areas, with three depths of monitoring bore installations at each site. Groundwater sampling in 2006 of new and existing wells indicated the following:

- Shallow level - highest dissolved mercury concentrations were found in the FCAP area and in the well in the Southlands;
- Intermediate level - dissolved mercury concentrations were elevated in the FCAP area and in the eastern part of Southlands;
- Deep level -dissolved mercury concentrations are slightly elevated in the FCAP area, but no mercury was detected elsewhere; and
- Elemental mercury was found in the well within FCAP area during sampling in 2006 (URS, 2006).

URS (2006) monitoring suggests that a plume of dissolved inorganic mercury is centred on the FCAP and extends to the southwest, and that dissolved mercury transport occurs primarily in the shallow and intermediate aquifer. In all three hydrostratigraphic units, mercury was detected in groundwater in concentrations above the ANZECC (2000) guidelines in the area of former Blocks A and G.

Studies undertaken by URS in 2007 (URS, 2007a; 2007b) included installation and sampling of wells downgradient of the FCAP area and in the Southlands. Groundwater sampling for mercury within the FCAP area only found that mercury in groundwater ranged from less than the LOR (0.0001 mg/L) to22.9 mg/L. Sampling found that just over 30% of wells had dissolved mercury above the ANZECC (2000) guidelines.

Methylmercury concentrations in onsite shallow and intermediate wells and in three downgradient wells within intermediate unit exceeded adopted Tier II SCV (Suter and Tsao, 1996) for aquatic ecosystems (0.0028 µg/L). Methylmercury occurs mainly in shallow wells but has also been found in wells installed in the intermediate hydrostratigraphic unit. The intermediate unit was targeted for methylmercury analysis as the downhole induction geophysical logging confirmed that this unit (10-14 mbgl) had the highest salinity concentration; therefore having the potential for highest mobility of mercury. Methylmercury concentrations within the onsite and offsite wells (as sampled in May 2007) indicate that it accounts for between 0.005% to 4% of dissolved mercury present (URS, 2007).

An additional groundwater monitoring event was undertaken in 2008 (URS, 2008) where groundwater was analysed for dissolved, methyl, elemental, and total mercury, in addition to major ions and redox indicators.

Results of mercury sampling (URS, 2008) indicate the following:

- Shallow unit continues to have dissolved mercury concentrations in all wells above 1 µg/L. Highest methylmercury concentrations (0.001 ug/L to 6.44 ug/L) were detected in the vicinity of the FCAP. Downgradient of the FCAP, methylmercury concentrations were detected in two wells. Elemental mercury was detected in FCAP area and downgradient, offsite. The study concludes that elemental mercury is formed by mercury desorption and demethylation during groundwater flow. The extent of the plume of dissolved mercury extends downgradient to MWC16;

- Intermediate unit has overall higher dissolved mercury concentrations than shallow unit in the FCAP area. Similar to dissolved mercury, the concentrations of methylmercury in this unit is higher than in shallow one. Elemental mercury was detected in all sampled wells but not offsite. The boundary of the plume has been defined to the south at MWC17;
- Deep groundwater has lowest dissolved mercury concentrations of all units. Methylmercury was detected in FCAP area within this unit, and upgradient in one well;
- Overall, elemental mercury and dissolved mercury concentrations are well correlated. However, elemental and dissolved mercury concentrations are not well correlated with methylmercury concentrations;
- In general, total mercury concentrations were greater than the sum of the individual mercury species indicating that mercury is likely to be associated with the solid phase through sorption or precipitation of solids ;and
- Mercury concentrations in the shallow and intermediate aquifers in the vicinity of the former FCAP show fluctuating concentrations over time, indicating that this area is still acting as a source for dissolved mercury.

A groundwater sampling round undertaken in late 2009 (URS, 2010) included installation of additional two wells downgradient and offsite to delineate the mercury plume in the westerly direction. Total and dissolved mercury concentrations fluctuated. However, they were detected in new wells located to the west of the FCAP and Southlands. Testing of wells at primary containment area (PCA) indicates that the salinity and mercury concentrations are low.

Groundwater monitoring event undertaken in late 2012 (Golder, 2013) found that highest dissolved oxygen compound (in shallow unit) is recorded at the locations where highest mercury is present. Distribution of mercury in groundwater in the wells just downgradient of FCAP has increased, and so have the concentrations in offsite downgradient wells. Methylmercury concentrations were similar to the historical values and to the levels predicted by Laase (2010) model. Total mercury values were higher than the dissolved mercury at all monitored groundwater locations. The general trend was a decrease in mercury concentration with depth and distance from the FCAP area is consistent with previous sampling rounds. There are exceptions to this trend.

Higher dissolved mercury concentrations do not necessarily follow the trend of high EC , which is contrary to the previously modelled data. The Golder study (2013) concludes that geochemical parameters recorded during December 2012 are consistent with those assessed in fate and transport model (URS, 2008).

6.3 Fate and Transport of Mercury

6.3.1 Mercury distribution Soils

Soils across the site comprise fine to medium grained sands in the shallower profile, with increasing clay content at depth overlaying sandstone bedrock at depths of 15 mbgl to >20 mbgl. Lateral and vertical heterogeneity within the soil is the result of consolidation stage of sands and clays. Discontinuous, thin (<0.5 m) layers and lenses consisting of peat, peaty clay, peaty sand, clayey sand and silty sand occur in some shallow areas of the site. Soil samples analysed for chemical parameters were from collected from around 1.5m depth.

Mercury concentration in soils up to 14,500 mg/kg was identified across the FCAP area (Block G in former cell rooms, and soil/fill materials). Visible mercury was identified in concrete slabs, underlaying soil and infrastructure beneath the former cell blocks.

A letter from Orica dated 8 February 1977 (Volume 2, Orica folders) stated that soil samples were collected at the Site boundary. Levels of mercury in these samples were between 0.2 – 7.6 mg/kg. Levels were found to reduce greatly after heavy rains.

There is not much data available on mercury levels in surface soils across Southlands. In the Phase 1 and Phase 2 assessments, samples were collected and mercury was commonly detected at concentrations below 10 mg/kg. Two hotspots were detected with elevated mercury levels (66 mg/kg and 70 mg/kg).

A study by CSIRO (2008) was undertaken to determine distribution coefficients (K_d) on samples taken from all three aquifer units at Orica site. K_d is used in environmental chemistry as an indication of the degree to which a specific compound will sorb (adsorptive affinity) to soil. The study looked at characterising the binding affinity of mercury Hg(II) to the soils and the effect of pH, chloride concentration on soil sorption. The study found that both pH and chloride concentrations are significant factors influencing the partitioning and mobility of mercury in soils. Interactions of pH and chloride on K_d values were found to be complex. K_d values increased with pH and was highest under alkaline conditions. Increasing the chloride concentration lowered K_d values at most of the pH values tested. In most cases K_d values increased with increasing pH with the highest values being found under alkaline conditions. The investigation concluded that the potential for mercury to sorb to soils decreases with increasing chloride concentrations.

URS (2008) in their study concluded that sorption coefficients in the shallow, intermediate and deep aquifers south of the PCA are found to be low (K_d likely to be <100 L/g). This implies that only limited retardation of mercury is likely to occur in groundwater to the south west of the FCAP.

Recently (10 July 2013) Grace Campbell Reserve was assessed by JBS&G. 39 soil samples were collected (0.1-0.3 mBGL). Total mercury levels were <0.1 – 0.9 mg/kg in the 39 analysed samples. During field sampling soil samples were screened using a XRF. In all XRF screened samples mercury was non detect.

6.3.2 Surface Water

Sampling in 1990 (AGEE and Woodward Clyde, 1990) found elevated mercury in the estuary and Floodvale Drain. Resampling in 1996 (Woodward Clyde , 1996) did not detect mercury in surface water samples collected from Springvale Drain. This lead to the conclusion that the mercury contamination is not sourced or mobilised via surface water. The occurrence of mercury in the 1990 monitoring event is most likely due to runoff event which resulted in surface water contamination.

Sampling in 1997 (Woodward Clyde, 1997) indicated slightly elevated mercury levels in surface water from Springvale Drain (up to 0.0005 mg/L). Both the FCAP area and Springvale Drain were remediated in 1999 and the majority of the formerly contaminated area was sealed to prevent any transport of contaminated material (soil and water).

6.3.3 Sediment and Biota

6.3.3.1 Springvale Drain

Historically sediment samples were collected from Springvale Drain from 0.15m depth with some cores collected from depth of 0.75 to 1.6m. Prior to remediation, Springvale Drain stratigraphy comprised organic soils, underlain by sand and peat. All sediment samples collected from the drain in 1996 (Woodward Clyde, 1996) from upstream of the ICI site to downstream of the Springvale had mercury detected (up to 220 mg/kg). The concentrations of mercury were higher during sampling in 1996 compared to 1990. Mercury concentrations were also detected in surface sediments in the estuary (1mg/kg to 3mg/kg).

The findings of the report in 1990 (Woodward Clyde, 1990) indicated that the source of mercury on site was the boiler ash and paper waste that was used as fill material, however high mercury concentrations found in the Springvale Drain point out to an additional source. The 1996 Woodward Clyde report suggests that the cause of high mercury in the Springvale Drain sediments in Southlands is wastewater and contaminated water flowing through the Springvale Drain. Depending on characteristics of soils and biogeochemical reactions, relatively insoluble elemental mercury may have accumulated at the soil surface. Peat bands, present in the Springvale Drain, could then have adsorbed the elemental mercury.

Reducing conditions, the high biological oxygen demand and low sulphide concentrations, cause organics to decompose under anaerobic conditions. These conditions may have developed in shallow soils across the site, coupled with fluctuations in redox can cause changing mobility of metals. Investigation of groundwater seepage into the Springvale Drain (Woodward Clyde, 1996) indicates that precipitation of Mercury sulfide is not a possible mechanism for accumulation of Mercury in sediments due to: surface water being oxidised and groundwater that feeds the seeps is more reduced favouring precipitation of Mercury sulfide.

6.3.3.2 Penrhyn Estuary

This section presents available data relevant to the assessment of health risks associated with Penrhyn Estuary. **Appendix K** includes a summary (in chronological order) of all available and relevant data in regards to sediments and biota (plants and animals in an environment) within the Penrhyn Estuary. Some of these plants and animals might be sources of food, clothing, or medicines for people and sediments.

Given the following findings:

- Highest mercury flux to the Penrhyn Estuary was prior to 1958 and decreased significantly subsequently. Since 1958 the shoreline changed dramatically (as can be seen on the attached aerial photos) and historically, the most contaminated sediments are either remediated or contained by the soils above (Caltex Oil Terminal Parking area on Botany Road). It is unclear to what extent contaminated materials were removed/capped/disposed;
- There is a time lag before fish concentrations reflect the decreased discharge to the environment. It appears that the mercury levels in fish (sea mullet and silver biddy samples were available for three sampling rounds) collected between 1993 and 2004 did not improve. However, mercury levels were low on all occasions and in the same order of magnitude as mercury levels in fish caught at other sites around the Bay (SPCC, Toxic Chemicals study 1978). Some concentrations of mercury in benthic invertebrates were relatively high. Further evaluation is required to examine issues of habitat and food webs to evaluate time trends;

- All recorded Mercury levels (1989 – 1998) in fish and shellfish were below the Maximum Permitted Concentration (MPC, 1 mg/kg for mercury), which is similar to a Maximum Residue Limit (MRL), but applies to naturally occurring elements such as metals. The MPC is set for elements such as mercury, lead and cadmium with safety margins so that a provisional tolerable weekly intake is never exceeded. (CDM Smith: it is unknown what type of mercury was analysed for during those assessments. Total mercury or methyl mercury);
- Both 'old' and 'new (1994)' boat ramps (see document 85 and 86) in the Penrhyn Estuary are no longer accessible to the public due to closure of the Penrhyn Road resulting in limited access of the up-stream areas within the Estuary (note that a new boat ramp is now constructed (late 2000s) on Foreshore Road); and
- Sediments that currently settle within the Estuary will potentially form a sort of cap for the historical sediments especially now that disturbance by boat propelled boats has been limited. This however needs to be addressed.

CDM Smith recommends using the historically collected biota and sediment data as a worst-case scenario (assuming all reported mercury in biota is methyl mercury) in the Stage 3 Human Health Risk Assessment for the Residents. The data available from Penrhyn Estuary (biota and sediment) should be completed with additional biota testing for middle trophic species which may obtain a significant portion of their diet from Penrhyn Estuary. Both historical and new data to be included in the Stage 3 - Health Risk Assessment for Public Health Concerns;

In addition to this it would be good practice to collect additional biota and sediment data to confirm the assumption that mercury within biota living within the Penrhyn Estuary have indeed decreased by establishing a trend line. The results of such an assessment could potentially be used to lift the fishing ban (gazetted by the NSW Government in November 2004) in Penrhyn Estuary however other compounds namely hexachlorobenzene and hexachlorobutadiene which have levels reported in biota from the estuary above the guidelines should then be included also. Methyl- mercury should be specifically included in the analyses. Also, CDM Smith suggest evaluation of PCDF in sediments as furans are a characteristic by-product of mercury cell process.

Finally, CDM Smith has observed that Orica collects surface water, pore water and groundwater samples on a quarterly basis from within the Penrhyn estuary. These samples are not being analysed for mercury (methyl mercury and/or total mercury). CDM Smith recommends that, at a minimum the surface water samples be included during a few following rounds representative of various conditions as they will provide an additional line of evidence and will help to alleviate community concerns at minimal effort.

6.3.4 Groundwater

6.3.4.1 Mercury in Groundwater -literature overview

In aquatic systems mercury occurs as Hg (II), Hg (I) and Hg (0). Each of these species behaves differently depending on biogeochemistry. Fate and transport of mercury in groundwater is strongly influenced by oxidation-reduction, precipitation –dissolution, aqueous complexation and adsorption-desorption reactions. Characteristics of soils and biogeochemical reactions are also important for transport of mercury to and within groundwater.

Mercury can enter soils and surface water from atmospheric sources, and can move through soils to groundwater. Relatively insoluble elemental mercury may accumulate at the soil surface or migrate vertically through the soil profile to peat/clay bands and to the sandstone bedrock. Peat bands can adsorb elemental mercury and restrict its vertical migration, the capacity of these bands

to adsorb significant quantities of mercury is unknown. If Hg(II) binds to colloidal solids (< 1um particles formed by clay minerals) its mobility can increase as a result of small and unstable characteristics of colloids.

The mercury mobility in groundwater and soils will be influenced by pH, presence of iron, dissolved organic material and oxidising or reducing conditions which drive dissolution or precipitation of mercury in groundwater as shown by numerous studies (Krabbenhoft and Babiarz, 1992; Barringer et al, 2010). In its elemental form, mercury is not soluble so in order to move through the soil it would need to be oxidised to form a complex. In an oxidizing environment, mercury is predominately present in the redox state Hg (II) and in a reducing environment it is Hg(0). Hg(I) can predominately form complexes with OH- or Cl- (i.e. $Hg(OH)_2$, $Hg(Cl)_2$). At low or high pH, mercury in complex form is present as $HgCl_2$ or $Hg(OH)_2$, respectively (Gabriel and Williamson, 2004; Schuster, 1991). These mercury salts and complexes are highly soluble and mobile, as an example $HgCl_2$ solubility is 69,000 mg/L (Neculita *et al*, 2005).

An important mechanism for sorption and therefore attenuation of mercury is iron geochemistry. Hg(II) has been shown to sorb to pyrite and iron oxides (pH>5.5) (Barringer and Szabo, 2006;Ryuba, 2000), and form hydroxide and chloride complexes, reducing available mercury in groundwater. However, iron complexes can also be dissolved by sulphide, causing the reduction in Fe(III) to Fe(II) and an increase in dissolved mercury (Slowey and Brown, 2007; Barringher and MacLead, 2001).

In general, the reducing conditions for mercury can occur as a result of presence of organic matter, presence of microbes (sulphide or iron reducing bacteria) and other anoxic conditions. These conditions mean an increase in dissolved mercury. Where high dissolved organic matter and high salinity are present, there is no reduction (methylation) of mercury as mercury is found in formed complex and not available to methylating bacteria (Barkay *et al*, 1999; Benoit *et al,* 1999). In these circumstances, the sorption of mercury will limit its concentration in groundwater and its mobility.

Mercury speciation (**Figure 6-4**) below shows that elemental mercury is stable in reducing conditions but under a whole range of pH. Therefore, in deep groundwater where anaerobic conditions and mildly acidic pH prevails, mercury would tend to occur either as elemental or as Mercury sulfide.

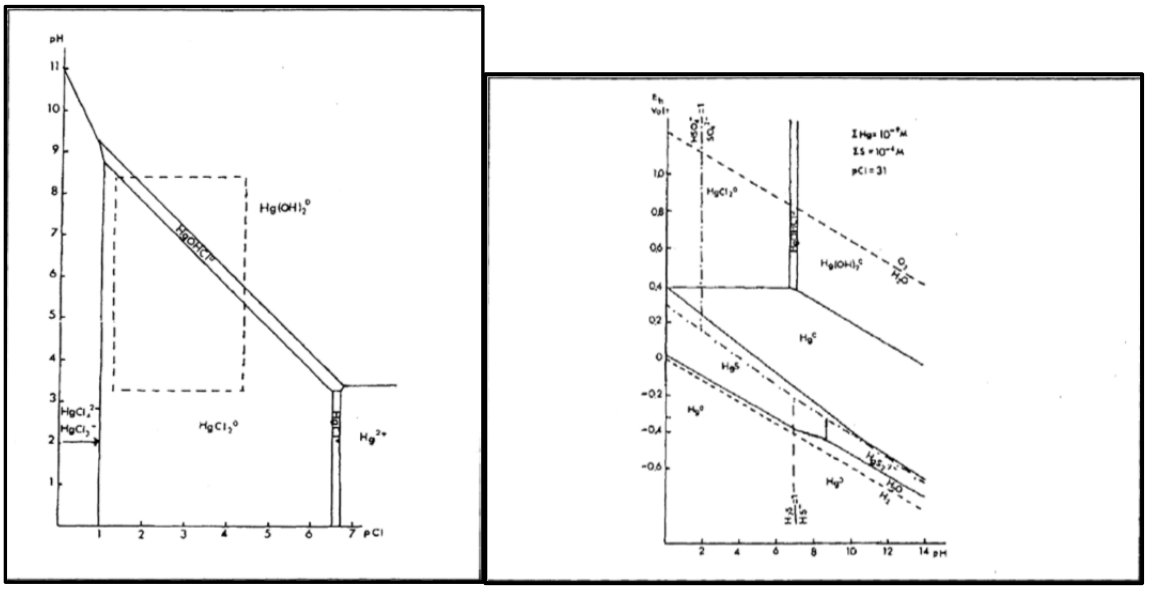


Figure 6-4 Mercury Speciation (Inorganic) pCl, pH and Under Oxidised Conditions and as a Function of pH and Redox, Andersson, 1979

Methylmercury is formed from inorganic mercury by methylation process: the action of anaerobic organisms that live in aquatic systems including lakes, rivers, wetlands, sediments, soils and the open ocean (Ullrich et al, 2001). This process converts inorganic mercury to methylmercury in the natural environment, with the formation of methylmercury species increased at lower pH and higher mercury concentrations. It is also the dominant species formed when mercury is desorbed from surfaces. Historically methylmercury was produced directly and indirectly as part of several industrial processes such as the burning of wastes containing inorganic mercury and from the burning of fossil fuels, particularly coal (Barriner et al, 2013).

6.3.4.2 Mercury fate and transport – on and offsite

The results of groundwater quality sampling, geochemical modelling (URS, 2008; URS, 2010; Laase, 2010) and literature review lead to the following understanding of the fate and transport of mercury in the FCAP area and offsite (**Figure 6-5** and **Figure 6-6**:

- The density of elemental mercury was the driving force for vertical migration within aquifer over FCAP area, since it is 13.5 times greater than that of water;
- Over the FCAP area the high density of elemental mercury and presence of brines historically may have resulted in the preferential downward migration as opposed to lateral movement. This can be seen in dissolved, elemental, and total mercury concentrations in intermediate and deep units;
- The transport of elemental mercury occurs via preferential pathways (i.e. low entry-pressure, high hydraulic conductivity) and has a high tendency to continue migration due to its high density. Once a low permeability material such as clay lens is encountered, mercury will tend to flow over the lens rather than infiltrating low permeability layer. The horizontal flow along the impermeable layer might enhance flow of elemental mercury as it can continue horizontal spreading until it finds a discontinuity in lens, fracture or other pathway. This is significant across Orica site where peat and clay layers are discontinuous;

- The vertical downward flow in the FCAP area is controlled by high salinity in the intermediate unit where an upward hydraulic gradient exists. This provides possible restriction to mercury transport to deeper units;
- Chloride concentrations and Cl/Br ratio indicate that mercury mobility is in most cases associated with brines;
- Dissolution of disseminated elemental mercury or desorption and demethylation of mercury may be a source of dissolved mercury. This is the likely scenario in the shallow unit where elevated mercury concentrations are present along with lower groundwater salinity;
- Over the immediate FCAP area the dominant mercury species in all hydrostratigraphic units is Hg (I). Dissolved mercury sorption to clays and colloid particles in groundwater occurs as a result of presence of Hg(I). The sorption hypothesis is confirmed by the presence of higher concentrations of total mercury relative to the sum of speciated mercury. However, in the downgradient areas of the plume $HgCl_3$ dominates;
- Higher methylmercury concentrations and methylmercury to dissolved mercury ratios in the source zone are consistent with increased sorption in some areas;
- In highly reducing or organic rich groundwater zones, methylmercury might be degraded as indicated by inverse relationships between methylmercury and DOC or methane;
- The FCAP area continues to behave as the source for the dissolved mercury notwithstanding change in salinity and the concentrations of total mercury, methylmercury and elemental mercury remain elevated;
- The extent of brine in the south-westerly direction offsite in shallow and intermediate unit is not necessarily linked to transport of mercury downgradient. However the transport of mercury offsite appears to be more related to freshwater flow along the preferential flowpath;
- Downgradient and offsite the $HgCl_3$ has the potential for sorption onto soils and the subsequent formation of methylmercury during desorption. However, the sorption onto clays is less likely than with dominant Hg(I) in the source zone;
- The presence of continuous mercury source in the FCAP area has minor impact on migration of mercury downgradient. Overall transport of mercury offsite in groundwater is limited as confirmed by the elemental mercury concentrations downgradient of FCAP site and significant sorption of mercury species;
- Freshwater contribution to the intermediate unit and pumping at the PCA (since 2005) are likely to prevent ongoing migration of mercury plume downgradient; and
- Increased dissolved organic carbon levels reduce methylation of mercury in the water column, possibly as a result of the binding of free mercury ions to the DOC at low pH, thus reducing their availability for methylation.

It must be noted that this fate and transport model (**Figure 6-5**) does not take into consideration the results of remediation activities such as surface sealing and onsite containment and capping and construction of containment wall at Block G as proposed in Golder (2012). These measures will be undertaken with the objection to reduce the impact of groundwater by changing the groundwater chemistry and influencing the mobility of mercury.

A groundwater transport model was developed for Orica Botany site in 2010 to assess mercury migration in groundwater in the vicinity of the FCAP. The MT3D transport model aimed to

calibrate the observed 2009 mercury plume, but it did not include degradation (precipitation and irreversible sorption) of dissolved mercury as it claims that these processes were not identified in recent studies (Laase, 2010). The particle tracking in the model (Laase, 2005) represents the water flow and not the dissolved mercury. The dissolved mercury is significantly retarded relative to groundwater flow and the presence of dissolved mercury in downgradient wells to the east has been attributed to historical pumping which may have altered the groundwater flow direction and therefore mercury concentrations. The model tries to explain the dissolved mercury concentrations by mainly adjusting the historical pumping and using partition coefficient. The partition coefficient (indicating migration potential of contaminants present in aqueous solutions in contact with surface, subsurface and suspended solids) is considered to be primarily a function of salinity therefore mercury transport is closely linked to this parameter (Laase, 2010). The study used partition coefficient to estimate the retardation factor based on pH value (pH=6) and chloride concentration. The model also assumed that mercury concentrations increased over time, which may not be entirely correct as shown in URS 2008 study. Sensitivity to partition coefficient has shown that plume migration remains the same, however the transport velocity changes.

Mercury concentrations and migration offsite to Southlands area are predicted by the model (Laase, 2010) to decrease due to dispersion, and interception by PCA system.

URS (2010) report indicates that total mercury concentrations in the 2009 monitoring round were higher than sum of mercury species in shallow wells indicating that mercury is associated with the solid phase, potentially through sorption or precipitation of solids such as mercury sulphides on aquifer solids. Geochemical modelling has shown that Hg (I) is the dominant mercury species in groundwater, except in the new well located to the southwest of the site where $HgCl_3$ is dominant species (influenced by high salinity). In the southwest of the FCAP area (new wells), mercury is understood to be influenced by sorption and associated with aquifer solids. Based on previous sorption testing, it has been concluded that retardation is not likely to occur in groundwater in the southwest of the FCAP. Aqueous species of mercury dominant in all aquifers that were monitored (based on pH and Eh conditions), therefore Mercury-sulfide species are unlikely to be stable in groundwater, precipitate and remove mercury from the system.

Based on previous modelling (URS, 2008) and the measured pH (around 8) of groundwater from the southwest of the FCAP, there is the potential for increased sorption to occur in the deeper unit and limited potential for sorption in shallow and intermediate units where groundwater is highly alkaline.

Brine and mercury plumes have extended to the south of PCA in the shallow, intermediate and to a lesser degree in the deep aquifer. PCE system appears to be causing a decrease in mercury concentration in some wells and changing the direction of the brine and mercury plume.

In order to confirm the accuracy of the fate and transport model for mercury and provide early warning for any changes in mercury concentration, it is important to continue the groundwater monitoring regime as per Groundwater Management Plan (Golder, 2012).

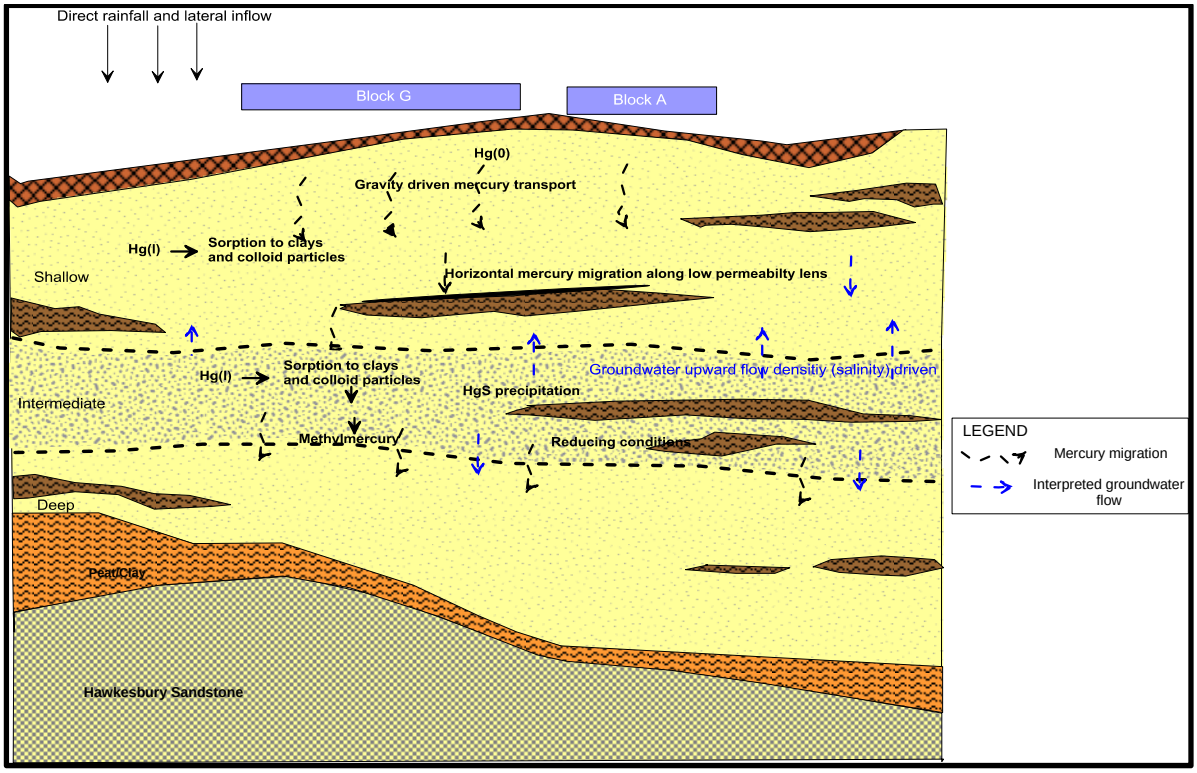


Figure 6-5 Conceptual Mercury Fate and Transport Model -Northwest -Southeast Cross Section Immediately Downgradient of FCAP area (Adapted After URS 2008)

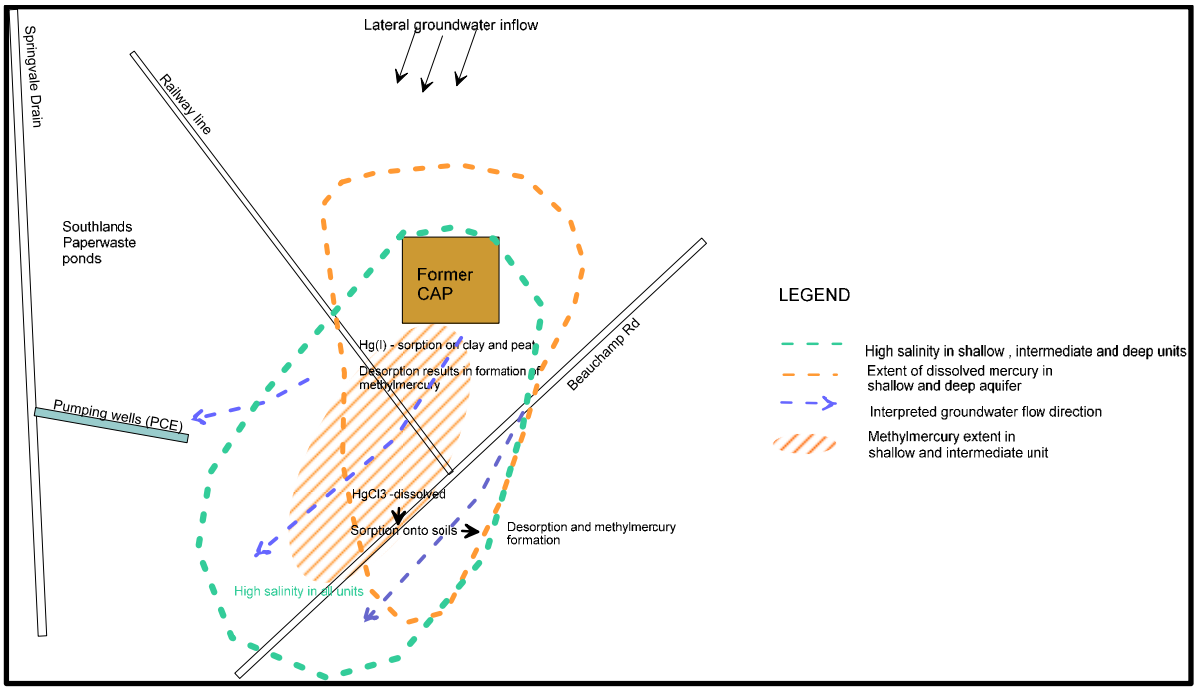


Figure 6-6 Conceptual Model of Mercury Fate and Transport (Adapted from URS (2008)

6.3.4.3 Conceptual geochemical model

Based on the modelling work and groundwater quality results from 2008 , the main components of geochemical conceptual groundwater model (URS, 2008) are:

- General groundwater flow direction is in to the southwest towards the Botany Bay;
- Vertical groundwater gradients are downward from intermediate to deep unit within the FCAP area; however they are upward between the intermediate and shallow units. The upward gradients are due to density difference between these two units. These conditions are present downgradient of the FCAP area, however the cause may be a combination of brine migration and seawater intrusion closer to the Bay. Cl/Br ratios confirm this hypothesis;
- A freshwater input to the shallow unit occurs via direct rainfall recharge and laterally from upgradient areas. There is limited connection with deeper units due to density differences. A shift to lower EC values in the intermediate aquifer is considered to be a result of operation of pumping system on site;
- Mercury species in groundwater in the vicinity of the FCAP are controlled by redox conditions, and chloride and mercury concentrations and to a minor extent by pH;
- Dominant modelled mercury species in groundwater from all three aquifers in the immediate vicinity of the FCAP is Hg(I); and elsewhere across the site it is $HgCl_3$;
- The change in EC values across the site can have an impact to mercury speciation, with the formation of Hg (II) resulting in an increase in sorption to soils. The formation of these mercury species occurs in the environments where lower EC values are accompanied by higher bicarbonate than chloride; and
- Mobility of mercury in the aquifer was found to be (URS,2008) significantly affected by both pH and chloride concentrations whereby an increase in chloride concentrations lowers the sorption. When modelled chloride concentrations were fixed, sorption capacity increased with pH and was highest under moderately alkaline conditions. Less sorption was found to be occurring in more alkaline environments and the potential for mercury to sorb to soils decreases with increasing chloride concentrations.

The disadvantage of the geochemical model is that it does not consider the presence of secondary mercury sources. Secondary mercury sources are disposal or dumping locations, or soil that may release mercury to groundwater and surface water and these in general have not resulted in major increase in mercury concentrations on site. Those have been considered but are of less importance as the concentrations are low, and some of these areas (such as Springvale Drain and Southlands) have been rehabilitated, therefore the secondary source has been removed at these locations.

6.3.5 Air

Typically, mercury is released into the atmosphere in one of three forms:

- Elemental mercury: can travel a range of distances, may remain in the atmosphere up to one year and may travel globally before undergoing transformation;
- Particle-bound mercury: can fall out of the air over a range of distances; and
- Oxidized mercury (sometimes called ionic or reactive gaseous mercury (RGM)): found predominantly in water-soluble forms, which may be deposited at a range of distances from sources depending on a variety of factors including topographic and meteorologic conditions downwind of a source.

In one of their most recent reports, the UNEP commented that one of the largest sources of uncertainty in mercury models is the chemical mechanism used to determine how mercury

changes forms in the air. Improved experimental data can help improve model performance by making sure that the right reactions are simulated. The processes that lead from deposition to re-emission also need to be understood better. Advances in this area show promise, with model results becoming closer to estimates based on experimental data

6.4 Community Exposure

It is important to note that mercury is ubiquitous in the environment, and that all of us are exposed to background levels of mercury present in air, soil, and food (particularly if people ingest certain species of fish). As a localized source of mercury emissions, the Orica facility may have led to mercury exposures above and beyond background concentrations.

In particular, the Orica Botany plant released mercury to air, soil, surface water and groundwater at and near the industrial park. People working, living, or recreating at or near the plant may have contacted mercury associated with historical plant operations. Contact with mercury has been evaluated to a limited extent, with a focus on mercury contamination in groundwater beneath the industrial park, soil contamination within the industrial park, and an examination of contamination with organic chemicals found in a bore at Mutch Park. Water from the Mutch Park bore was used in the past for irrigation, but such use has been discontinued. These assessments have attempted to identify and delineate contamination outside of residential areas, and have not been designed to address concerns about releases of mercury into residential communities adjacent the FCAP.

In contrast, this report is the result of a review process designed to gather information on mercury releases to the community and, as much as possible, use this information to address community concerns about mercury in their environment. As data relevant for this assessment are at present limited, the Conceptual Site Model (CSM; presented above) outlines conceivable ways in which mercury was or may have been released from the FCAP and means by which this mercury may have entered communities near the plant. To extend the CSM to a Conceptual Exposure Model (CEM), ways in which people in adjacent communities might have taken mercury into their bodies are discussed below. At this time, information is not sufficient to provide quantitative estimates of possible impacts from mercury. Thus, the discussion below sets the stage for identifying gaps in our knowledge of the plant and its historical operations, and of the industrial park and surrounding communities. The discussion is illustrated graphically in Figure 6-7 at the end of this Section.

6.4.1 Exposure Media

Exposure Media may include any or all of air, soil, groundwater, surface water, sediment, and food items. Exposure (uptake of mercury into the body) can take place via contact with any or all of these media.

As explained above, mercury was, or may have been, released in a variety of ways.

- Fugitive and vent emissions to ambient (that is, outdoor) air;
- Discharge to sewers, storm drains and/or surface waters;
- Disposal of mercury cell sludge;
- Leaks of brine, sludge, mercury or manufactured products; and
- Direct discharge of brine, sludge, mercury or manufactured products.

All of these release mechanisms are illustrated on the left side of **Figure 6-7**. In the centre of this figure, one can trace these releases to media that people may contact.

Mercury vapours in fugitive and vent emissions would have been carried by winds toward residential areas some of the time. During these time periods, determined by the direction of winds, the air in nearby communities would have contained elevated levels of mercury. Thus, air in the community is an exposure medium that was historically affected by emissions from the FCAP.

Mercury might also have been released to air and carried into nearby communities in wind-blown dust from contaminated soils in the industrial park. The current potential for fugitive dust emissions is limited by paved and covered surfaces, though more open areas may have existed in the past. To travel outside of the industrial park, any re-suspended dust would likely have been dominated by small particles likely to remain in air for extended distances. Both wind speed and wind direction would influence if and how much mercury may have found its way into the community by this mechanism, as well as the prevalence of open land, soil disturbance, and industrial activities that generate dust. Of note, it is possible that such mercury emissions may have continued for some time after mercury cell process closure as both mercury vapour and mercury in dust. Residual soil contamination may have continued to be a source for dispersion of mercury in air into nearby communities. While one would expect such emissions to be small, compared to emissions during plant operations, they may still be relevant to the investigation of mercury impacts in nearby communities.

Discharge of wastes from the plant to sewers would enter the treatment process at the waste water treatment facilities both onsite and offsite. Some chemicals from the plant could be present in processed sewage, but it seems unlikely that the community at large would contact residuals following treatment. Discharge to sewers does not appear to result in an opportunity for exposure for the community.

Discharge of plant wastes to storm drains and/or directly to surface water (e.g., Springvale Drain that flows into Penhryn Estuary) might both lead to contamination of sediments in the estuary and in Botany Bay near the point(s) of discharge. Sediments might be an exposure medium if members of the community recreate in areas where sediments are contaminated. Typically mercury levels in surface water are too low to be an issue for human health. At this time, surface water is considered more as a way that mercury could be transported from the site than as an exposure medium. However, information on surface water concentrations is sparse and this lack of information is further addressed in the data gaps section of this report.

Disposal practices, leaks and spills and/or dumping, if such occurred, have apparently led to contamination of soils at the plant site and in surrounding industrial properties. For residents, soil on the plant site is not likely to be an exposure medium. However, as noted above, onsite soils could have been and may still be a source of mercury to air. In addition, mercury in soil has migrated to shallow groundwater beneath the site, and subsequently has migrated downgradient in groundwater. This contaminated groundwater is not currently used for any purpose, and certainly not as a potable water source for nearby residents. The area is in fact situated in a groundwater extraction exclusion zone. Direct contact with groundwater at the site is unlikely and groundwater is not considered an exposure medium.

To date, investigation of groundwater has not substantiated that a release of mercury to the estuary or bay has occurred. The shallow groundwater gradient and poor mobility of mercury suggest that the transport of mercury from onsite soil to surface water via groundwater is inefficient, at best. Groundwater is therefore not, at this time, considered a source of mercury to either sediments or surface water.

Three other exposure media were identified during the review of historical records and understanding of the community and environment surrounding the plant.

First, as noted above, mercury in air can deposit onto soils, and soil in residential yards is also considered an exposure medium. Over time, mercury might have built up and resulted in mercury levels above background in residential yards.

Second, mercury in soils may be taken up by fruits and vegetables grown in home gardens, and also may deposit directly to vegetation (if present in appropriate chemical forms). This home grown produce is also considered an exposure medium.

Third, mercury, if released to sediments, may be transformed by bacteria in sediments and water into methylmercury, which, as noted in the following section, can accumulate up the food chain into shellfish, fish and marine mammals. Consumption of shellfish and fish taken from contaminated areas my thus be a source of exposure to mercury.

6.4.2 Contact with Exposure Media

Community residents may contact mercury in exposure media in one or more of three ways – inhalation (breathing in mercury), ingestion (consuming/eating media containing mercury) and/or dermal contact (absorbing mercury through the skin). These three "routes of exposure" are discussed below and are illustrated on the right side of **Figure 6-7**.

Air may have been, and may still be, the most significant exposure medium for community residents. Inhalation of air containing mercury results in absorption of mercury across the lungs and into the body. Inhalation of dusts and aerosols containing mercury and/or inhalation of mercury vapours from residual soil contamination may also have added to historical exposure and could, possibly, be an ongoing source of exposure in the community. Inhalation is considered a primary route of exposure for residents.

Ingestion of mercury might have occurred in one of three ways. Children playing in yards where soil is contaminated will typically have some soil stick to their fingers and hands. Hand-to-mouth activity may then lead to swallowing small amounts of contaminated soil. Adults may not ingest as much soil as young children, but some incidental ingestion of soil may still occur. A common example is a gardener who smokes and transfers soil from hands to the cigarette. The two other ingestion exposures involve eating home grown produce that has taken up mercury from soil and eating shellfish and/or fish that may be contaminated with methylmercury. The importance of ingestion of mercury originating from the FCAP is difficult to judge at this time due to lack of information. Ingestion (e.g. via home grown products such as root vegetables and backyard chicken(eggs)) is possibly an important historical and, perhaps, ongoing source of exposure. This issue is further discussed in the subsequent section on data gaps.

Uptake of mercury through the skin (dermal uptake) might occur if either elemental mercury or methylmercury was present in soils, sediments or surface water in locations where substantial amounts of soil or sediment might stick to the skin or where skin may contact surface water for an extended period (e.g., during swimming/wading). Dermal uptake is likely not as important a route of exposure as either inhalation or ingestion, but cannot be eliminated from consideration at this stage of the investigation.

6.4.3 People Exposed

People exposed to mercury at or near the FCAP may include a variety of populations, including former and current workers at the industrial park, people who trespass in the industrial park,

people who work in the community, but outside of the industrial park, adult and child residents in adjacent communities, and people recreating in the estuary and/or bay, including anglers who may take and eat shellfish and/or fish. Not all of these people, termed "receptors", are included in the conceptual exposure model (Figure 6-7). In particular, Orica workers will not be evaluated as part of this project. On the far right hand side of the figure, a subset of receptors is identified. Evaluation of these receptors is considered adequate to address community concerns. Cases that are not specifically considered can typically be evaluated through comparison to exposure evaluation for other receptors. For example, exposure received by children visiting the community sporadically can be evaluated through comparison with exposures for child residents.

6.4.3.1 Residents

People living near the FCAP may have been exposed to mercury over years to decades. Thus, adult residents are considered receptors in the CEM. Pregnant women are considered as a special category of adults to focus on potential neonatal exposures. In addition, young children are considered separately in the CEM for exposure via ingestion and dermal contact. Children have lower body weights than adults, ingest larger amounts of soil by hand-to-mouth behaviours, and are likely to have more intimate contact with soil during play. Since mercury releases may have changed over time in response to practices at the facility, the assessment of risk may require addressing exposure over a series of time periods between 1945 and 2002.

Further, residents may inhale mercury in different locations - at their homes, possibly at work at local businesses, at local schools, and recreating in local parks and/or at the estuary and bay. Depending on amounts of mercury released to air, prevailing winds and locations of homes, businesses and recreational areas, exposures for resident receptors might have varied considerably over time. Several scenarios for mercury exposure may be needed to fully assess historical exposures and risks. Additional information and data will need to be collected to determine how historical and, possibly, ongoing exposure should be evaluated. Such information may include estimates of mercury releases for different time periods, meteorological data from nearby airports, land use maps of the communities (schools, commercial areas, low and high density residential areas, and parks and recreation areas), aerial photography depicting development in the area over the operational time period of the Orica plant.

6.4.3.2 Recreational Visitors

People who recreate in parks, schools, the estuary and/or bay or other areas near the plant may have inhaled mercury above background concentrations in the past and, perhaps, currently. Initially, recreational visitors are considered receptors, but will not be quantitatively evaluated for mercury exposure. Instead, the most heavily exposed visitors will be assumed to be local residents. People who visited or still visit the site from outside the direct influence of historical plant mercury emissions should have had or should currently have less exposure than residents. Thus, if residential exposures are below thresholds that are considered safe, then visitor exposures would also have been low. As discussed under data gaps, additional information and data are needed to determine the full scope of any assessment of health impacts.

6.4.3.3 Recreational Fishers

One exception for recreational visitors is for people who take and consume shellfish and fish from the estuary and/or bay. Exposure to mercury taken up into shellfish and fish could be significant depending on how widespread mercury contamination is in sediments, and how efficiently mercury is transformed into methylmercury. People individually visit the site and consume seafood taken from near the site are considered a separate group of receptors.

6.4.4 Summary

The initial analysis of possible exposure to mercury released from the FCAP identified several exposure media, routes of exposure, and receptors. This information is summarised below and depicted graphically in **Figure 6-7**.

- Exposure Media:
  - Outdoor (ambient) air;
  - Residential soil;
  - Home-grown produce;
  - Sediment in Penhryn Estuary and Botany Bay;
  - Shellfish and fish from Penhryn Estuary and Botany Bay;
- Routes of Exposure;
  - Inhalation of mercury vapours and mercury-containing dust and aerosols;
  - Ingestion of mercury-containing soil, home-grown produce, sediment and seafood;
  - Dermal contact with mercury-containing soil and sediment;
- Receptors;
  - Residents (Adult);
  - Residents (Child); and
  - Recreational Visitors (anglers).

Additional exposure media (e.g. surface water) and receptors (e.g. workers in the industrial that were/are also residents in adjacent communities) may be added to this list as additional information becomes available.

Figure 6-7 Preliminary Conceptual Site Exposure Model Orica ICI Chlor-Alkali Plant Sydney, Australia

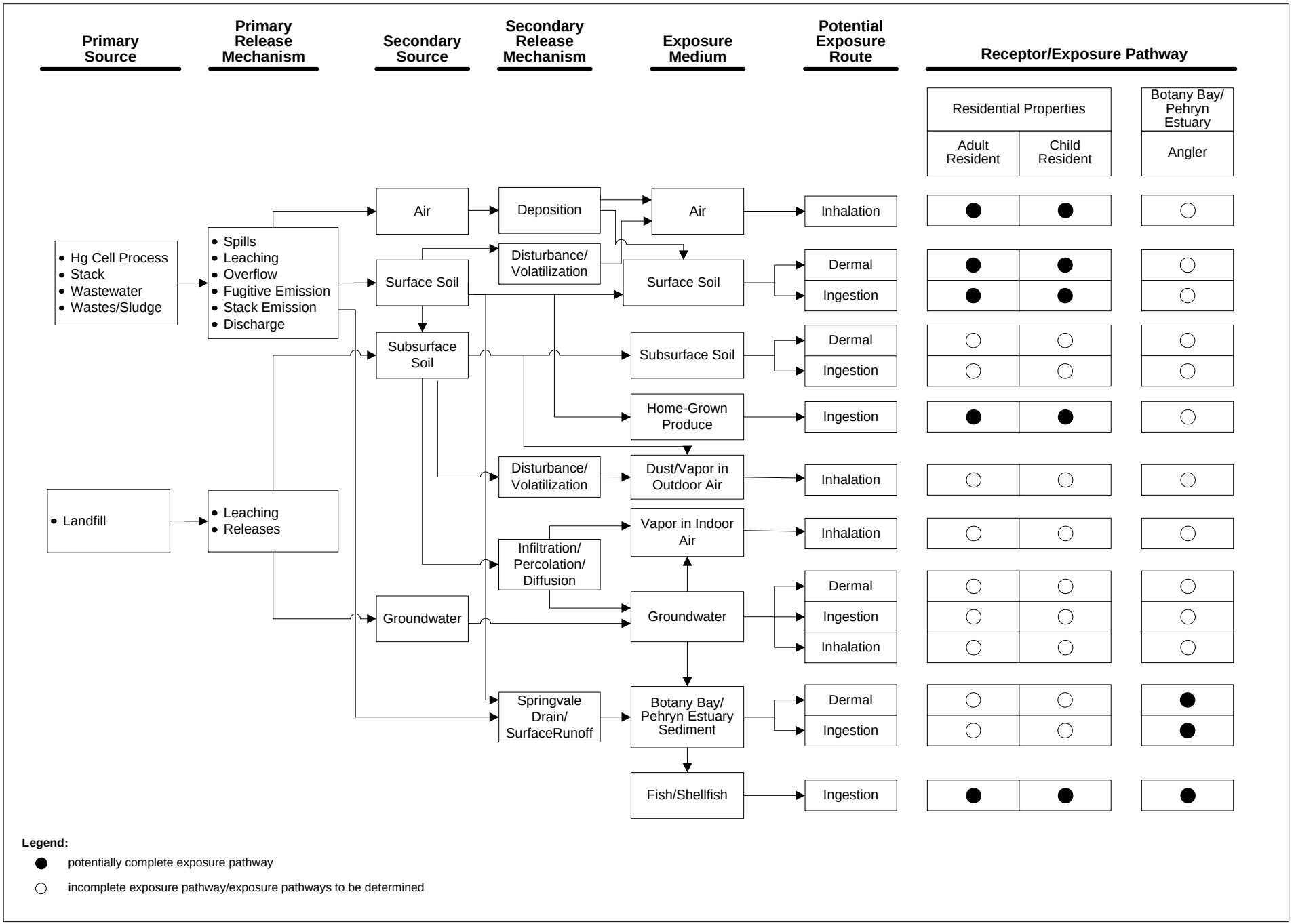


Figure 6-7
Preliminary Conceptual Site Exposure Model
Orica ICI Chlor-Alkali Plant
Sydney, Australia

Section 7 Mercury Toxicology and Environmental Exposure

Members of the community have requested information about the health effects of mercury. This information is also critical to this report, since it forms the basis for health-based investigation levels (in Australia the correct terminology is Health Investigation Levels (HILs) whereas US guidelines refer to "screening" levels or values. Screening levels and HILs have the same purpose as their provide a Tier 1 level and should be compared with actual or estimated levels of mercury in air, soil, sediment, and other media at and near the FCAP. Exceedance of a Tier 1 criteria often requires further (site specific) risk assessment.

A very brief summary of mercury toxicology follows. Following this review, a discussion of Tier 1 criteria in various media is presented. A detailed review of mercury toxicology has been undertaken by Clarkson and Magos (2006). A copy of this report can be obtained from CDM Smith directly.

Whether and how mercury harms people's health depends on (1) the chemical form of mercury, and (2) how much mercury a person inhales, ingests, and/or absorbs through his or her skin.

Chlorine and caustic soda production at the Orica Botany Industrial Park facility from 1945 through 2002 used a process that involved mercury. This Chlor-Alkali process used mercury in the form of elemental mercury, which is the silvery liquid form of the metal (chemically, Hg^0). Elemental metal is relatively volatile — that is some of the metal evaporates into the air as mercury vapours at ambient temperatures. Mercury vapours released to factory air would have entered the surrounding neighbourhood through roof vents and by other means.

Inhalation of mercury vapours at and above certain threshold concentrations can adversely affect the kidney and the nervous system. In particular, chronic inhalation of air that contains elemental mercury at concentrations on the order of 500 micrograms per cubic metre (500 $\mu g/m^3$) can result in compromised kidney function, tremors, and/or peripheral nerve damage (Peripheral nerves are nerves that are outside of the brain and spinal cord, and serve the arms, legs, and rest of the body). Long-term exposures to even higher concentrations of mercury vapour (concentrations that are seldom if ever achieved in outdoor air) can damage the brain, leading to psychological changes. A well know example of this toxicity occurred in people working in factories that made felt hats. The process involved use of elemental mercury. Since work occurred indoors, mercury vapours built up to high levels – levels high enough to affect the central nervous system.

To protect against the adverse effects of exposure to elemental mercury in air, health scientists recommend that workers (with one exception, as discussed below) not be exposed to more than 25 micrograms of mercury per cubic meter of air ($\mu g/m^3$) on a chronic basis (meaning 8 hours per day, 5 days per week, for a working lifetime; ACGIH, 2001). Twenty-five micrograms of mercury is the equivalent of about 2 millionths of a cubic centimetre (cc) of liquid mercury metal.

Studies of pregnant laboratory animals suggest that high-level exposures to elemental mercury in air can adversely affect the brain of the developing fetus. However, because most people who have been overexposed to mercury in the workplace have been men, whether (and if so, how) high levels of elemental mercury in air might adversely affect human fetuses is not known. Nonetheless, based on the laboratory animal evidence, it is recommended that women of childbearing age not be exposed occupationally to air that contains more than 10 $\mu g/m^3$ of elemental mercury (Koos and Longo, 1976).

Workplace exposures aside, the form of mercury of greatest toxicological significance is not elemental mercury, but is instead an organic form of mercury known as methyl mercury. This is the form of mercury that can be present in relatively high concentrations in predatory fish and marine mammals (it bioaccumulates up the aqueous food chain. Bioaccumulation occurs when chemicals, such as methyl mercury, are taken up by plants and animals at rates greater than the rates by which they are transformed and/or excreted. When these plants and animals are eaten by animals farther up the food chain (up through and including humans), bioaccumulative chemicals are further concentrated), and it is the reason that women of child-bearing age are advised to limit their consumption of species such as sharks, swordfish, dolphins, and whales.

Finally, those of us with silver-mercury dental fillings are exposed to several micrograms per day of elemental mercury vapour from "off-gassing" of those fillings (Halbach, 1995). There is no reliable evidence that exposures of this magnitude harm health. As noted by the U.S. Food and Drug Administration (2009), ". . . mercury exposure from dental amalgam is not believed by USPHS [U.S. Public Health Service] and WHO [the World Health Organization] to represent levels associated with adverse health effects in humans, including sensitive populations."

Mercury is a natural and ubiquitous substance, so that all of us inhale and/or ingest small amounts of mercury daily. It is not possible to prove that these "background" exposures are unequivocally safe. However, the mechanisms by which mercury acts — and the ability of other ubiquitous substances, such as selenium, to counteract mercury toxicity —suggest that our daily background exposures to mercury are not harmful. Additional investigation and modelling studies will help determine whether people's potential additional exposures from living near the Orica Botany facility may have reached levels of concern.

7.1.1 Mercury in Outdoor (Ambient) Air

The effects of long-term exposure to mercury vapours in air have been examined by occupational and environmental toxicologists at many regulatory agencies around the world. These agencies have developed investigation/screening levels designed to protect residents in their communities, including people, such as pregnant women, who deserve extra protection because of the vulnerability of the developing nervous system of the foetus to the potentially adverse effects of mercury.

As shown below (**Table 7-1**) different agencies have developed somewhat different Tier 1 levels for mercury in ambient air. These levels are based on the same series of health studies, and differ primarily on the number and magnitude of "safety factors" chosen by each agency. Despite the large literature available on mercury toxicology, reasonable scientists disagree on the degree of confidence that can be placed in available information.

Table 7-1 Screening Levels for Mercury in Ambient Air, for the protection of the general public (including pregnant women)

Agency	Tier 1 (Screening) Level	Comments
California EPA[1]	0.03 µg/m^3	Long-term exposure. Worker study. Subtle central nervous system effects and developmental considerations. Safety factor of 300. (2008)
ATSDR[2]	0.2 µg /m^3	Long-term exposure. Worker study. Subtle central nervous system effects. Safety factor of 100. (1999)
WHO[4]	0.2 µg /m^3	Long-term exposure for elemental mercury. (2007)
US EPA[3]	0.3 µg /m^3	Long-term exposure. Worker study. Subtle central nervous system effects. Safety factor of 30. (1995)
WHO[4]	1 µg /m^3	Long-term exposure for inorganic mercury. Worker study. Subtle central nervous system effects. Safety factor of 20. (2000)

1) Office of Environmental Health Hazard Assessment (OEHHA) – chronic Reference Exposure Limit (REL)
2) Agency for Toxic Substances and Disease Registry – long-term Minimal Risk Level (MRL)
3) United States Environmental Protection Agency – Regional Screening Level (RSL)
4) World Health Organization – Air Quality Guideline

Below CDM Smith has summarized additional relevant information regarding mercury in ambient air:

- Orica's POEO licence 2148 (http://www.epa.nsw.gov.au/prpoeoapp/ViewPOEOLicence.aspx?DOCID=33268&SYSUID=1&LICID=2148) condition E2.12.6 states that "*if any measured 24 hour average mercury level at EPA point 39, 43 or 44 is greater than or equal to 1 µg/m^3 but less than 4 µg/m^3, then the licensee must….*";

- When referring to the Ambient Air Quality Research Project (1996-2001), Internal working paper no. 4 ambient air concentrations of heavy metals in NSW (http://www.environment.nsw.gov.au/resources/air/heavymetals.pdf) were measured. Mercury was included in the study however it couldn't be analysed by the method used. The paper has a table (table 7) presenting internationally recognised goals. These were sourced from European Commission, the WHO and the US EPA however no preferred sequence was given;

- In the National Air Toxics Tier 2 Prioritisation Methodology (June 2006) mercury is prioritised as pollutant 24 in NSW (e.g. benzene is number one). The purpose of the developed methodology was to identify priority pollutants in ambient air that are of national significance in terms of exposure and that may pose a risk to human health (emphasis on public not occupational). Hazardous identification score for mercury was 17.5% and exposure estimation was 17% resulting in an overall total score of 5% ranking mercury as pollutant number 28 on the national list (compare this to benzene (ranked number one) with an overall total score of 61%);

- A threshold approach for inorganic mercury and methyl mercury is considered appropriate in the NEPM1999 as amended in 2013 for the Assessment of Site Contamination (soil guidelines);

- The "*Methodology for setting air quality standards in Australia*, Part A, February 2011" (http://www.scew.gov.au/system/files/resources/458719dc-73eb-4cfd-a688-a36b32e80f6c/files/methodology-air-quality-standards-australia-parta.pdf) was developed to provide an overall framework for setting air quality standards in Australia. The methodology provide the level of health protection to be built into standards uncertainty factors (or 'safety factors'). In section 5.6 of this methodology it is stated that historically a default uncertainty

factor of 100 (product of interspecies differences (factor 10) and human variability uncertainty (factor 10)) was used.

All of the Tier 1 values in Table 7-1 will be considered as the risk assessment for the community is developed. However CDM Smith's preferred Tier 1 risk assessment criteria would be the WHO and ATSDR levels (0.2 µg/m3) as these were provided by the (globally) most recognised agencies..

The levels in **Table 7-1** were used in an initial evaluation of possible historical releases of mercury vapour from the cell building at Orica. This evaluation used air dispersion modelling (described in **Appendix L**) to estimate a range of possible concentrations of mercury in air at different distances from the plant. The modelling is not designed to estimate present mercury vapour concentrations in the community as it considers releases associated with the operational period of the Orica facility. It was developed solely to provide an early indication of whether mercury levels in the community could have historically exceeded any or all of the Tier 1 criteria in **Table 7-1**.

The following limitations and assumptions should be read in conjunction with the screening model:

- AERMOD and AERSCREEN are currently listed as the preferred models in the United States Environmental Protection Agency's;
- The screening model used provide "worst-case" 1-hour concentrations (i.e., higher concentrations than would be obtained using arefined model) without the need to provide actual, hourly meteorological data;
- Not site specific but mostly default values were used for most input parameters;
- Worst case stack and fugitive emission rates were used (plant operating at maximum capacity and maximum emission rates). The worst case scenario is only applicable for the period 1965 to 1979;
- Output from AERSCREEN calculations are not estimates of levels of mercury that may have existed in any locations within the community. These "worst case" estimates only provide justification for additional analysis, using more site-specific data and full dispersion modeling. Such modeling will use local meteorological data, refined emissions information and comparisons with similar chlor-alkali plants elsewhere in the world.

Where screening modelling suggests some possibility of exceeding Tier 1 (screening) levels, additional effort is needed to provide refined, site-specific estimates of historic mercury vapour concentrations.

In fact, the screening modelling does indicate that such additional effort would be required. Preliminary "worst case" estimates of mercury levels were somewhat higher than Tier 1 (screening) levels (**Figure 7-1**). In Stage 2 of the project, more sophisticated modelling is recommended based on the use of site-specific (or nearby) weather data to provide more confident estimates of historical mercury levels in the community. The dispersion models recommended in NSW DEC 2005 "*Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales August 2005"* are AUSPLUME, CALPUFF, and The Air Pollution Model (TAPM). AUSPLUME v. 6.0 is a steady-state Gaussian plume model that is based on the Victorian EPA's Plume Calculation Procedure, which is an extension of the ISCST3 model developed by the U.S. EPA. CALPUFF is a non-steady-state Gaussian puff model that simulates the effects of time- and space-varying meteorological conditions. TAPM is to be used in areas where meteorological data is limited or non-existent. Because of coastal effects (sea breeze

and changing wind directions), the CALPUFF model should also be considered for Stage 2 however this model is typically suited for impacts occurring over 50 kilometres from the facility. Because the algorithms in AUSPLUME are over 30 years old, AERMOD would be recommended in lieu of AUSPLUME. Note that EPA Victoria, which developed AUSPLUME, requires the use of AERMOD as of January 1, 2014. Therefore, AERMOD will be the recommended refined model to use during Stage 2.

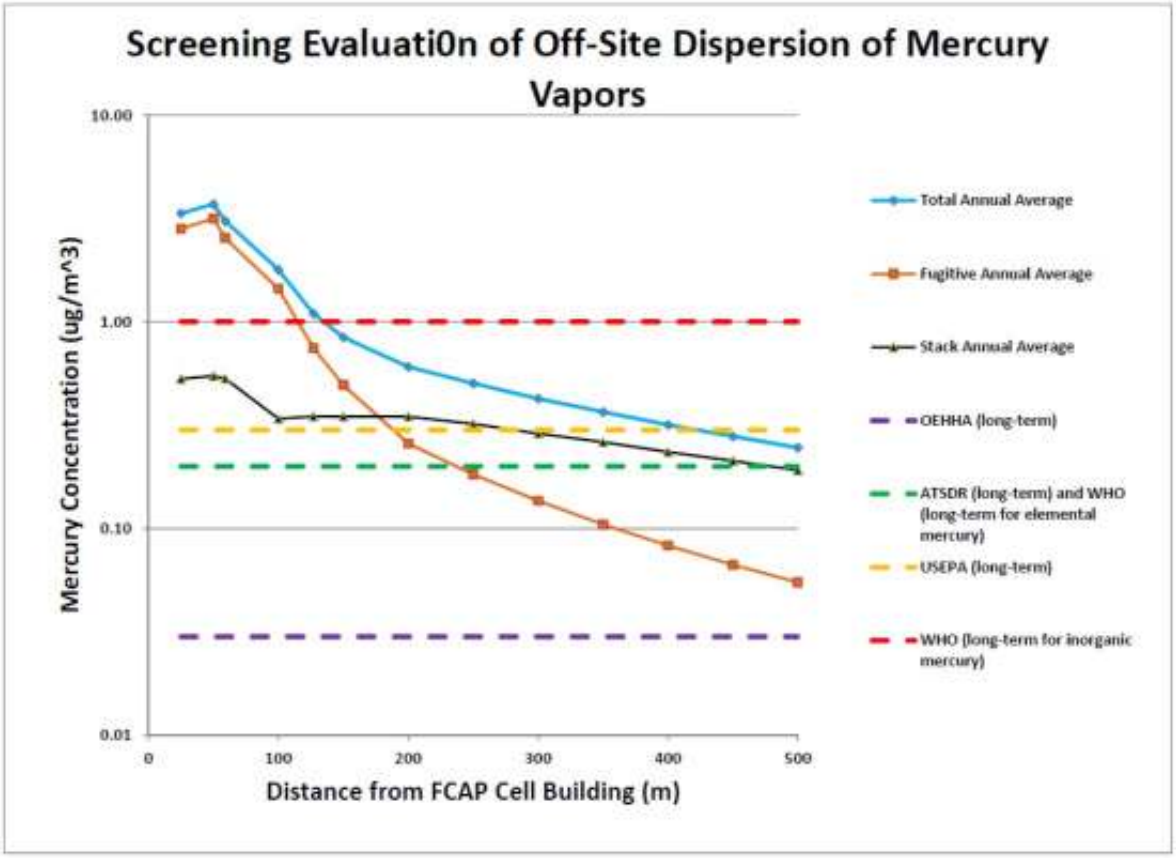


Figure 7-1 Screening Evaluation of Off Site Dispersion of Mercury Vapours

7.1.2 Mercury Contamination in Soils in the Community

Tier 1 levels for mercury in soil are based on assessment of possible risk for children exposed by direct contact with soil in residential yards or public parks. Calculations of such risks rely both on interpretations from the toxicological literature and on a number of assumptions about exposure conditions and child behaviour that vary across regulatory agencies. A range of Tier 1 levels is presented in **Table 7-2** to illustrate the range of interpretation of mercury toxicity and childhood exposure.

Table 7-2 Tier 1 Levels for Mercury in Soil Based on Residential Landuse

Agency	Tier 1 Level	Comments
NEPM[3]	10 mg/kg	Methyl mercury
US EPA[1]	10 mg/kg	Elemental mercury. Long-term exposure based on volatilization and inhalation. May exceed the soil saturation limit for elemental mercury.
US EPA[2]	23 mg/kg	Inorganic mercury. Long-term exposure. Reference dose of 0.0003 mg/kg-day. Assumes residential land use, direct contact with soil, incidental ingestion of 200 mg soil/day, consumption of home-grown produce is not considered.
NEPM[3]	40 mg/kg	Inorganic mercury. Long-term exposure. Toxicity Reference Value of 0.0006 mg/kg-day. Assumes residential land use, direct contact with soil, incidental ingestion of 100 mg soil/day, includes consumption of home grown produce. Applicable to suburban setting with individual homes with yards.
NEPM [4]	120 mg/kg	Inorganic mercury. Long-term exposure. Toxicity Reference Value of 0.0006 mg/kg-day. Assumes residential land use, direct contact with soil, incidental ingestion of 25 mg soil/day, consumption of home-grown produce is not considered. Applicable to urban and apartment settings where yards are very small or non-existent and where most of the ground is covered with buildings and hardstand (concrete/asphalt).

1) USEPA – Regional Screening Level (RSL)
2) USEPA – RSL
3) NEPM – Health Investigation Limit (HIL-A)
4) NEPM – HIL-B

Australian guidance for mercury investigation levels, is based on an assessment that inorganic mercury, excluding elemental mercury, is somewhat less toxic than the US EPA considers it to be. The NEPM criteria are based on an acceptable exposure level (TRV) of 0.0006 mg/kg-day, while USEPA assigns a value of 0.0003 mg/kg-day as acceptable. Further, for typical suburban residential land use, the NEPM criteria assume that children will ingest less soil incidentally (100 mg/d) than does the US (200 mg/d). Moreover, the NEPM values assume that gardens provide significant produce for consumption. In the US, gardens are evaluated on a case-by-case basis. The combination of differing toxicity and exposure assumptions yields a factor of about 6 for a range of values for inorganic mercury in soil. All of these Tier 1 levels (screening levels or investigation levels) can be used to assess possible exposure and risk for residents depending on characteristics of the community. Soil data in the residential community is lacking, and no initial screening of soil concentrations is possible at this time.

The Australian NEPM soil HILs for mercury do not apply to elemental mercury (but to methyl- and inorganic mercury) as assessment of soil contamination with elemental mercury must be dealt with on a case-by-case basis and may require measurement of mercury vapour released from soil. However the US EPA screening-level of 10 mg/kg for elemental mercury is based on an inhalation exposure model, since elemental mercury is relatively non-toxic when ingested. The US EPA also indicates that elemental mercury at this level would exist as liquid droplets in soil, since the saturation limit for elemental mercury is soil is only 3.1 mg/kg *per* U.S. EPA modelling assumptions. For the purpose of the Stage 2 assessment CDM Smith recommends using the US EPA Screening level for elemental mercury as the appropriate Tier 1 criteria.

7.1.3 Mercury Contamination in Sediments

Tier 1 levels for mercury in sediments are not readily available. Screening (Tier 1 risk assessment) is difficult because the major issue for sediments is conversion of inorganic mercury to methylmercury, with subsequent uptake and accumulation in the food chain. This process is sensitive to conditions in the sediment and water in which mercury is methylated and to the

structure of the food chain in habitats affected by mercury contamination. Sufficient information appears to be available for a preliminary assessment of risks due to ingestion of fish and shellfish from the estuary and bay. Thus, mercury in sediments will be evaluated indirectly via a Tier 1 risk assessment based on fish tissue levels. Should elevated risk levels be found, consideration of the contribution of Orica releases to mercury levels in fish may be necessary.

For direct contact with sediments, Tier 1 soil levels are appropriate for use as a conservative (that is, health protective) initial step. Tier 1 risk assessment intentionally errs on the side of protection of public health, and the assumed contact rates with soil (by a resident) are much greater than likely contact rates with sediments (by people who recreate in the estuary or bay). Thus Tier 1 soil levels will be protective for evaluating direct contact with sediments.

7.1.4 Mercury Contamination in Groundwater

As indicated in the CSM (**Section 6**), groundwater is not identified as an exposure medium for community residents. For this reason, no Tier 1 levels for mercury in groundwater were identified.

7.1.5 Mercury Contamination in Fish Tissues

As indicated in **Section 6.3.3.2**, a preliminary assessment of risks due to consuming fish and shellfish from the estuary and bay will be developed using existing data, augmented with additional data collected during the Stage 2 of the project (middle tropic species). Tier 1 levels for fish and shellfish consumption are difficult because of large differences in seafood consumptions patterns in different locations, and even greater differences in patterns for taking and eating fish and shellfish from local resources. Instead, a preliminary risk assessment will be more relevant and informative for evaluating mercury exposure via seafood consumption than use of generic and perhaps non-applicable Tier 1 levels.

Assessment of mercury exposure in the past used a comparison to a maximum permitted concentration (MPC) of 1 mg/kg in edible fish tissue as a Tier 1 screening level. This concentration was not exceeded in fish caught in Penrhyn Estuary. A preliminary risk assessment would examine the issue of risk in more detail using available data and information. The assessment will also consider the current restriction on access to the estuary and the capacity of the estuary to provide forage fish for game fish in the bay. Parenthetically, using methods consistent with US EPA and assuming all mercury in fish tissue is present as methylmercury, a concentration of 1 mg/kg in edible fish would yield an acceptable consumption rate of 1 meal of 140 g per month, or about 1.7 kg of fish per year.

7.2 Other Chemicals

The mercury cell process used at the FCAP used a large amount of electricity and generated considerable heat to produce chlorine and sodium from brine. This energy promoted the formation of by-products during the process. Many of these chemicals were not volatile , and remained in a waste sludge. This sludge had to be removed, treated and disposed on a regular basis.

Chemicals formed in the process likely included chlorophenols, chlorinated dibenzofurans, hexachlorobenzene, hexachlorobutadiene and probably additional chemicals. Inappropriate handling and/or disposal of sludge containing some or all of these chemicals would result in releases to the area surrounding the plant and/or to areas surrounding disposal site(s). In some instances, considerable amounts of waste material have escaped containment. At a site along the

Willamette River in Portland, Oregon USA, large amounts of chlorinated dibenzofurans were released to the river and remain as in sediment offshore of the FCAP that operated at the site. In this instance, onsite handling of sludge was ineffective at containing wastes. Waste handling has often, in the past, been less robust than it is currently.

The only indication that could indicate a release associated with wastes from the Orica plant is the finding of chlorinated organic chemicals, including hexachlorobutadiene, in groundwater from the Mutch Park bore. Mutch Park appears to be upgradient of the plant and contaminants that originated from the plant would apparently have had to have been disposed away from the plant site to impact groundwater in this area. Chemicals detected in the Mutch Park bore are not uncommon industrial chemicals and could have sources other than the Orica plant. Thus, no definitive evidence exists to suggest that the plant released measurable contamination in the form of cell sludge. The issue of release of chemicals other than mercury from the plant is further discussed under data gaps.

7.3 References - Section 7

- Agency for Toxic Substances and Disease Registry (ATSDR). (1991) Toxicological Profile for Mercury. http://www.atsdr.cdc.gov/toxprofiles/tp.asp?id=115&tid=24
- American Conference of Governmental Industrial Hygienists (ACGIH). 2001. *Documentation of the Threshold Limit Values and Biological Exposure Indices*, 7th Edition.
- Halbach, S. (1995). Combined estimation of mercury species released from amalgam. *J. Dent. Res.* 74(4):1103-9.
- Koos, B.J., Longo, L.D. (1976). Mercury Toxicity in the Pregnant Woman, Fetus, and Newborn Infant. *Am. J. Obstet. Gynecol*. 126:390-409.
- National Environment Protection (Assessment of Site Contamination) Measure 1999 (amended May 2013). Schedule B7, Appendix A1, The Derivation of HILs for Metals and Inorganics. Federal Register of Legislative Instruments F2013C00288
- U.S. Environmental Protection Agency (US EPA). (2013) Regional Screening Levels Tables.http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/docs/master_sl_table_run_MAY2013.pdf
- US EPA. (2013). Integrated Risk Information System. Elemental Mercury. http://www.epa.gov/iris/subst/0370.htm
- U.S. Food and Drug Administration (FDA). (2009). White *Paper: FDA Update/Review of Potential Adverse Health Risks Associated with Exposure to Mercury in Dental Amalgam*.

Section 8 Data Gap Summary

Earlier sections of this report have identified gaps in knowledge of mercury emissions, transport, and levels in exposure media (air, soil, sediment, surface water, home-grown produce, shellfish and fish). This section summarises data that would be required to thoroughly investigate historical and current levels of exposure of community members to mercury historically released from the FCAP.

8.1 Mercury in Outdoor Air

As discussed in **Section 7.1.1** and **Appendix L**, the historical impact of the FCAP on ambient air in residential areas is not well understood. To assess the potential historic impacts appropriately, these have to be simulated using estimates for historic mercury vapour emissions over time, using a model that can estimate ambient air concentrations using typical weather conditions for the Botany Bay vicinity. The data needed to undertake this modelling includes:

- Meteorologic (weather) data from a nearby airport (or other meteorologic station), processed appropriately for use in air dispersion modelling. Hourly data dating from recent times to the early years of operation should be sought to provide representative weather data over the long operational period of the plant;
- Robust estimates for historic mercury releases overtime – by year if possible should be sought as input to the air dispersion modelling. Significant data is already available to the CDM Smith team; however additional, more detailed data would increase confidence in the modelling results;
- Ranges for mercury emissions from similar Chlor-Alkali plants should be sought to provide an appropriate context for the results of the air dispersion modelling. It is expected that releases from similar plants around the world would fall within a range dictated by the process chain. Emissions estimates for the Orica plant should be reasonably similar to other plants of the same basic design; and
- Historical aerial photographs are important for evaluation of land use patterns over time. Locations of residences, commercial areas, schools and parks/recreation areas will be overlaid with estimates for elemental mercury concentrations from dispersion modelling to help illustrate possible exposures across the community.

8.2 Mercury Contamination in Soils Outside the Boundary of the Site

Very limited data exists in relation to the concentrations of mercury in soils surrounding the Orica site. Limited sampling has been undertaken in Grace Campbell Reserve, the Southlands property adjoining the site to the west, and some sampling has previously been undertaken onsite, but near the boundaries of the Orica property. The limited data suggests that residual accumulations from historic air emissions and deposition are likely to be low, however further offsite sampling in residential and public open areas is considered necessary to confirm this, and address community concerns.

Some mercury historically released into the air may have deposited onto soil in yards and other areas in the community in the vicinity of the FCAP. Some mercury could also have, in theory, been

released as a result of inappropriate disposal and/or dumping in or near the community. This has been highlighted as a community concern, and all available historic records were reviewed for any evidence that dumping may have occurred, or for gaps in historical records where significant uncertainty existed in relation to solid waste disposal practices. No evidence of any potential inappropriate/illegal dumping or disposal was identified, and no significant gaps in the records relating to solid waste disposal appear to exist.

Claims made by one or two community members pertaining to historic illegal dumping in the Botany area could not be verified. CDM Smith requested contact details, or for anonymous meetings to be arranged with the individuals believed to have firsthand knowledge of such historic practices, however none were forthcoming. No credible evidence or potential witnesses to such activity could be identified.

A preliminary review of available historical aerial photographs appears to show the previous location of onsite ponds, believed to have been historically used for disposal of some waste sludge. These were located within the boundary of the Botany Industrial Park, north of the FCAP. Until approximately 1958, effluent from the FCAP was directed to Springvale Drain until the sewer was installed and all waste effluent, including sludge was piped to the Malabar treatment plant. In aerial photographs from the 1960's, post-installation of the sewer connection, the onsite ponds are no longer visible, as they would no longer have been required.

Given there was ample space onsite for the creation of ponds and disposal of excess waste sludge, if required, it is considered improbable that wastes were transported offsite for disposal by any inappropriate or illegal means. Regardless, in order to adequately address community concerns it is recommended that a detailed review is undertaken of available historical aerial photographs, and both surface and shallow soil sampling be performed in public parks and recreational areas to confirm the absence of elevated mercury concentrations at these locations.

CDM Smith did not identify any data on mercury concentrations in residential yards or publically accessible areas (except Grace Campbell Reserve) in the community, and this lack of data precludes evaluation of current exposure via direct contact with soil. The following issues are important data gaps.

- Surface soil data is needed to evaluate current potential exposure in the community from historical releases. Analyses should include both total mercury and speciation of mercury via sequential extraction; and
- Subsurface soil data is needed to help assess historical release of mercury. Some leaching into soil may have occurred over time, and any tilling of soil undertaken may have mixed surface contamination with deeper soils. The proposed depth of sampling will need only to cover the root zone (approximately the top 30 cm). Analyses should include both total mercury and speciation of mercury via sequential extraction.

8.3 Mercury in Groundwater

Sampling for mercury in groundwater has been completed extensively for the past 5 to 6 years. Geochemical modelling was undertaken in 2008, followed by development of a groundwater fate and transport model in 2010. The groundwater plume, and fate and transport of mercury related to potential receptors, are well identified and continue to be updated with every groundwater monitoring round where mercury is sampled.

Ongoing groundwater sampling for mercury is recommended to continue as per the existing groundwater management plan on a yearly basis. Should the groundwater monitoring results depart from the conceptual model, further geochemical modelling would need to be undertaken to assess the significance.

8.4 Mercury in Sediments

CDM Smith recommends using the historically collected biota and sediment data as a worst-case scenario (assuming all reported mercury in biota is methyl mercury) in the Stage 3 Human Health Risk Assessment for the Residents. In Stage 2, the data available from Penrhyn Estuary (biota and sediment) should be completed with additional biota testing (middle trophic species). Both historical and new data to be included in the Stage 3 - Health Risk Assessment for Public Health Concerns;

However it would be good practice to collect additional biota and sediment data to confirm the assumption that mercury within biota living within the Penrhyn Estuary have indeed decreased by establishing a trend line. The results of such an assessment could potentially be used to lift the fishing ban (gazetted by the NSW Government in November 2004) in Penrhyn Estuary however other compounds namely hexachlorobenzene and hexachlorobutadiene which have levels reported in biota from the estuary above the guidelines should then be included also. Methyl-mercury should be specifically included in the analyses. Also, CDM Smith suggest evaluation of PCDF in sediments as furans are a characteristic by-product of mercury cell process.

Finally, CDM Smith has noticed that Orica collects surface water, pore water and groundwater samples on a quarterly basis from within the Penrhyn estuary. Currently these samples are not analysed for mercury (methyl mercury and total mercury). CDM Smith recommend these analytes to be included in the following rounds as they will provide valuable data at minimal effort.

8.5 Other

In order to adequately address community concerns it is recommended that a detailed review is undertaken of available historical aerial photographs, and both surface and shallow soil sampling be performed in public parks and recreational areas to confirm the absence of elevated mercury concentrations at these locations.

Section 9 Independent Review Findings and Proposed Actions Summary

In this section CDM Smith has summarised our findings and proposed actions.

9.1 Findings

As part of the comprehensive independent mercury review, CDM Smith received and reviewed the following information:

- 174 documents/files from the EPA, including 45 public submissions;
- 155 questionnaires completed by local residents and businesses. This is a 3.4% response rate based on the 4,500 questionnaires mailed;
- 24 folders (approximately 12,000 pages) of information held at Orica, which was reviewed and summarised onsite at their facility;
- 3 interviews with former employees and 1 interview with a community expert; and
- numerous emails from Steering Panel members and community representatives.

CDM Smith has summarised all this information in a Conceptual Site Model and this comprehensive review report. Our most notable findings were:

- CDM Smith estimated that Orica-ICI purchased approximately 950 tonnes of mercury during the life span of the FCAP. This number is considerably lower than what was previously estimated or suggested by community members or representatives. Please note that previous estimates of historic mercury usage at the site were based entirely on assumptions and not on the site specific data that was available for review by CDM Smith. Our assessment of the available data indicated that at least 50% of the mercury used can be accounted for. When using less conservative values for reported mercury concentrations in our mass balance model, this figure increases substantially, and approximately 95% of the mercury used can be accounted for. The large range of possible values in the mass balance model is due to the considerable uncertainty in the historic measurement of mercury concentrations in waste streams, based on measurement accuracy and variability of the waste streams, and a number of potential areas within the plant that mercury could accumulate and escape measurement. The mercury accountability of the Botany plant appears to have been consistent with that of Chlor-Alkali plants internationally;
- CDM Smith has not identified any evidence of potential or actual unauthorised offsite dumping of mercury waste originating from the Chlor-AlkaliFCAP. The documents reviewed also show a consistent timeline of plant operations and waste streams, and the opportunity for onsite disposal of excess Chlor-Alkali wastes in what appear to be onsite disposal ponds in aerial photographs from the 1950's. There does not appear to have been any need or incentive for Orica/ICI to have undertaken any unauthorised dumping offsite;
- CDM Smith has provided appropriate Health-based Tier 1 (Screening or Investigation) Levels for mercury in air, soil, sediment and groundwater published by national and international agencies and organisations. These Tier 1 levels should be referred to in Stage 2 and Stage 3 of the Independent Review;

- The data available from Penrhyn Estuary (biota and sediment) should be completed with additional biota testing (middle trophic species). Both historical and new data to be included in the Stage 3 - Health Risk Assessment for Public Health Concerns;
- Orica has maintained extensive files on the plant performance and environmental issues relating to historic mercury releases from the FCAP. Overall, the documents indicate a significant focus by Orica/ICI management since at least the early 1970's onwards when management became aware of issues surrounding mercury toxicity. Significant work was undertaken in relation to addressing the issues surrounding mercury consumption, accountability and discharge to waste streams, appropriate disposal of solid wastes to landfill, and subsequent need for environmental investigations and remediation programs to address issues as they were identified; and
- CDM Smith has addressed most of the concerns and questions raised by community members. In order to provide a conclusive statement regarding potential health effects and impacts on nearby residents from the historic FCAP operations, an offsite environmental testing program (Stage 2), and human health risk assessment needs to be undertaken (Stage 3).

9.2 Recommendations

Proposed actions for Stage 2 – Environmental Testing Regime are discussed in **Section 8** and summarised (in chronological order) below:

- A detailed review of available historical aerial photographs is recommended;
- It is recommended that refining the preliminary air model developed by CDM Smith be completed with actual meteorological data, to provide a better understanding of how the fugitive and stack emissions for mercury could have been dispersed during plant operations. Furthermore, the AERMOD modelling system should be refined to include deposition and decay. Outcomes of the modelling should be taken into account before finalising the Stage 2 soil sampling locations;
- Offsite sampling (Stage 2) within residential areas and local parks and reserves (both surface and shallow soil sampling) is considered necessary to evaluate current potential exposure to the community from historical mercury releases, and alleviate the concerns raised. Prior to the start of the Stage 2 fieldworks, a document should be prepared by the Consultant that sets out the seven-step Data Quality Objective (DQO) process as presented in Appendix IV of the NSW DEC (2006) Guidelines for the NSW Site Auditor Scheme (2nd edition);
- Additional biota sampling is recommended to complete the existing biota dataset; and
- A Stage 3 – Health Risk Assessment for Public Health Concerns should be undertaken once the results from Stage 2 are available.

Section 10 Orica Botany Mercury Independent Review: Stage 2 – Sampling, Analysis, and Quality Plan (SAQP)

In order to address one of the key community concerns, and also a primary data gap identified, sampling of residential properties and various public parks surrounding the FCAP is considered necessary to confirm that there are no adverse risks to the community from historic mercury releases from the Orica site.

The proposed sampling program, rationale and methodology are outlined below, and the indicative sampling locations are shown in **Figure 10-1** (see **Appendix O** [1]). It should be noted that prior to the start of the Stage 2 fieldworks, a detailed document should be prepared by the Consultant that sets out the seven-step Data Quality Objective (DQO) process as presented in Appendix IV of the NSW DEC (2006) Guidelines for the NSW Site Auditor Scheme (2nd edition).

10.1 Offsite Soil Sampling

10.1.1 Residential Properties

Preliminary air dispersion modelling was undertaken by CDM Smith using the assumptions and input parameters outlined in **Appendix L**. The results of the preliminary modelling indicate that the likely maximum radius from the FCAP that mercury concentrations in ambient air may have exceeded current US exposure standards, is in the order of 500m. This is not to say that elemental mercury was not transported greater distances from the FCAP, but provides a preliminary radius to focus initial soil sampling within, as the region of highest potential exposure.

In addition to targeting residential properties, public parks and open space, and council land within this zone (subject to obtaining landowner consent), the properties of all respondents to the community survey living within a 1.25km radius of the FCAP and requesting additional sampling to be undertaken at their property (Q4 from the questionnaire), are also proposed to be sampled. It is noted that this includes 46 single dwelling properties, and 22 multi-dwelling properties for which contact details and addresses have been supplied. Where permission cannot be obtained to conduct sampling, such as from the Owners Corporation of multi-dwelling residential complexes, permission should be sought from Council to undertake sampling from nature strips in front of or near to those properties. Note that CDM Smith will approach the owners of these properties to ask permission to release their contact details to the Consultant conducting Stage 2.

Sampling from a further 80 locations, in addition to the 46 single dwellings, and 22 multi-dwelling properties, is proposed in either private properties, or public land, subject to receipt of permission to collect samples. Of the additional 80 sample locations, 52 would be collected within a 500 m radius of the FCAP as outlined below (to give 59 locations within 500m as explained in Section 10.1.1.1), an additional 18 would be scattered uniformly throughout the residential target area shown in Figure 10-1. Note specific sampling locations (the 80 locations) are subject to change pending the completion of revised air dispersion and deposition modelling proposed for Stage 2.

[1] Figure 10-1 has been prepared by CDM Smith and will be released to the Consultant for Stage 2 under confidentiality.

The remaining 10 samples would be collected as background samples for comparison with the results obtained. The 10 background sample locations would be selected from areas outside of a 5km radius from the FCAP.

It is proposed that two sample locations, and two sample depths, per residential property would be collected, allowing for at least one of these to be placed in a specific location requested by the landowner if they so choose.

10.1.1.1 Sampling Density Rationale

In order to derive a defensible and scientifically robust sampling rationale CDM Smith has used the methodology outlined in the NSW-EPA Sampling Design Guidelines (NSW EPA September 1995).

As indicated in the report, CDM Smith has not found any evidence of unauthorised or illegal off site dumping of wastes related to the FCAP. In view of this, primary contributor of mercury contamination to soil within the residential area is through historic deposition via air. Deposition is a process that occurs with a great manner of uniformity and goes beyond property boundaries. Therefore CDM Smith recommends a sampling rationale suitable to determine the arithmetic average concentration within the area of interest. This is a method that requires fewer sampling locations as the sampling program does not have to be designed to target hotspots of a particular size. The sampling pattern needs to be designed so that it supports the statistical procedure to determine the arithmetic average concentration.

The NSW Sampling Design Guidelines (1995) requires at least 59 samples to determine whether or not 95% of the area has concentrations less than the acceptable limits outlined in **Table 10-1**. If CDM Smith use Procedure B in the NSW Sampling Design Guidelines (1995) to determine the appropriate number of samples based on expected concentrations and standard deviation of the data, this method generates a very low number of required samples to satisfy the objectives. Using the sampling results from Grace Campbell Reserve, where the mercury concentration in 39 samples was found to be below 0.9 mg/kg, and conservatively estimating that the average mercury concentration will be 5 mg/kg with a conservative standard deviation of 5 mg/kg, and an acceptable limit of 10 mg/kg (for elemental mercury), the number of samples to be collected would be 6. When using more realistic numbers; average concentration - 1 mg/kg; standard deviation – 1 mg/kg, and an acceptable limit of 10 mg/kg, the number of samples to be collected would be less than 1. The reason for this is that the difference between the acceptable limit and the expected concentrations is so large.

In view of this, in order to minimise sampling uncertainty, the offsite sampling program should be designed to collect sufficient data to determine the 95% UCL of the mean of mercury concentrations in soil, and the 95% UCL should be lower than the acceptable limit (see **Table 10-1**). Therefore CDM Smith suggests collection of samples from 148 locations, 68 from residential properties where residents are concerned about mercury concentrations at their properties, 59 locations within the 500 m radius representing the area where the air dispersion model indicated a possible exceedance of the WHO – tolerable Long-Term inhalation exposure and ATSDR – Long-Term Minimal Risk Level (MRL) (0.2 ug/m^3). It is proposed that the offsite testing program employ a systematic sampling pattern (grid pattern), as aerial deposition occurred in a homogenous manner.

10.1.2 Public Parks and Recreational Open Space

As part of the community consultation process, concerns were raised regarding the possibility that dumping, illegal or otherwise, may have historically occurred at locations that are now occupied

by local parks and playgrounds. Some of these are known to have been formerly used as municipal tips.

CDM Smith did not identify any information as part of this Independent Review, which indicates or suggests that such disposal had historically occurred. Additionally, despite conducting a community consultation process, in addition to those previously conducted, CDM Smith was not able to identify any current or former members of the community, or former Orica employees, with any knowledge of such activities having previously taken place.

Regardless, due to the extent of concern that exists in the community about the possibility of historic dumping, sampling for mercury in public parks and playgrounds is recommended to address this issue and help alleviate these concerns.

It is anticipated that samples would be collected at between 2 and 6 locations, at two depths per location (as for residential samples), in each public park and reserve nominated.

A number of parks and playgrounds have been identified for sampling. These are highlighted on **Figure 10-2** (**Appendix O**) and include:

- Mutch Park;
- Pioneers Park;
- Grace Campbell Reserve;
- Rhodes Street Reserve;
- Purcell Park;
- Barwon Park;
- Jauncey Place Reserve;
- Garnet Jackson Reserve;
- Nagle Park;
- Heffron Park;
- Block of land on the corner of Page Street and Holloway Street; and
- Various small unnamed reserves east and south-east of the FCAP, including along Franklin and Wassell Streets, and also Anderson Street to the north-west.

10.2 Storm Drains

Vapour sampling of storm drains in the vicinity of the FCAP is proposed using a hand-held mercury vapour monitor.

10.3 Estuary

In Stage 2, the data available from Penrhyn Estuary (biota and sediment) should be completed with additional biota testing (middle tropic species). Both historical and new data to be included in the Stage 3 - Health Risk Assessment for Public Health Concerns.

Beside some additional biota sampling as per above, other sampling in Penrhyn Estuary is not proposed for the following reasons:

- Previous sampling undertaken in 2004 showed mercury concentrations in fish to be below the guideline level;
- Discharges of mercury have been significantly reduced, by virtue of closure of the FCAP, diversion and remediation of high mercury concentrations along Springvale Drain; and
- Deposition of new sediments in the estuary, which based on the works completed would be expected to contain much lower levels of potential contaminants, is expected to be acting as a natural capping layer for the contaminated sediments, thereby improving water quality and bioaccumulation in fish tissue.

10.4 Soil Assessment Guidelines

The proposed offsite soil sampling program is designed to provide a comprehensive assessment of potential offsite risk and community exposure from mercury in soil. The sampling methodology, and quality assurance/quality control (QA/QC) program are based on the following state and national guidance:

- NSW EPA (1995) Sampling Design Guidelines;
- NSW DEC (2006) Guidelines for the NSW Site Auditor Scheme (Second Edition);
- NEPC (1999, revised 2013) National Environmental Protection Measure (NEPM); and
- Australian Standard AS 4482.1 (2005), Guide to the investigation and sampling of sites with potentially contaminated soil - Non-volatile and semi-volatile compounds.

10.4.1Sampling Methodology

Soil assessment samples will be collected by hand-auger from the surface, or near surface (approx 5cm below root zone) where grass is present, and at slightly greater depth, approximately 0.3-0.5m, due to the possibility that reworking of shallow soil has occurred following historic contamination of surface soils.

10.4.2Field Screening

Field screening, comprising vapour sampling of ambient air while collecting soil samples at the proposed locations, and within multi-dwelling properties where soil samples cannot be obtained, is proposed using a hand-held mercury vapour monitor.

10.4.3Sample Containers

In accordance with AS4482.1 and the NEPM, soil samples will be collected in 250 mL acid-washed plastic containers that have been laboratory washed and certified clean. Waterproof labels that record the project number, discrete sample identification and sampling date will be affixed to each jar.

10.4.4 Field Logging

To ensure that sample integrity is maintained, the following information will be recorded at the time of sampling. To the extent possible, each sample will be carefully examined and the physical properties of the sample described. For each soil sample collected, the following information will be recorded:

- Project title/number and sampling date;
- Name of person collecting sample;
- Location and identification of sampling point;
- Method of sample collection;
- Surface conditions;
- Soil grain size, colour, texture, odour, moisture content, plasticity and staining will be recorded as per the Unified Soil Classification System (USCS and AS 1726 Geotechnical Site Investigation);
- Foreign materials such as ash from power stations should carefully be selected and described during fieldworks; and
- Depth of sample collected.

10.4.5 Soil Analytical Program

Soil samples collected would be analysed for the following:

- Total mercury;
- In all soil samples where mercury is analysed above the Screening Level, the subsequent sample must be tested for mercury speciation by sequential extraction (which will require skilled specialist analysts) in a minimum of at least 20% of all analysed soil samples, mercury speciation must be undertaken;
- A number of soil samples (to be specified in Stage 2) where mercury is found will have to be analysed for PCDF (in particular 2,3,7,8-tetrachlorodibenzo furan) to enable assessment for PCDF that could have been formed as a by-product from the FCAP process; and
- pH.

Additional analyses may be necessary based on the results of the initial phase of sampling.

10.5 Soil Assessment and Validation Criteria

Tier 1 levels for mercury in soil are based on assessment of possible risk for children exposed by direct contact with soil in residential yards or public parks. Calculations of such risks rely both on interpretations from the toxicological literature and on a number of assumptions about exposure conditions and child behaviour that vary across regulatory agencies. A range of Tier 1 levels is presented in **Table 10-1** to illustrate the range of interpretation of mercury toxicity and childhood exposure.

Table 10-1 Tier 1 Levels for Mercury in Soil Based on Residential Landuse

Agency	Screening Level	Comments
NEPM[3]	10 mg/kg	Methyl mercury
US EPA[1]	10 mg/kg	Elemental mercury. Long-term exposure based on volatilization and inhalation. May exceed the soil saturation limit for elemental mercury.
US EPA[2]	23 mg/kg	Inorganic mercury. Long-term exposure. Reference dose of 0.0003 mg/kg-day. Assumes residential land use, direct contact with soil, incidental ingestion of 200 mg soil/day, consumption of home-grown produce is not considered.
NEPM[3]	40 mg/kg	Inorganic mercury. Long-term exposure. Toxicity Reference Value of 0.0006 mg/kg-day. Assumes residential land use, direct contact with soil, incidental ingestion of 100 mg soil/day, includes consumption of home grown produce. Applicable to suburban setting with individual homes with yards.
NEPM [4]	120 mg/kg	Inorganic mercury. Long-term exposure. Toxicity Reference Value of 0.0006 mg/kg-day. Assumes residential land use, direct contact with soil, incidental ingestion of 25 mg soil/day, consumption of home-grown produce is not considered. Applicable to urban and apartment settings where yards are very small or non-existent and where most of the ground is covered with buildings and hardstand (concrete/asphalt).

1) USEPA – Regional Screening Level (RSL)
2) USEPA – RSL
3) NEPM – Health Investigation Limit (HIL-A)
4) NEPM – HIL-B

Australian guidance for mercury investigation levels, is based on an assessment that inorganic mercury, excluding elemental mercury, is somewhat less toxic than the US EPA considers it to be. The NEPM criteria are based on an acceptable exposure level (TRV) of 0.0006 mg/kg-d, while USEPA assigns a value of 0.0003 mg/kg-day as acceptable. Further, for typical suburban residential land use, the NEPM criteria assume that children will ingest less soil incidentally (100 mg/d) than does the US (200 mg/d). Moreover, the NEPM values assume that gardens provide significant produce for consumption. In the US, gardens are evaluated on a case-by case basis. The combination of differing toxicity and exposure assumptions yields a factor of about 6 for a range of values for inorganic mercury in soil. All of these Tier 1 levels can be used to assess possible exposure and risk for residents depending on characteristics of the community. Soil data in the residential community is lacking, and no initial Tier 1 risk assessment (screening) of soil concentrations is possible at this time.

The US EPA screening-level of 10 mg/kg for elemental mercury is based on an inhalation exposure model, since elemental mercury is relatively non-toxic when ingested. The US EPA also indicates that elemental mercury at this level would exist as liquid droplets in soil, since the saturation limit for elemental mercury is soil is only 3.1 mg/kg *per* U.S. EPA modelling assumptions.

Where NEPM criteria is available these must be used for the Phase 2 assessment as these criteria's are enforceable in NSW.

On the basis of this, a preliminary, Tier 1 screening level of 10 mg/kg for elemental mercury, 10 mg/kg for methyl mercury and 40 mg/kg for inorganic mercury is proposed. This does not indicate that a total mercury concentration above 40 mg/kg represents an actual adverse risk to the health of the community, but will identify that a potential risk may exist, and further assessment and analysis, including mercury speciation, is necessary to properly quantity the risk posed.

This approach is consistent with the Amended NEPM and Australian regulatory guidance and is appropriate for the initial assessment strategy for addressing the community concerns. The use of

different Tier 1 criteria could be discussed in the Stage 2 report if this would result in a different assessment outcome.

10.6 Quality Assurance/Quality Control Program

The Quality Assurance / Quality Control (QA/QC) program will be assessed by data quality indicators as set out in the *Guidelines for the NSW Site Auditor Scheme (2nd Edition)*;

- Completeness – all critical locations will be sampled as per this SAQP, sample documentation will be complete, sample holding times will be complied with, appropriate methods will be used, and all documentation will be included in the report to demonstrate this;
- Comparability – experienced samplers will be used and the same approach to sampling will be taken, the same standard technical operating procedures will be used in the field on each occasion, climatic conditions will be recorded, same laboratories will be used for all primary samples. All deviation from the standard technical operating procedures will be discussed in the report;
- Representativeness – samples will be collected which represent the characteristics of the media sampled, samples will be homogeneous, appropriate collection, handling, storage and preservation will take place, and laboratory artefacts will be detected by the use of contaminant blanks (the Data Quality Indicators (DQIs) for trip blanks will be non-detect);
- Precision – standard operating procedures will be complied within the field, laboratory and inter-laboratory duplicates, field duplicates and laboratory-prepared volatile trip spikes (70-130% of the original concentration) will be used and the coefficient of variance of field duplicates by relative percent difference (RPD) will be assessed (RPDs of greater than 50 percent will be assessed further); and
- Accuracy – standard operating procedures will be complied with in the field and analysis of laboratory blanks (the DQIs for laboratory blanks will be non-detected), controls and spikes (recoveries of 70 – 130% of original concentration) will be conducted to eliminate the bias associated with cross contamination.

10.7 QA/QC Program

The quality assurance program during the soil assessment includes the following:

- Preservation and storage of samples upon collection and during transport to the laboratory;
- Sample holding times;
- Use of appropriate analytical and field sampling procedures;
- Required limits of reporting; and
- Frequency of conducting quality control measures.

The quality control program will include the following, where appropriate:

- Rinsate and field blanks;
- Field duplicates - blind duplicates and inter-laboratory duplicates (split samples);

- Trip blank samples;
- Trip spike samples; and
- Data validation to assess for and clarify the occurrence of apparent unusual or anomalous results, e.g. laboratory results that appear to be inconsistent with field observations or measurements.

10.8 Field QA/QC

The field QA/QC program implemented during the soil assessment will include:

- Duplicate and triplicate samples split in the field and submitted to two separate laboratories in accordance with the requirements of the Amended NEPM. One duplicate per 10 primary samples and one triplicate per 20 primary samples submitted to the laboratory for analysis, will be collected for analysis;
- Rinsate blanks when reusable sampling equipment is used;
- One trip blank and if required one trip spike per day of sampling submitted to the laboratory for analysis;
- Documentation of sample collection, handling and transportation procedures, appropriate to meet the project DQOs;
- Details of;
    - the sampling team;
    - sampling method(s), including the actual methods employed for obtaining samples, type(s) of sample containers, order and degree of filling, preservation, labelling, logging, custody;
    - evidence of appropriate decontamination procedures carried out between sampling events;
    - logs for each sample collected showing time, location, initials of sampler, duplicate locations, duplicate type, chemical analyses to be performed, site observations and weather conditions;
    - COC documentation fully identifying for each sample the name of the sampler, the nature of the sample, collection date, analyses to be performed, sample preservation method, departure time from the site and dispatch courier(s) and condition of samples at dispatch;
    - sample splitting techniques;
    - a statement of duplicate frequency for intra-laboratory and inter-laboratory duplicate samples and duplicate sample results;
    - field blank results; and
    - trip blank results.

10.9 Laboratory and Field QA/QC

All analytical laboratories used by CDM Smith are required to adhere to NATA-endorsed methodologies and conduct regular control checks on their analyses. CDM Smith requires these laboratories to regularly provide results of control/method blanks, repeat duplicates and recoveries. Data quality assurance and control will have to be addressed in the DQO report to be provided prior to the start of the fieldworks in Stage 2. The DQO report and Stage 2 assessment report will include details of;

- Analytical methods used for each potential contaminant in the matrix used by laboratories accredited for those analyses by NATA or an equivalent;
- Laboratory method detection limits for the chemicals of concern for use in the assessment of risk;
- The following information;
    - A copy of signed chain-of-custody forms acknowledging receipt date and time, conditions of samples on receipt and identity of samples including in shipments;
    - Record of holding times and a comparison with method specifications;
    - Analytical methods used;
    - Laboratory accreditation for analytical methods used; and
    - The results for blind duplicate samples collected from the field.

The project laboratory will also provide evidence of the following QA/QC procedures:

- Sample receipt and registration documentation;
- Instrument blank analyses;
- Surrogate spike and matrix spike analyses; and
- Laboratory duplicates.

10.9.1 Decontamination Procedures

Decontamination will be required during the investigations, as reusable sampling equipment will be used. All sampling equipment which will come into contact with the samples will be decontaminated before moving to the next location to avoid cross-contamination. A rinsate blank will be taken from the rinsate off the cleaned digging and sampling equipment.

10.9.2 Sample Storage, Preservation and Transport

Soil and groundwater samples will be stored in a cool esky containing ice immediately after they have been taken in accordance with AS4482.1-2005. Samples will be transported to the chosen laboratory within NATA recommended relevant holding times specified and with the relevant COC documentation.

10.9.3 Blind Duplicate Samples (Intra-Laboratory Duplicates)

These samples identify the variation in analyte concentration between samples collected from the same sampling point and/or also the repeatability of the laboratory's analysis (AS4482.1, 2005). Blind duplicates will be collected at a ratio of 1 sample per 10 primary samples. Blind duplicates will be collected at the same time and in the same fashion as the primary sample.

10.9.4 Split Duplicate Samples (Inter-Laboratory Duplicates)

These samples provide a check on the analytical proficiency of the laboratories (AS4482.1, 2005). Split duplicates will be collected at a ratio of 1 sample per 20 primary samples. Split samples will be collected at the same time and in the same fashion as the primary sample.

10.9.5 Rinsate Blank Samples

These samples will provide an indication of whether cross-contamination of analytes from the sampling equipment has occurred. Rinsate samples will be collected at a rate of one rinsate blank per day, per matrix, per piece of equipment (AS4482.1, 2005).

10.9.6 Trip Blank Samples

Trip blank samples will be prepared and transported with primary samples to ensure cross-contamination of samples has not occurred during transportation of the samples. The frequency of trip blanks will be a minimum of one per sampling event.

10.9.7 Laboratory Quality Assurance/Quality Control

Laboratory QA/QC will consist of the following procedures:

- Analysis and reporting of laboratory duplicates;
- Analysis and reporting of laboratory method blank samples;
- Analysis and reporting of internal laboratory standards and calibration blanks; and
- Analysis and reporting of laboratory control spikes, matrix and matrix spike duplicates (MS/MSD) and surrogate spikes.

10.9.8 Sample Holding Times

Schedule B3 of the Amended NEPM specifies a holding time of 28 days for mercury analysis in soil.

10.9.9 QA/QC Documentation

The following QA/QC documentation will be provided:

- The QA/QC checklist items in the NSW EPA (2000) *Guidelines for Consultants Reporting on Contaminated Sites* related to field quality assurance and quality control, laboratory QA/QC and data evaluation QA/QC;
- The names of the accredited laboratories used and relevant details of their accreditation for each analytical method;
- The limits of reporting (LORs);

- The acceptance limit(s) for each QC test, such as duplicate RPDs and recoveries for laboratory quality control analyses;
- The QC results relevant to the sample analysis;
- For each sample, the highest measurement result wherever replicate measurements are taken (or all measurement results for each sample);
- Results for all data tabulated separately; and
- Analytical laboratory reports specifying compliance with the requirements of the Amended NEPM and equivalence with the reference method or non-standard methods.

10.9.10 Sample Nomenclature

The proposed sample nomenclature to be used is provided in **Table 10-2** below:

Table 10-2 Soil and Groundwater Sample Nomenclature

Sample Recovery Method	Sample Nomenclature	Comments
Primary Soil Samples		
Soil Sample	S###/#.#	S### represents the location of the sample, #.#m denotes the depth of the sample in metres.
Soil QA/QC Samples		
Duplicates	QS###	QS### represents the duplicate samples collected
Triplicates	QS###A	QS###A represents the triplicate samples collected
Trip Spike	TS###	TS### represents the number of trip spike samples collected
Trip Blank	TB###	TB### represents the number of trip blank samples collected

Appendix A - Disclaimer and Limitations

This report has been prepared by CDM Smith Australia Pty Ltd (CDM Smith) for the sole benefit of NSW Environment Protection Authority for the sole purpose of undertaking an independent review of offsite mercury impacts associated with the FCAP.

This report was written and published by CDM Smith. The NSW Environment Protection Authority contracted CDM Smith as independent consultants to undertake Stage One of the Orica Mercury Independent Review.

This report should not be used or relied upon for any other purpose without CDM Smith's prior written consent. CDM Smith, nor any officer or employee of CDM Smith, accepts no responsibility or liability in any way whatsoever for the use or reliance of this report for any purpose other than that for which it has been prepared.

Except with CDM Smith's prior written consent, this report may not be:

(a) released to any other party, whether in whole or in part (other than NSW Environment Protection Authority's officers, employees and advisers);

(b) used or relied upon by any other party; or

(c) filed with any Governmental agency or other person or quoted or referred to in any public document.

CDM Smith, nor any officer or employee of CDM Smith, accepts no liability or responsibility whatsoever for or in respect of any use or reliance upon this report by any third party.

The information on which this report is based has been provided by NSW Environment Protection Authority and third parties. CDM Smith (including its officer and employee):

(a) has relied upon and presumed the accuracy of this information;

(b) has not verified the accuracy or reliability of this information (other than as expressly stated in this report);

(c) has not made any independent investigations or enquiries in respect of those matters of which it has no actual knowledge at the time of giving this report to NSW Environment Protection Authority; and

(d) makes no warranty or guarantee, expressed or implied, as to the accuracy or reliability of this information.

In recognition of the limited use to be made by NSW Environment Protection Authority of this report, NSW Environment Protection Authority agrees that, to the maximum extent permitted by law, CDM Smith (including its officer and employee) shall not be liable for any losses, claims, costs, expenses, damages (whether in statute, in contract or tort for negligence or otherwise) suffered or incurred by NSW Environment Protection Authority or any third party as a result of or in connection with the information, findings, opinions, estimates, recommendations and conclusions provided in the course of this report.

If further information becomes available, or additional assumptions need to be made, CDM Smith reserves its right to amend this report.

Appendix B - Communication and Consultation Memo

Memorandum

To: *Zack Thomas, Project Manager Orica Mercury Independent Review*

From: *Andrew Kita / Loek Munnichs*

Date: *11 September 2013*

Subject: *Community Consultation and Engagement – Orica Mercury Independent Review*

Purpose and Objectives

The EPA requested CDM Smith to make preparations for a community engagement plan for the Orica Mercury Independent Review project.

The purpose of the Community Consultation and Engagement (CCaE) is to obtain community input for consideration and involve the community in the final decision making process. The engagement should continue throughout the review process. The objective of the CCaE is to answer or at a minimum seek to address ALL concerns raised and restore public confidence in the EPA.

NSW EPA considered community engagement essential in this project which has been undertaken to date by the EPA. EPA has requested (via email list and local newspapers) submissions from the public for the VMP/RAP and recently regarding past industrial practices on and around the Chlor Alkali Plant (e.g. offsite waste disposal).

A Steering Committee has been formed to oversee the independent review process. The committee meets on a regular basis.

CDM Smith will engage the Committee and Community in a professional and effective manner. We will seek to answer and/or address ALL questions/concerns raised. This will be undertaken in an honest, transparent, frank and unbiased manner at all times.

Questions or concerns raised by community members in regard to the remediation and the EPA's regulation will be managed directly by the EPA and will not be directed toward CDMS and the Independent Review process.

NEPM2013, Schedule B8 *"Guideline on Community Engagement and risk Communication"* has been adopted as the most appropriate guideline for the consultation process.

Stakeholders

CDM Smith has identified the following stakeholders (not exhaustive):

- All residents and landowners within the previously identified 1,25km radius from the Chlor Alkali Plant (CAP), Building G;
- The Steering Committee;
- Councils and Local Councillors from Botany Bay Council and Randwick Council;
- Primary and High schools within Hillsdale and Matraville;
- Orica; and
- All other parties that will make contact with CDM Smith in regard to the review process.

Proposed Engagement Methods and Milestones

In the table below we have identified on which milestones and with which message we need to consult the Community. All above identified stakeholders will be engaged by CDM Smith.

In order to reach the entire community CDM Smith recommends a letter drop, preferably personally addressed otherwise "to the resident/occupant". Also on the envelope a statement must be printed that "this envelope contains important information in regards to the independent Orica mercury review".

Date	Milestone	Method of Engagement	Message	Comments
Mid Sept	Start of Independent Review by CDM Smith	Letter drop	Short introduction CDM Smith, explain our role, purpose of the independent review, timeline and ask for (anonymous) submission. Inform that CDMS has received previous public submissions for review as part of the process Present dates for Open House Meetings Reiterate the EPAs email list and website Submissions can be made via email/letter/in person/phone call (all confidential)	On letterhead CDM Smith (Sydney office) Email: sydney@cdmsmith.com EPA to organise individual addresses from Councils Re-open submission form on EPA website? Point of Contact in table below

Date	Milestone	Method of Engagement	Message	Comments
Begin Oct	-	Open House (2*)	Open house to facilitate the interaction (two-way process) between CDMS and concerned community members	Community Hall Matraville and Hillsdale (7pm – 9pm)
Half Oct	Memo midterm and discussion	News letter on EPA Website	Inform public on our progress and announcement date for the community meeting	Notification via EPAs website, Council websites and local newspapers Email (from CDMS) to people on the email list
End Oct	Presentation to Community	Letter Drop	Invitation for the community meeting (one meeting)	EPA to organise individual addresses from Councils
First week Nov	Presentation to the Community	Public Meeting	At the meeting CDMS will present the results, outline further testing considered necessary and recommendations. All raised concerns shall be addressed [1]	Venue TBA
First week of Nov	Presentation to the Community	News letter	Inform public on results and recommendation. Also tabulate concerns and how these were (or will be) addressed. Inform people on Stage 2 and timeline	Newsletter, door delivered and published on EPA Website

1 one week prior to the public meeting we will present our results and recommendations to the Steering Committee.

CDM Smith Point of Contacts

Main Points of Contact within CDM Smith are presented in the Table below:

Stakeholder	CDM Smith main point of contact	Phone number
Community members	1. Loek Munnichs 2. Andrew Kita 3. Michael Nicholls	02 8918 8815 02 8918 8810 02 8918 8819
EPA and Steering Committee	1. Andrew Kita	02 8918 8810
Media	1. Stephanie Scott	02 8918 8825
Internal	1. Loek Munnichs 2. Andrew Kita	02 8918 8815 02 8918 8810

Note: CDM Smith Australia Pty Ltd Sydney Office number: 0289188800

cc: Loek Munnichs, Michael Nicholls

Appendix C - Questions for Orica

Questions for Orica

As part of the Orica Botany Mercury Independent Review – Stage 1 – Data and Information collection and Review, we have identified the following questions for Orica:

- How was waste tracking preformed prior to when the NSW EPA licence system came in place? Please provide available records.
- How much Mercury did ICI/Orica buy over the total lifespan of the former chlor alkali plant (FCAP)? If unknown, what annual or monthly mercury purchasing data is available?
- From where was mercury obtained and who were the suppliers? Can you please provide us with their details and authorise us to speak with them on Orica's behalf;
- Monthly mercury monitoring (air emissions). Orica calculated, as part of their annual licence returns, a mass of 260 kg/year (1998-1999). How was this calculated? Was this purely stack emissions or also fugitive emissions (We have received the mercury emission concentrations taken from monitoring points 1 and 2, licence 2148). What was the air flow in the stacks?
- Can Orica provide us with a mercury mass balance from the FCAP?
- Does Orica have any other information or knowledge in relation to ongoing mercury consumption/loss rates during the previous operation of the FCAP?
- Please provide us with waste classification results (both chemical concentrations and leachate test results) regarding waste codes D120 (Mercury waste) and N170 (Brine blocks).
- How much elemental mercury has been recovered during remediation works at the site?
- How much caustic soda and chlorine (annual basis) were produced during the years 1942-2002? If this is unknown, what were typical annual production rates?
- How much cement was used in the brine blocks? What was the mass % of sludge in the brine blocks? And the percentage or concentration of mercury in the sludge?
- Compared to other chlor alkali plants (with mercury cells), was the Botany plant considered to use more or less mercury (on average) over the entire life span of the plant?
- Please provide us with a project completion report for the onsite stormwater drain replacements.
- In the CLC meeting (17 September 2013) a residential bore monitoring program was mentioned. Can you please provide CDM Smith with the available investigation reports for the site and surrounding areas.

Appendix D - Questionnaire

Level 11, 90 Arthur Street, North Sydney NSW 2060

25 September 2013

Dear Resident/Business/Stakeholder,

Re: Independent Mercury Review – Request for Information

CDM Smith was engaged as an independent consultant in September 2013 by the NSW Environmental Protection Authority (EPA) in consultation with the Independent Review Steering Panel formed by members from the NSW Ministry of Health, relevant experts, local councils and community representatives. CDM Smith will be providing an independent expert review of documentation and other pertinent information relating to the potential historic emission and distribution of mercury or mercury-contaminated material from the Orica chlor-alkali plant at Botany. This review is intended to address community concerns and determine the appropriate scope of environmental testing required to assess potential health risks associated with any historic releases of mercury into the environment. If additional testing is required, it is expected that this will be undertaken towards the end of this year or in early 2014.

CDM Smith is a global environmental company with more than 5,100 staff in 125 offices worldwide, and has worked on numerous large, sensitive environmental investigations, both in NSW, elsewhere nationally, and also internationally. A team of CDM Smith experts (mercury expert, human health risk assessors, toxicologist, hydro-geologist and vapour intrusion experts) will assist NSW EPA and the Steering Committee with completion of this project.

For more information about the independent mercury review please visit the following website: http://www.epa.nsw.gov.au/Oricabotanycttee/indrevoricabotany.htm

Purpose of this Letter:

To complete their work, the CDM Smith team needs input from community members, who are located within a radius of 1.25 km of the Orica Botany site, who have concerns about mercury contamination stemming from operations at Orica/ICI Botany site between 1944 and 2001.

Questionnaire:

The EPA provided our team with all their files and documents regarding the Orica site and we are reviewing these documents at the moment. The EPA also provided us with recent written communications from the community. However, a deeper understanding of the community is needed to focus review efforts on addressing questions raised and/or to define further environmental testing aimed at supporting analysis of impacts of historical plant operations. To this end, we would greatly appreciate your assistance by filling out the questionnaire we have attached to this letter and returning it to us at your earliest convenience but before the 11th October. Your responses will be used solely to help our team understand your community better and will be kept internal. All submissions will stay strictly confidential, and will not be provided to any third parties, including Orica or the NSW EPA.

You may, of course, return the questionnaire anonymously; and we will gladly accept submissions via email, letter, in person or by phone call.

Level 11, 90 Arthur Street, North Sydney NSW 2060

Community Request for Information – Orica Botany
25 September 2013

Timeline:

The timeline to finish the independent review is very strict and we have identified the following community consultation events to keep you informed on our progress:

Event	Date	Details
Request for information (this letter)	Return questionnaire before 15th October 2013 by using the reply-paid addressed envelope, email or phone call	IndependentMercury@cdmsmith.com 02 8918 8800
Open house to meet CDM Smith experts and ask questions or share information	8th October 2013, between 7pm – 9pm	Hillsdale Community Hall, 236 Bunnerong Rd
Open house to meet CDM Smith experts and ask questions or share information	9th October 2013, between 1pm – 3pm	Matraville Youth and Cultural Hall (Corner Knowles Avenue and Pozieres Avenue)
Newsletter	Mid- October 2013	Will be posted on EPA website and sent to the EPA e-mailing list [1)]
Community Meeting	Beginning of November 2013	Will be announced via letter, email and local newspapers.
Newsletter	One week after the community meeting	Summary of our results and recommendations for testing via letter and EPA e-mailing list [1)]

1 If you want to receive notifications please send an email to info.botany@epa.nsw.gov.au

To provide any other additional information please send an email to IndependentMercury@cdmsmith.com or phone (02) 8918 8800.

If English is not your first language:

- If English is not your first language, and you would like clarification or to provide information in another language, please contact us via email at IndependentMercury@cdmsmith.com
- Αν τα Αγγλικά δεν είναι η πρώτη γλώσσα σας, και θα θέλατε διευκρινίσεις ή να παρέχουν πληροφορίες σε άλλη γλώσσα, παρακαλούμε επικοινωνήστε μαζί μας για IndependentMercury@cdmsmith.com
- ইংরেজী আপনার প্রথম ভাষা না হয়, এবং আপনি ব্যাখ্যা করতে চান অথবা অন্য ভাষায় তথ্য প্রদান করা হলে, IndependentMercury@cdmsmith.com এ ইমেইলের মাধ্যমে আমাদের সাথে যোগাযোগ করুন
- Jika bahasa Inggris bukan bahasa pertama Anda, dan Anda ingin klarifikasi atau untuk memberikan informasi dalam bahasa lain, silahkan hubungi kami di IndependentMercury@cdmsmith.com
- Si el Inglés no es su idioma nativo y quieres aclarar o proporcionar información en otro idioma, por favor póngase en contacto con nosotros por correo electronico IndependentMercury@cdmsmith.com
- **如果英**语不是你的第一语言，你想澄清或提供另一种语言的信息，请联系我们 IndependentMercury@cdmsmith.com

Yours sincerely,

Loek Munnichs – Project Manager CDM Smith Australia – IndependentMercury@cdmsmith.com

Please return before 15th October 2013 using the reply-paid addressed envelope or email IndependentMercury@cdmsmith.com

You may return this anonymously, but if you would like us to follow up with you, please provide your preferred contact details below:

Name: .....

Address: .....

Phone No: .....

Email: .....

Please complete the questionnaire below (please tick the appropriate boxes):

QUESTION	YES	NO
Are you aware of environmental investigations of mercury releases from the Orica Chlor-Alkali plant to the surrounding environment/community?	☐	☐
Are you aware that the Environmental Protection Agency (EPA) initiated an independent review and that a Steering Committee that includes community members has been established to oversee this review?	☐	☐
How long have you lived in the Botany Area: • 0 to 5 years • 5 to 10 years • 10 to 20 years • more than 20 years	 ☐ ☐ ☐ ☐	 ☐ ☐ ☐ ☐
Do you believe your property needs to be tested for mercury contamination?	☐	☐
How would you like to be kept informed about the Environmental Review process: • attend community meetings • receiving written information in the mail • receiving information by email • accessing information on a website • accessing information at a local library	 ☐ ☐ ☐ ☐ ☐	 ☐ ☐ ☐ ☐ ☐
If any answers are Yes to the questions below, please provide further detail in the comments section on the other side. *(If there is not enough space for your response, please attach additional pages.)*		
Have you observed any signs that could be associated with a release from the Orica Chlor-Alkali plant? Signs might include observing air emissions (e.g. smoke, fumes); discoloration in surface water or storm water; dead or dying vegetation in only particular areas	☐	☐
Did you ever work at the Orica/ICI Chlor-Alkali plant and would you be willing to share information about historical plant operations?	☐	☐
Do you need additional information on specific topics in order to form an adequate opinion on possible health impacts associated with historical and/or current operations at the Orica/ICI Chlor-Alkali Plant?	☐	☐

See other side

Please return before 15th October 2013 using the reply-paid addressed envelope or email IndependentMercury@cdmsmith.com

For the following questions where you are asked to give your level of agreement with statements about Orica/ICI Chlor-Alkali Plant impacts, consider that "1" means completely agree, "5" means completely disagree and "2", "3" and "4" indicate decreasing levels of agreement

QUESTION	1	2	3	4	5
The Orica/ICI Chlor-alkali Plant at Botany Bay has in the past released mercury to residential properties in the surrounding community					
The Orica/ICI Chlor-alkali Plant at Botany Bay continues to release mercury to residential properties in the surrounding community					
Residents living near the Orica/ICI Chlor-Alkali Plant have been exposed to mercury by inhaling vapours of mercury released during historical plant operations					
Residents living near the Orica/ICI Chlor-Alkali Plant continue to be exposed to mercury by inhaling vapours of mercury released during historical plant operations					
Residents living near the Orica/ICI Chlor-Alkali Plant have been exposed to mercury by contact with soil on which mercury from the Orica/ICI Chlor-Alkali Plant deposited over time					
Mercury continues to be released from the Orica/ICI Chlor-Alkali Plant and continues to deposit onto soils in residential properties					
Mercury continues to be released to the environment during current operations of the Orica/ICI Chlor-Alkali Plant					
The Orica/ICI Chlor-Alkali Plant at Botany Bay has released mercury and perhaps other chemicals the Penrhyn estuary and ultimately Botany Bay itself					
I know that a human health and environmental evaluation was prepared for the Orica/ICI site and surrounding offsite areas					
I have read at least parts of the human health and environmental evaluation prepared in 2013 for the Orica/ICI site and surrounding offsite areas					
I have heard and understand criticisms of the human health and environmental evaluation prepared in 2013 for the Orica/ICI site and surrounding offsite areas					
I understand the health problems that mercury can cause in children and adults					
I have read at least parts of the human health and environmental evaluation prepared in 2013 for the Orica/ICI site and surrounding offsite areas					
Orica/ICI has handled the problem of releases from their plant well					
NSW EPA has handled investigation and remediation efforts by Orica/ICI well					

Please provide any other questions, information or criticisms in the space below. CDM Smith and the Steering Panel are seeking all information that may assist the independent review. Relevant information would include issues not covered in the questionnaire above

Comments: .....

.....

.....

See other side

Appendix E - Questionnaire Responses

Survey Respondent	Q1	Q2	Q3	Q4	Q5 (1)	Q5 (2)	Q5 (3)	Q5 (4)	Q5 (5)	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Comments
1	No	No	0 to 5 years	Yes	No	Yes	No	No	Yes	No	No	No	one	one	one	one	two	one	two	one	five	five	five	one	five	five	five	
2	No	No	more than 20 years	Yes	Yes	Yes	Unanswered	Unanswered	Unanswered	Yes	No	Yes	one	one	one	one	one	one	one	one	four	five	five	five	five	five	five	Given that we did not know that environment investigations were occurring in relation to mercury it seem that community involvement has been insufficient. Please inform the community as much as you can. A relative states they notice dying tress and strange water.
3	No	No	more than 20 years	Yes	Unanswered	Yes	Unanswered	Unanswered	Unanswered	Yes	No	Yes	one	two	one	one	two	one	two	two	one	four	five	one	one	five	three	three	The bore water in our area is also affected by the chemicals dumped into the ground over the years. It can not be used as recommended by the EPA.
4	Yes	Yes	5 to 10 years	Yes	Yes	Yes	Unanswered	Unanswered	Unanswered	Yes	No	Yes	one	two	one	one	one	one	one	one	three	four	four	one	four	five	five	Lack of transparency and independence when it comes to Orica/ICI Chlor operations and leakages/incidents. No confidence in Orica PR and comms.
5	Yes	Yes	10 to 20 years	Yes	Yes	Yes	Yes	Yes	Unanswered	Unanswered	No	Yes	five	three	three	three	three	three	three	three	five	five	one	five	five	one	one	Very concerned that we may be impacted by mercury poisoning and want to know what I can do to avoid this beyond moving gout of the area.
6	Yes	Yes	more than 20 years	No	Unanswered	Yes	Yes	Yes	Unanswered	Yes	No	No	five	three	three	two	three	three	four	five	five	one	three	five	one	two	three	
7	Yes	Yes	more than 20 years	No	Unanswered	Yes	Unanswered	Unanswered	Unanswered	No	No	No	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	
8	No	No	more than 20 years	Yes	No	No	Yes	No	No	Yes	No	No	three	three	three	four	three	three	three	four	five	four	three	four	five	three	two	Why are questions 10 (q18) and 13 (q21) the same? Activities by Orica have contaminated the water table and threaten to pollute Botany Bay.
9	Yes	Yes	more than 20 years	Yes	Unanswered	Yes	Unanswered	Unanswered	Unanswered	Unanswered	No	Yes	one	Unanswered	one	one	Unanswered	one	Unanswered	one	Unanswered	Unanswered	one	one	five	Unanswered	Unanswered	Orica should not be on populated area and next to sport events.
10	Yes	Yes	10 to 20 years	Yes	Unanswered	Yes	Unanswered	Yes	Yes	No	No	No	three	three	three	three	three	three	three	one	one	one	one	one	one	two	five	
11	No	No	0 to 5 years	Unanswered	Unanswered	Yes	Unanswered	Unanswered	Unanswered	Yes	No	Yes	three	three	three	three	three	three	three	five	five	five	five	five	five	three	five	Don't know about health issues in relation to mercury.
12	Yes	Yes	more than 20 years	No	Unanswered	Yes	Unanswered	Unanswered	Unanswered	Yes	No	one	two	three	three	three	three	three	three	one	Unanswered	three	one	one	two	three	three	Occasionally the fumes make terrible smell in the atmosphere (like rotten onions).
13	Yes	Yes	0 to 5 years	Yes	Unanswered	Unanswered	Yes	Unanswered	Unanswered	No	No	Yes	three	three	three	three	three	three	three	three	five	five	five	three	five	three	three	Advice on historical records associated with Hg contamination or advice on where this can be found.
14	No	Yes	5 to 10 years	Yes	Unanswered	Unanswered	Yes	Unanswered	Unanswered	No	No	Yes	one	four	two	two	one	two	three	one	three	one	three	one	one	three	two	one	
15	Yes	Yes	5 to 10 years	No	Unanswered	Unanswered	Yes	Unanswered	Unanswered	No	No	No	three	three	three	three	three	three	three	three	five	five	five	one	five	three	three	
16	Yes	Yes	0 to 5 years	Unanswered	Unanswered	Unanswered	Unanswered	Yes	Unanswered	No	No	Yes	two	three	two	three	two	four	three	one	one	four	two	one	four	two	two	I am concerned the factories behind my property in <XXX> St may be contaminated are they are on same ground level and during heavy wind soil enters my swimming pool. I also witness a smell from the tap water Christmas dec 2012.
17	Yes	No	10 to 20 years	Yes	Yes	Unanswered	Unanswered	Unanswered	Unanswered	Yes	No	No	one	one	one	one	one	one	one	one	one	one	two	two	one	two	five	five	The air in the morning smells from the plant. It is strong fumes.
18	Yes	Yes	more than 20 years	Unanswered	Unanswered	Yes	Yes	Unanswered	Unanswered	Yes	No	No	one	one	two	two	two	two	two	two	two	two	two	two	two	two	Unanswered	one	
19	Yes	Yes	0 to 5 years	Yes	Unanswered	Yes	Unanswered	Unanswered	Unanswered	Yes	No	No	one	one	one	one	one	two	one	one	one	four	five	five	one	five	five	five	Air emission are smelling badly at times.
20	Yes	No	more than 20 years	Unanswered	No	Yes	Yes	Yes	No	Yes	No	Yes	five	five	one	three	five	five	five	one	one	three	three	one	three	one	one	The smoke and fumes becoming poison and also our soil and tree are dread from the Orica lici.
21	Yes	No	more than 20 years	Yes	Unanswered	Yes	Yes	No	No	Yes	No	Yes	one	one	one	one	one	one	one	one	one	four	four	five	five	five	five	My daughter and I have complained on many occasions to Orica and the EPA but it seams to fall on deaf ears. About 30 shipping containers are storing HCB waste not even 100 meters away from residents.
22	Yes	No	more than 20 years	Yes	Unanswered	Yes	Unanswered	Unanswered	Unanswered	Yes	No	Yes	two	one	two	one	two	one	unanswered	unanswered	one	three	five	two	four	five	three	Unanswered	When we lived at XXX XXXXX Rd we would observed large burst of steam which would not normally be noticed. Our attention would be drawn to the loud sound of escaping steam/smoke.
23	Yes	Yes	0 to 5 years	No	Unanswered	Yes	Yes	Yes	Unanswered	Yes	No	Yes	one	three	three	three	three	three	three	two	two	four	three	two	four	five	three	
24	Yes	Yes	more than 20 years	No	Unanswered	Unanswered	Unanswered	Unanswered	Yes	Yes	No	No	one	one	one	one	three	three	three	one	one	one	one	one	one	five	five	
25	Yes	No	0 to 5 years	No	Unanswered	Yes	Yes	Unanswered	Unanswered	No	No	Yes	two	Unanswered	two	Unanswered	three	Unanswered	Unanswered	two	five	five	five	one	five	Unanswered	Unanswered	We are new to the area. Would appreciate a map showing areas of heavy metal issues similar to a aircraft noise map)
26	Yes	Yes	0 to 5 years	No	Yes	No	Yes	Yes	No	No	No	Yes	two	four	three	four	two	four	four	three	three	five	five	two	five	four	three	I am concerned specifically about risks to pregnant women and foetuses.
27	Yes	Yes	10 to 20 years	Unanswered	Yes	Yes	Unanswered	Yes	Unanswered	No	No	Yes	one	three	one	three	two	three	three	one	five	three	five	one	five	four	three	I would suggest air samples be taken at Heffron Park. Mercury levels have been taken by independent people and have been shown to be high. This is dependant on wind direction.
28	Yes	Yes	10 to 20 years	Yes	Unanswered	Yes	Unanswered	Unanswered	Unanswered	No	No	No	one	one	one	one	three	one	one	one	one	one	one	one	one	five	five	Our English is poor but we do worry about this plant. We believe Orica needs to be inspected seriously.
29	Yes	Yes	more than 20 years	No	Unanswered	Yes	Unanswered	Unanswered	Unanswered	No	No	No	three	three	four	three	two	two	five	one	two	one	one	one	one	one	one	I believe that Orica/ICI try to o the best for the community. I have lived in the area for 40 years and always read the newsletters.
30	Yes	Yes	more than 20 years	Yes	Unanswered	Unanswered	Yes	Unanswered	Unanswered	No	No	No	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	
31	Yes	No	5 to 10 years	Yes	Yes	Yes	Unanswered	Yes	Unanswered	Yes	No	No	one	two	two	two	one	one	two	one	three	five	three	one	five	three	three	Since my wife and myself have been in Hillsdale we have had health issues. Maybe related to contamination maybe not?
32	Yes	Yes	more than 20 years	No	Unanswered	Unanswered	Yes	Unanswered	Unanswered	Unanswered	No	No	one	three	two	two	two	two	two	one	one	two	one	one	two	four	five	This has to be addressed before any kind of future constructions especially on a dangerous goods route. No commercial businesses should be built.
33	Yes	Yes	more than 20 years	Yes	Unanswered	Yes	Unanswered	Unanswered	Unanswered	Yes	No	No	one	one	one	one	one	one	one	one	five	five	two	one	five	Unanswered	one	Not enough investigation of mercury or health has been done by independent body. Only be Orica paid investigations.
34	No	No	5 to 10 years	No	Unanswered	Yes	Unanswered	Unanswered	Unanswered	Yes	No	No	three	three	three	three	three	three	three	one	two	five	five	one	five	three	three	I have witnessed venting gases. I've assumed it to be water vapour. I received much information relation to HCB disposal etc I don't recall info regarding mercury contamination.
35	No	No	more than 20 years	Yes	Unanswered	Yes	Unanswered	Unanswered	Unanswered	No	No	No	one	three	two	two	three	four	three	one	four	five	five	one	five	five	four	
36	Yes	Yes	more than 20 years	Yes	Yes	Yes	No	No	No	Yes	No	Yes	one	three	one	three	one	three	five	one	five	five	three	one	five	five	five	Having resided in the area for over 50 years I have realised that there has been and perhaps still is a problem with Orica. How much confidence do you have in the EPA?
37	No	No	more than 20 years	Unanswered	Unanswered	Yes	Unanswered	Unanswered	Unanswered	Yes	No	Yes	three	three	three	three	three	three	three	one	three	three	three	two	five	five	five	I strongly suggest that Orica be relocated to a secure less population area. There is a disaster waiting to happen.
38	Yes	No	0 to 5 years	Yes	No	Yes	Yes	Yes	No	No	No	No	three	three	three	three	three	three	three	three	five	five	five	four	five	five	three	We do not know enough information for many of the questions above to agree or disagree.
39	Yes	Yes	5 to 10 years	Yes	Yes	Yes	Yes	Yes	Unanswered	Yes	No	No	one	one	two	two	one	one	one	one	four	four	four	one	three	four	three	After the incident on 15/9 I called the BIP helpline. I received a call the next day explaining the situation - a few hours later I received another call stating that person who needed to address the situation couldn't be contacted as his wife was sick. Responses systems need reviewing.
40	Yes	Yes	10 to 20 years	Yes	Unanswered	Unanswered	Yes	Unanswered	Unanswered	No	No	Yes	three	three	three	five	three	three	three	three	one	one	five	one	one	three	one	I would be interested in details regarding the monitoring and review programs implemented by the EPA in the Botany Bay area.
41	No	No	5 to 10 years	Yes	Unanswered	Yes	Unanswered	Unanswered	Unanswered	No	No	Yes	one	three	one	three	two	three	three	one	four	five	five	one	five	four	four	I would like to know how the current water supply is affected as we are now drinking recycled/ desalinated water which has a very strong odour. I have allergies and some respiratory difficulty as well as dermatitis which seem to have been exacerbated since moving to the area. What links, if any, could be attributed to mercury contamination of the air and water supply?
42	Yes	No	more than 20 years	Yes	Unanswered	Yes	Unanswered	Unanswered	Unanswered	Yes	Yes	Yes	one	five	one	five	one	five	five	one	five	five	five	one	five	five	five	I have seen tons of Mercury spilled onto the sand floor during making of Cl2 gas etc.
43	Yes	Yes	5 to 10 years	Yes	Unanswered	Yes	Unanswered	Unanswered	Unanswered	No	No	No	one	five	three	five	one	five	five	one	two	five	five	one	three	five	two	When will testing of my back yard soil be carried out to ensure the fruit and vegetables will no cause adverse health effects if consumed? I want this matter put to rest ASAP, it is causing considerable anxiety.
44	No	Yes	10 to 20 years	Yes	Unanswered	Yes	Unanswered	Unanswered	Unanswered	Yes	No	Yes	one	one	one	one	one	one	one	one	three	five	three	one	five	five	five	Please remove the Orica/ICI from our area.
45	Yes	Yes	10 to 20 years	No	Unanswered	Unanswered	No	Unanswered	Unanswered	No	No	No	one	one	one	one	one	one	Unanswered	one	one	Unanswered	Unanswered	one	Unanswered	four	four	
46	Yes	Yes	more than 20 years	No	Unanswered	Unanswered	Yes	Yes	Unanswered	No	No	Yes	two	two	one	two	one	two	two	one	two	two	two	two	two	four	three	
47	Yes	Yes	10 to 20 years	Yes	Unanswered	Yes	Unanswered	Unanswered	Unanswered	Yes	No	Yes	one	three	three	three	two	two	three	three	two	two	two	two	two	four	three	
48	No	No	0 to 5 years	Yes	Unanswered	Yes	Unanswered	Unanswered	Unanswered	Yes	Unanswered	Yes	one	two	two	two	two	two	three	one	three	five	two	two	five	four	three	
49	Yes	No	more than 20 years	Yes	Unanswered	Yes	Unanswered	Unanswered	Unanswered	No	No	Yes	three	two	two	three	two	two	two	four	three	three	one	three	four	three	Strong perfume smell occasionally and vapour emission from the plant.
50	Yes	No	10 to 20 years	No	Yes	Yes	Yes	No	No	Unanswered	No	Unanswered	one	three	one	three	three	three	three	five	five	five	one	one	five	five	five	I understand that elemental mercury is less of a risk than mercuric compounds. I would like community education in this area and would expect that a comprehensive assessment would included tests to mercuric compounds besides elemental mercury.
51	No	No	more than 20 years	Yes	Unanswered	Unanswered	Yes	Unanswered	Unanswered	Yes	No	Yes	one	one	one	one	one	one	one	one	five	three	four	one	five	five	three	
52	No	Yes	5 to 10 years	Yes	Unanswered	Yes	Unanswered	Yes	Yes	Yes	No	No	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	A few well checking holes are in council strips along fraser ave and not once have these wells been checked by Orica for ground water contamination.
53	No	No	10 to 20 years	Yes	Yes	Yes	Yes	Yes	Unanswered	Yes	No	Yes	one	one	one	one	one	one	one	three	five	five	five	one	one	five	five	five	happy to attend community information sessions or join a committee for feed back purposes.
54	Yes	Yes	more than 20 years	Yes	Unanswered	Yes	Unanswered	Unanswered	Unanswered	Yes	No	Unanswered	one	two	one	one	three	two	one	one	one	one	one	two	one	five	three	Suspect bore water contamination. Immediately adjacent properties have been provided with rainwater tanks in lieu of previous bore water.
55	No	No	10 to 20 years	Unanswered	Unanswered	Yes	Unanswered	Unanswered	Unanswered	Yes	No	Yes	three	three	four	four	three	three	three	two	three	five	two	two	five	four	four	Our the years I have witness minor explosions at the Orica site. This is a worry to me and my family.
56	No	No	0 to 5 years	Yes	Unanswered	Yes	Unanswered	Unanswered	Unanswered	No	No	Yes	four	three	three	four	three	two	three	three	three	three	one	one	two	four	four	We just recently moved here and totally unaware regarding this contamination thanks for letting us know about it.
57	Yes	Yes	more than 20 years	Unanswered	Unanswered	Yes	Unanswered	Unanswered	Unanswered	Yes	No	Yes	four	four	one	one	one	three	three	three	three	one	one	one	Unanswered	Unanswered	five	The people of the area are not living healthy life's smelling and breathing contaminated air.
58	Yes	No	5 to 10 years	Yes	Yes	Yes	Unanswered	Yes	Unanswered	Unanswered	Unanswered	Unanswered	one	one	one	one	one	one	one	one	five	five	five	one	five	five	five	Orica need to pack up and take all their toxic material back to Denmark and never come back. I'm sick of their operations and all of the disease they create and the EPA need to come down on them hard.
59	Yes	No	0 to 5 years	No	No	No	No	Yes	No	No	No	No	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	
60	Yes	No	5 to 10 years	No	No	Yes	Yes	Yes	Yes	Yes	No	Yes	one	three	one	two	one	two	two	one	three	three	three	one	three	four	five	
61	Yes	Yes	more than 20 years	Yes	Unanswered	Yes	Unanswered	Yes	Unanswered	No	No	No	two	four	two	four	two	four	four	two	four	five	five	two	five	four	four	
62	Yes	Yes	10 to 20 years	Yes	Unanswered	Yes	Unanswered	Unanswered	Unanswered	No	No	No	three	three	three	three	three	three	three	two	three	one	one	one	one	three	two	
63	No	No	more than 20 years	Yes	Unanswered	Yes	Unanswered	Unanswered	Unanswered	Yes	No	No	two	three	one	one	one	one	one	three	three	two	four	one	four	three	three	
64	No	Yes	more than 20 years	Yes	Unanswered	Unanswered	Unanswered	Yes	Unanswered	Yes	No	No	one	one	one	one	one	one	one	one	three	one	one	one	one	five	three	Something needs to be done asap.
65	Yes	Yes	more than 20 years	No	Unanswered	Yes	Unanswered	Unanswered	Unanswered	No	No	No	one	four	one	one	one	four	four	four	two	two	two	one	two	five	two	
66	Yes	Yes	0 to 5 years	Yes	Yes	Yes	Unanswered	Unanswered	Unanswered	No	No	No	two	four	four	three	three	four	four	four	three	two	two	two	three	four	two	Clarify the scientific evidence in plain language.
67	Yes	Yes	5 to 10 years	Yes	No	Yes	Yes	Yes	No	No	No	No	three	three	two	one	one	one	one	one	three	two	two	one	two	four	four	We would love to have stats from kids parks in the area as we take our child to play all over the local area.
68	No	No	more than 20 years	No	Unanswered	Yes	Unanswered	Unanswered	Unanswered	No	No	No	three	three	two	two	two	three	three	three	four	five	five	three	five	four	four	
69	Yes	Yes	0 to 5 years	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	
70	Yes	No	more than 20 years	Yes	Yes	Unanswered	Yes	Yes	Unanswered	Yes	No	Yes	one	two	one	two	one	two	one	one	three	two	one	one	two	five	four	Fumes and smoke released from Orica site.
71	Yes	No	more than 20 years	Yes	Yes	Unanswered	Yes	Unanswered	Unanswered	Yes	No	Yes	one	one	one	one	one	one	one	one	two	three	three	one	three	five	four	Odours and smog.
72	Yes	Yes	5 to 10 years	Yes	Unanswered	Yes	Yes	Yes	Unanswered	Yes	No	Yes	one	one	one	one	one	one	one	one	one	one	one	one	one	five	four	Signs of release from the Orica plant. Knowledge of high mercury level detected in people after blood test. Observations of air emissions smokes, fumes quite often flames etc.
73	No	No	more than 20 years	No	Unanswered	Unanswered	Yes	Unanswered	Unanswered	No	No	No	three	four	four	four	four	four	four	three	three	three	three	three	three	three	four	
74	Yes	Yes	0 to 5 years	Yes	No	Yes	Yes	Yes	No	Yes	No	Yes	one	four	three	four	three	four	four	two	one	two	two	two	three	two	two	
75	Yes	No	more than 20 years	Unanswered	Unanswered	Yes	Unanswered	Unanswered	Unanswered	No	No	Yes	one	three	one	three	two	four	four	one	four	three	three	one	three	two	three	
76	No	No	more than 20 years	No	Unanswered	Unanswered	Unanswered	Yes	Unanswered	Yes	No	Unanswered	one	one	one	one	one	one	one	one	three	five	three	one	five	five	five	For years we have witnessed huge flames and loud explosions, smells from Orica site. We don't believe that the company considers the local residents at any time. At meeting we have just heard spin and cover ups.
77	Yes	Yes	5 to 10 years	Unanswered	Unanswered	Yes	Unanswered	Unanswered	Unanswered	No	No	No	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	one	one	one	one	one	Those during environmental evaluation survey will keep us informed. I leave it to them to make any judgement necessary.
78	Yes	Yes	more than 20 years	No	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	No	No	No	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	I would have thought that in Matraville we would not be close enough to Orica fro Mercury (or and other) contamination. I sympathise with those who may have a problem we have been here long enough to have survived the outpouring of the Bunnerong Power House. We are now in our 80s. I doubt if a little Mercury if any will do much damage now. thank you for your concern.
79	Yes	No	10 to 20 years	Yes	Unanswered	Unanswered	Yes	Unanswered	Unanswered	No	No	Yes	one	two	one	one	one	one	one	one	one	three	one	two	four	four	three	Prior to the works undertaken in the last 7-9 years to remove the chemicals from the soil we were notified not to use our bore water. Since then no other contact was made with us. How can we be happy about this? The organisations were not willing to test out bore water for contaminants. these plants belong in non residential area.
80	Yes	Yes	more than 20 years	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	one	Unanswered	Unanswered	Sorry but I do not know enough to answer the questions on this page (2).

Survey Respondent	Q1	Q2	Q3	Q4	Q5 (1)	Q5 (2)	Q5 (3)	Q5 (4)	Q5 (5)	Q6	Q7	Q8
	Are you aware of environmental investigations of mercury releases from the Orica Chlor-Alkali plant to the surrounding environment/community?	Are you aware that the Environmental Protection Agency (EPA) initiated an independent review and that a Steering Committee that includes community members has been established to oversee this review?	How long have you lived in the Botany Area:	Do you believe your property needs to be tested for mercury contamination?	How would you like to be kept informed about the Environmental Review process: attend community meetings?	How would you like to be kept informed about the Environmental Review process: receiving written information in the mail?	How would you like to be kept informed about the Environmental Review process: receiving information by email?	How would you like to be kept informed about the Environmental Review process: accessing information on a website?	How would you like to be kept informed about the Environmental Review process: accessing information at a local library?	Have you observed any signs that could be associated with a release from the Orica Chlor-Alkali plant?	Did you ever work at the Orica/ICI Chlor-Alkali plant and would you be willing to share information about historical plant operations?	Do you need additional information on specific topics in order to form an adequate opinion on possible health impacts associated with historical and/or current operations at the Orica/ICI Chlor-Alkali Plant?
81	Yes	Yes	more than 20 years	Yes	Unanswered	Yes	Unanswered	Unanswered	Unanswered	No	No	No
82	No	No	0 to 5 years	Yes	No	Yes	No	Yes	No	No	No	No
83	Unanswered	Unanswered	0 to 5 years	Yes	Unanswered	Yes	Unanswered	Unanswered	Unanswered	No	No	No
84	Yes	Yes	more than 20 years	Yes	Unanswered	Yes	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered
85	Yes	No	10 to 20 years	Unanswered	Yes	Unanswered	Yes	Unanswered	Unanswered	No	No	No
86	Yes	Yes	0 to 5 years	Yes	No	Yes	No	No	No	No	No	No
87	Yes	Yes	more than 20 years	No	Unanswered	Yes	Unanswered	Unanswered	Unanswered	No	No	Yes
88	Yes	Yes	more than 20 years	Yes	Unanswered	Yes	Unanswered	Unanswered	Unanswered	Yes	No	Yes
89	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered
90	Yes	Yes	10 to 20 years	No	Unanswered	Yes	Unanswered	Unanswered	Unanswered	No	No	No
91	No	No	more than 20 years	No	Unanswered	Yes	Unanswered	Unanswered	Unanswered	No	No	Yes
92	No	No	0 to 5 years	Yes	No	Yes	Yes	No	No	Yes	No	No
93	Yes	No	0 to 5 years	no	unanswered	unanswered	yes	unanswered	unanswered	no	no	no
94	Yes	Yes	5 to 10 years	Yes	Yes	unanswered	yes	unanswered	unanswered	no	no	yes
95	yes	yes	5 to 10 years	no	unanswered	unanswered	yes	unanswered	unanswered	yes	no	no
96	yes	Yes	more than 20 years	Yes	Yes	yes	unanswered	unanswered	unanswered	yes	no	yes
97	Yes	Yes	more than 20 years	no	no	no	yes	yes	no	yes	no	no
98	Yes	No	more than 20 years	Yes	unanswered	yes	unanswered	unanswered	unanswered	yes	no	yes
99	Yes	Yes	10 to 20 years	Yes	unanswered	yes	unanswered	unanswered	unanswered	No	No	No
100	Yes	No	more than 20 years	unanswered	unanswered	unanswered	yes	unanswered	unanswered	yes	no	no
101	Yes	No	10 to 20 years	Yes	unanswered	yes	yes	unanswered	unanswered	no	no	no
102	Yes	Yes	0 to 5 years	unanswered	no	yes	yes	no	no	unanswered	no	unanswered
103	Yes	No	more than 20 years	unanswered	unanswered	yes	unanswered	unanswered	unanswered	unanswered	no	no
104	Yes	Yes	more than 20 years	no	no	no	yes	no	no	no	no	no
105	Yes	Yes	more than 20 years	Yes	unanswered	yes	unanswered	unanswered	unanswered	no	no	no
106	no	no	0 to 5 years	no	unanswered	unanswered	yes	unanswered	unanswered	no	no	yes
107	Yes	Yes	more than 20 years	Yes	unanswered	yes	unanswered	unanswered	unanswered	yes	yes	yes
108	Yes	No	more than 20 years	Yes	Yes	yes	unanswered	unanswered	unanswered	no	no	no
109	no	no	more than 20 years	no	unanswered	unanswered	yes	unanswered	unanswered	yes	no	yes
110	Yes	Yes	10 to 20 years	Yes	unanswered	yes	unanswered	unanswered	unanswered	yes	no	yes
111	Yes	No	more than 20 years	Yes	unanswered	yes	unanswered	unanswered	unanswered	no	no	yes
112	Yes	No	more than 20 years	Yes	unanswered	yes	unanswered	unanswered	unanswered	no	no	no
113	Yes	Yes	5 to 10 years	Yes	unanswered	yes	unanswered	unanswered	unanswered	no	no	no
114	Yes	Yes	more than 20 years	Yes	unanswered	yes	unanswered	unanswered	unanswered	no	no	no
115	Yes	No	0 to 5 years	Yes	unanswered	unanswered	yes	unanswered	unanswered	yes	no	yes
116	no	no	more than 20 years	Yes	unanswered	yes	unanswered	unanswered	unanswered	yes	no	yes
117	yes	yes	0 to 5 years	Yes	no	Yes	Yes	no	no	no	no	yes
118	yes	yes	0 to 5 years	Yes	Yes	unanswered	Yes	Yes	unanswered	no	no	yes
119	no	no	more than 20 years	no	unanswered	yes	unanswered	unanswered	unanswered	no	no	no
120	yes	yes	more than 20 years	Yes	unanswered	yes	unanswered	unanswered	unanswered	yes	no	yes
121	Yes	No	more than 20 years	Yes	unanswered	unanswered	Yes	unanswered	unanswered	yes	no	yes
122	Yes	No	more than 20 years	unanswered	Yes	Yes	Yes	Yes	Yes	yes	no	yes
123	yes	yes	more than 20 years	unanswered	unanswered	yes	unanswered	unanswered	unanswered	no	no	no
124	yes	yes	0 to 5 years	unanswered	unanswered	Yes	Yes	Yes	unanswered	no	no	yes
125	Yes	No	0 to 5 years	Yes	Yes	Yes	Yes	Yes	unanswered	no	no	yes
126	yes	yes	more than 20 years	unanswered	Yes	Yes	Yes	unanswered	unanswered	yes	no	yes
127	Yes	No	0 to 5 years	unanswered	unanswered	yes	unanswered	unanswered	unanswered	no	no	no
128	yes	yes	more than 20 years	no	unanswered	yes	unanswered	unanswered	unanswered	yes	no	no
129	yes	yes	5 to 10 years	Yes	unanswered	unanswered	unanswered	Yes	unanswered	no	no	no
130	no	no	more than 20 years	unanswered	no	Yes	no	no	no	no	no	yes
131	no	no	more than 20 years	no	unanswered	unanswered	Yes	unanswered	unanswered	yes	no	yes
132	no	no	0 to 5 years	Yes	unanswered	yes	unanswered	unanswered	unanswered	no	no	yes
133	Yes	No	more than 20 years	Yes	unanswered	yes	yes	yes	unanswered	yes	no	yes
134	Yes	Yes	5 to 10 years	unanswered	unanswered	unanswered	Yes	yes	unanswered	no	no	yes
135	no	no	more than 20 years	no	unanswered	unanswered	unanswered	unanswered	yes	no	no	no
136	no	no	0 to 5 years	unanswered	unanswered	yes	unanswered	unanswered	unanswered	no	no	no
137	Yes	Yes	0 to 5 years	no	yes	unanswered	unanswered	unanswered	unanswered	no	no	no
138	Yes	Yes	10 to 20 years	no	yes	yes	yes	unanswered	unanswered	no	no	yes
139	Yes	no	more than 20 years	unanswered	yes	unanswered	yes	unanswered	unanswered	no	no	yes
140	Yes	no	10 to 20 years	Yes	yes	yes	yes	yes	yes	yes	yes	yes
141	Yes	No	more than 20 years	No	Unanswered	Yes	Unanswered	Unanswered	Unanswered	No	No	No
142	Unanswered	Unanswered		Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered
143	Yes	Yes	0 to 5 years	Yes	Yes	Yes	Unanswered	Unanswered	Unanswered	Yes	No	Yes
144	Yes	No	more than 20 years	Yes	Unanswered	Yes	Unanswered	Unanswered	Unanswered	Yes	No	Yes
145	No	No	0 to 5 years	Yes	Yes	Yes	Unanswered	Unanswered	Unanswered	No	No	Yes
146	Yes	No	more than 20 years	Unanswered	Yes	Yes	Unanswered	Unanswered	Unanswered	Yes	No	Yes
147	Yes	No	10 to 20 years	No	Unanswered	Unanswered	Yes	Unanswered		Yes	No	No
148	Yes	Yes	more than 20 years	No	Unanswered	Yes	Unanswered	Unanswered	Unanswered	Yes	No	Yes
149	No	No	5 to 10 years	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Yes	No	Yes
150	No	No	5 to 10 years	Yes	No	Yes	Yes	Yes	No	No	No	Yes
151	No	No	10 to 20 years	Yes	Unanswered	Yes	Unanswered	Unanswered	Unanswered	No	No	Yes
152	No	No	0 to 5 years	Yes	Unanswered	Yes	Yes	Yes	Unanswered	No	No	No
153	Yes	Unanswered	10 to 20 years	Unanswered	Yes	Yes	Yes	Unanswered	Unanswered	Yes	Yes	Yes
154	Yes	No	more than 20 years	Yes	Unanswered	Yes	Unanswered	Unanswered	Unanswered	Yes	No	No
155	Yes	No	10 to 20 years	Yes	Unanswered	Yes	Unanswered	Unanswered	Unanswered	Yes	No	No
	Yes 113	**Yes** 76	**0 to 5 years** 34	**Yes** 88	**Yes** 33	**Yes** 111	**Yes** 60	**Yes** 38	**Yes** 10	**Yes** 70	**Yes** 4	**Yes** 79
	No 39	**No** 75	**5 to 10 years** 21	**No** 39	**No** 17	**No** 5	**No** 7	**No** 11	**No** 19	**No** 75	**No** 146	**No** 68
	Unanswered 3	**Unanswered** 4	**10 to 20 years** 25	**Unanswered** 28	**Unanswered** 105	**Unanswered** 39	**Unanswered** 88	**Unanswered** 106	**Unanswered** 125	**Unanswered** 10	**Unanswered** 5	**Unanswered** 8
			more than 20 years 73									
	Yes 73%	**Yes** 49%	**0 to 5 years** 22%	**Yes** 57%	**Yes** 21%	**Yes** 72%	**Yes** 39%	**Yes** 25%	**Yes** 6%	**Yes** 45%	**Yes** 3%	**Yes** 51%
	No 25%	**No** 48%	**5 to 10 years** 14%	**No** 25%	**No** 11%	**No** 3%	**No** 5%	**No** 7%	**No** 12%	**No** 48%	**No** 94%	**No** 44%
	Unanswered 2%	**Unanswered** 3%	**10 to 20 years** 16%	**Unanswered** 18%	**Unanswered** 68%	**Unanswered** 25%	**Unanswered** 57%	**Unanswered** 68%	**Unanswered** 81%	**Unanswered** 6%	**Unanswered** 3%	**Unanswered** 5%
			more than 20 years 47%									

Survey Respondent	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Comments
	The Orica/ICI Chlor-alkali Plant at Botany Bay has in the past released mercury to residential properties in the surrounding community	The Orica/ICI Chlor-alkali Plant at Botany Bay continues to release mercury to residential properties in the surrounding community	Residents living near the Orica/ICI Chlor-Alkali Plant have been exposed to mercury by inhaling vapours of mercury released during historical plant operations	Residents living near the Orica/ICI Chlor-Alkali Plant continue to be exposed to mercury by inhaling vapours of mercury released during historical plant operations	Residents living near the Orica/ICI Chlor-Alkali Plant have been exposed to mercury by contact with soil on which mercury from the Orica/ICI Chlor-Alkali Plant deposited over time	Mercury continues to be released from the Orica/ICI Chlor-Alkali Plant and continues to deposit onto soils in residential properties	Mercury continues to be released to the environment during current operations of the Orica/ICI Chlor-Alkali Plant	The Orica/ICI Chlor-Alkali Plant at Botany Bay has released mercury and perhaps other chemicals the Penrhyn estuary and ultimately Botany Bay itself	I know that a human health and environmental evaluation was prepared for the Orica/ICI site and surrounding offsite areas	I have read at least parts of the human health and environmental evaluation prepared in 2013 for the Orica/ICI site and surrounding offsite areas	I have heard and understand criticisms of the human health and environmental evaluation prepared in 2013 for the Orica/ICI site and surrounding offsite areas	I understand the health problems that mercury can cause in children and adults	I have read at least parts of the human health and environmental evaluation prepared in 2013 for the Orica/ICI site and surrounding offsite areas	Orica/ICI has handled the problem of releases from their plant well	NSW EPA has handled investigation and remediation efforts by Orica/ICI well	
81	one	two	three	three	one	two	two	one	two	three	one	two	four	five	five	
82	two	four	two	four	four	three	three	two	two	two	four	four	four	three	two	I an unaware of the extent of contamination in the past. I understand that this is historic and am concerned as to why the questions indicate that there may be some doubt about their current operations.
83	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	
84	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	one	Unanswered	Unanswered	Unanswered	
85	four	three	three	three	three	three	three	three	three	three	three	one	five	four	four	Not followed or received any information apart fro this but 6-8 months ago there were allegations of mercury contamination in Botany bay. That was the first stage of being aware of the mercury contamination.
86	four	four	four	four	four	four	four	four	three	three	three	four	three	two	three	
87	two	four	one	two	one	two	Unanswered	one	one	five	five	one	four	three	three	I live XXX meters from Beauchamp Rd and I don't believe that the underground water mixed with chemical only reached up to XXX and XXX. For that reason I never dig for ground water to water my garden.
88	one	three	one	two	one	two	two	one	one	five	five	one	five	three	three	Fumes, dead trees, breathing, eyes and skin problems in particular premature ageing.
89	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Only been living in the area for the last two years and have no knowledge of Orica history.
90	one	three	two	four	two	four	three	one	three	five	three	one	five	two	two	
91	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	five	five	five	two	five	Unanswered	Unanswered	I believe that is your job to answer most of the questions of fact above. I wouldn't know and wouldn't rely on media and other reports.
92	Unanswered	one	one	one	one	one	one	one	five	four	three	two	five	five	three	I see smoke/fume emissions and it's horrible to see what is being released.
93	three	three	two	two	four	three	three	three	five	five	five	two	five	three	three	
94	two	two	three	three	three	two	four	one	one	one	one	one	one	five	four	
95	one	four	four	four	three	five	four	one	one	two	three	one	three	Unanswered	one	The damage was done a long time ago and nearly a hundred years later its being cleaned up. Lets get it done.
96	one	one	one	one	one	one	one	one	one	five	one	two	five	five	five	Testing is required offsite to confirm levels of mercury and other chemicals.
97	one	three	two	three	three	four	five	one	one	five	one	two	five	four	three	Regular discharge of smoke from Orica site has been seen over last 20+ years.
98	one	three	three	three	one	three	three	one	one	five	five	one	five	three	two	I would like to know more about the bore water. I have had it installed.
99	one	two	two	two	four	two	one	one	three	three	one	one	two	four	three	
100	one	one	one	one	one	one	one	one	five	five	three	two	Unanswered	one	Unanswered	Is it safe to ingest fruit of vegetables if the soil is contaminated by mercury.
101	one	one	two	two	two	three	three	two	four	four	four	four	five	five	three	
102	three	four	three	three	three	three	four	two	five	five	five	two	five	four	four	We received this mail on the 10th of October after both the information and question sessions that were held at Hillsdale on the 8th and Matraville on the 9th.
103	two	four	three	five	two	five	two	one	two	two	two	one	two	three	two	Continuing to monitor Orica's compliance and continuing to inform the community is very important. Monitoring needs to be independent and not left to Orica.
104	three	three	three	three	three	three	three	three	two	five	three	one	three	three	three	
105	one	three	two	one	three	two	two	four	three	three	one	five	five	one	Unanswered	
106	two	three	two	three	two	three	three	two	four	five	five	one	five	three	three	This is the first time I have been informed of this issue.
107	one	three	one	three	one	three	three	one	five	five	three	one	five	three	three	My husband who passed away in march 1990 worked at ICI plastics labs as a colour matcher for 15 was diagnosed with lung cancer and many types of lead poisoning and aluminium in all of his blood results. I also worked in the office of ICI and had to retire early to look after him.
108	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	one	Unanswered	three	five	
109	three	three	three	three	three	three	three	two	five	five	five	one	five	five	three	
110	one	three	one	three	two	four	three	three	three	five	five	three	five	two	one	
111	three	three	three	three	three	three	three	three	three	three	three	three	three	four	three	
112	three	three	two	two	two	three	three	one	four	four	two	one	three	three	four	
113	one	one	one	one	one	one	one	one	three	one	three	one	five	three	Unanswered	
114	one	three	one	four	one	four	four	one	one	one	one	one	one	four	three	
115	one	three	three	three	one	three	three	one	three	five	five	one	five	three	three	
116	three	two	three	three	three	two	two	two	two	three	three	four	three	three	two	
117	one	five	four	five	two	four	four	two	four	four	five	three	five	three	three	One of our biggest concerns is the affects on ground water.
118	one	two	one	two	one	two	two	one	three	three	two	one	three	five	five	I would like independent information in the form of a human health and environmental evaluation of mercury and other chemicals for residential properties in the surrounding community. Current and future risks, risk levels, risk mitigation etc. Also to understand Orica's responsibilities and penalties in the event of releases.
119	one	one	one	one	one	two	two	one	one	two	two	one	three	two	one	
120	one	one	one	one	one	one	one	one	one	one	one	one	one	four	two	
121	one	one	one	one	one	one	two	one	four	three	three	four	four	five	five	
122	one	one	one	three	one	one	one	one	four	five	five	one	five	five	five	Sometime ago I attended an inspection with authorities and police. We were restricted to what we could see (unable to see leaching of drums that we knew were there).
123	three	five	four	five	three	five	five	four	one	three	three	two	three	Unanswered	two	
124	one	three	one	three	one	two	three	two	three	five	three	two	five	five	three	Clarification on the scope/impact this (mercury exposure) will have on residents in the area would be great please We have 3 very small children who spend a lot of time in the front and back yard. Concerned about their exposure to potential mercury in our soil.
125	three	three	three	three	three	three	three	three	five	five	five	one	five	three	three	I don't have information to be able to agree or disagree with most of the statements above. At the same time I'm very concerned.
126	one	one	one	one	one	one	one	one	five	five	Unanswered	one	Unanswered	five	five	The whole site is out of date. They do not even release communications to the community as to how dangerous they are.
127	two	three	two	two	three	two	two	two	three	five	five	three	five	five	four	
128	one	one	two	two	two	one	one	one	one	two	two	one	one	two	two	
129	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	
130	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	
131	one	three	one	one	one	three	three	one	four	four	one	one	four	five	five	My family all worked for ICI and have all passed away. No family history of cancer, all died of cancer. My father told stories of being told to dump chemicals into the storm water during shutdowns etc.
132	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	I can move from botany, do you think I should be doing that?
133	one	one	one	one	one	one	one	one	one	Unanswered	one	one	Unanswered	five	five	
134	three	four	two	four	three	four	four	two	two	five	five	three	five	five	four	The soils in our garden are very sandy any pollution would not be identifiable in the soil but would settle straight into the water table. This is what concerns us. Is this possible?
135	two	four	five	five	five	five	four	four	three	two	four	four	two	three	three	
136	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	This is the first I have ever heard about it. I am concerned as I have a 2 year old and currently pregnant. Are we getting poisoned?
137	five	five	five	three	three	two	two	three	four	four	four	five	four	one	four	
138	one	two	two	five	three	five	five	three	one	one	one	one	one	one	one	
139	three	three	three	two	one	two	one	three	three	one	three	five	five	two	two	
140	one	one	one	one	one	one	one	one	one	one	one	one	one	three	five	Chemical industrial areas should not be based near residential and school area. Botany bay area should only be storage warehouse area.
141	Unanswered	one	three	three	three	three	three	four	three	three	three	one	three	four	four	
142	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	
143	three	three	three	three					two	Unanswered	one	one	Unanswered	five	four	The above questions are rediculous. They need an opportunity for residents and state they don't know.
144	five	four	four	four	four	five	four	four	four	four	three	four	three	three	two	Orica has exposed the community to chemicals, gases.
145	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	Unanswered	five	Unanswered	Unanswered	Unanswered	I am unable to answer the above questions as this is the first I've heard about Orica/ICI Chlor-alkali Plant and Mercury poisoning.
146	one	one	one	one	two	two	one	one	three	four	four	one	four	four	four	
147	one	five	three	three	one	five	two	two	five	five	five	two	five	four	four	Self monitoring never works. Dust contamination should also be reviewed as a concern. Another environmental concern to Mr is Miss director Lighting at night from the Statutory. Bob
148	one	three	one	one	one	three	three	one	one	three	one	one	one	three	three	I am aware that the properties closer to Orica have been affected by mercury and other chemicals but the biggest effect has been on botany bay and the water ways. The effect we have experienced most is pollution odour vapour not only from Orica but toehr surrounding plants.
149	one	one	one	one	one	one	one	one	five	four	one	one	five	five	three	We resided directly opposite Orica 10 years ago and noticed heavy emmisions and the like beign released and affected our health. (Breathing complications ie. Asthma) Having moved away and recently returning to the area, feel that the emmissions have increased and for that those health issues may return & heighten.
150	three	three	three	three	three	three	three	three	two	five	five	four	five	four	four	we have an extensive veggie garden and grow a large proportion of our own veggies. what impact could the leak have had on our soil and water (bore) supplies and therefore our food grown in the veggies patch.
151	two	one	two	two	two	two	two	one	four	five	five	three	five	five	five	We have not received any information apart from EPA stating that all is safe in the local papers.
152	three	three	three	three	three	three	three	three	three	five	five	five	five	five	three	
153	one	one	one	Unanswered	one	one	two	two	two	Unanswered	two	one	three	five	five	every night I can smell a smoke, and a fume. I can see a discoloration in surface water and a storm water. I have a child diagnosed with cancer, Leukaemia which makes me believe that this area has a high mercury release from Orica.
154	one	three	one	three	one	three	three	one	three	five	two	one	four	three	three	
155	two	three	two	two	two	three	three	three	four	five	five	two	four	three	three	you can smell the polution in the air, see smoke clouds at night over/near the Orica site.
	one 79	37	60	40	57	36	35	77	30	18	35	86	19	8	12	
	two 16	17	28	26	26	28	21	20	18	17	20	25	13	13	16	
	three 30	56	37	46	43	43	49	26	37	26	30	9	24	34	47	
	four 4	17	9	14	6	16	17	8	23	14	10	10	14	29	24	
	five 3	7	2	8	2	10	8	4	27	57	41	11	63	47	33	
	Unanswered 21	21	19	21	20	21	24	19	20	23	19	14	22	24	23	
	one 51%	24%	39%	26%	37%	23%	23%	50%	19%	12%	23%	55%	12%	5%	8%	
	two 10%	11%	18%	17%	17%	18%	14%	13%	12%	11%	13%	16%	8%	8%	10%	
	three 19%	36%	24%	30%	28%	28%	32%	17%	24%	17%	19%	6%	15%	22%	30%	
	four 3%	11%	6%	9%	4%	10%	11%	5%	15%	9%	6%	6%	9%	19%	15%	
	five 2%	5%	1%	5%	1%	6%	5%	3%	17%	37%	26%	7%	41%	30%	21%	
	Unanswered 14%	14%	12%	14%	13%	14%	15%	12%	13%	15%	12%	9%	14%	15%	15%	

Appendix F – Fact Sheet Mercury Toxicity – South Eastern Sydney Public Health Unit

Fact Sheet

NSW GOVERNMENT Health
South Eastern Sydney Local Health District

Mercury exposure and health

What is mercury?
Mercury is a naturally occurring metal found in air, water, and soil. It is distributed throughout the environment by both natural and human processes. Mercury exists in several forms (elemental or metallic, inorganic and organic) and is persistent in the environment. Metallic mercury is a shiny silver-white odourless liquid which readily releases a colourless vapour. It combines with other elements such as chlorine, sulphur and oxygen, to form inorganic mercury. It also combines with carbon to make organic mercury, mainly methyl and ethyl mercury.

What are the main sources of mercury exposure?
The major human activities in Australia which release metallic and inorganic mercury into the atmosphere are gold production, coal fired power plants, and production of alumina from bauxite. Mercury also enters the air from bush fires and volcanic activity, mining of ore deposits, waste incineration, and from some manufacturing plants. It enters water and soil from natural deposits, disposal of wastes and from mercury present in the air. Once in the environment, mercury can be transformed by bacteria into methyl mercury. Methyl mercury bio-accumulates in fish and shellfish.

When exposure occurs above certain levels, mercury poisoning may occur. The amount of exposure required to cause poisoning depends on the form of the mercury, the amount and the way the mercury is taken into the body. As well, the developing embryo/fetus, infant and young child are more sensitive to the health effects of mercury than other age groups.

Common background exposures
Dental amalgam ('silver fillings') is an important source of mercury exposure in the general population, through the breathing in of mercury vapour from fillings. However, the use of mercury dental amalgams is declining.

Advice from Australian authorities on mercury in dental amalgam is available at http://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/d18.pdf

Consumption of **fish and shellfish** is also a major source of intake of mercury, in the form of methyl mercury. While the levels of mercury in fish caught in Australian waters are generally low, pregnant or breast-feeding women and children under the age of 6 should limit the amount of fish or seafood they eat (see below).

Accidental exposure
Examples include spillage of **metallic mercury** in the home (eg. from a broken mercury thermometer or barometer) with inappropriate cleaning up; accidental swallowing of batteries containing mercury; or exposure to vapour from a broken fluorescent light. Ingestion of soil contaminated with mercury as a result of previous industrial or mining activity is another avenue for exposure, particularly for young children who often put things into their mouths. Soil may also be brought into the house on the feet of occupants or their pets, whilst soil contaminated with metallic mercury may release mercury vapour.

Occupational exposure
Artisanal (cottage industry) and small-scale gold mining is one of the major sources of environmental mercury contamination, especially in developing countries. It leads to dangerous exposure of workers who burn the amalgam and of members of their households. Where there are poor industrial hygiene practices, occupational exposures to metallic mercury may also occur, for example in factories in which mercury is used in manufacture, such as in the production of thermometers or fluorescent lights, in the chemical industry including mercury cell chlor-alkali plants or in laboratories using mercury or mercury containing equipment.

Use of medicines and cosmetics
Toxicity has also occurred from unregulated use of mercury compounds in both Western and traditional medicines, or in cosmetics such as skin lightening creams and soaps. In the first half of the last century, widespread use of mercury in 'teething powders' caused a form of infantile mercury poisoning called pink disease, marked by pink, swollen hands and feet, rash, lethargy, and hair and tooth loss.

Mercury in the form of thiomersal (which contains ethyl mercury) may be used as a preservative in vaccines; in Australia all childhood vaccines and most vaccines used in adults are mercury-free. Detailed information can be found at:
http://ncirs.edu.au/immunisation/fact-sheets/thiomersal-fact-sheet.pdf

How does mercury affect health?
All humans are exposed to some level of mercury. Severity of health effects depend on the form of mercury, dose, developmental stage and age, duration and route of exposure.

Inhalation of mercury vapour
Mercury vapour is easily absorbed through the lungs, with about 70-80% entering the blood stream following inhalation. Prolonged inhalational exposure leads to central nervous system damage causing neurological symptoms such as irritability, memory loss, anxiety, depression, personality change and tremor. 'Mad Hatter's disease' caused by intense and prolonged exposure to the vapour of metallic mercury used to produce felt for hat making is a historical example.

At high doses, nausea and vomiting occur, whilst effects on the lungs are severe, leading to shortness of breath and eventually death due to respiratory failure.

Ingestion (swallowing) of mercury or mercury containing foods and objects
Metallic mercury is usually poorly absorbed into the body but will be absorbed if there is a delay during movement through the intestinal tract (for example, if an infant swallows a mercury battery). Some of the elemental mercury can turn into mercury compounds which are highly corrosive to the intestine. In acute exposure, the toxic effects usually occur within 10-15 minutes and can cause loss of appetite, abdominal pain, vomiting and bloody diarrhoea.

Methyl mercury found in contaminated seafood is readily absorbed and finds its way to almost every organ in the body, but particularly to the brain and kidneys. Effects on the brain and nervous system caused by eating fish heavily contaminated with methyl mercury, as happened in Minamata, Japan, include irritability, memory loss, anxiety, depression, personality change, tremor, unsteadiness, and visual and other sensory

disturbances. Kidney inflammation may occur, whilst in acute, high-level exposures, kidney failure has ensued within 24 hours.

Who are at most risk?
Mercury can affect anybody, but there are certain groups who are higher risk.

Pregnant women and the developing fetus
In pregnant women mercury can pass through the placenta and affect the baby in the womb, potentially harming the development of a baby's central nervous system. Pregnant and lactating women are generally advised to reduce their consumption of certain types of fish (see below).

Young children (< 6 years)
Young children tend to put their hands or other objects into their mouths (e.g. soil). As their brains are still developing, they are more likely to be sensitive to mercury exposure. Effects observed in young children include behaviour, attention and learning problems, and difficulties thinking through tasks.

People with pre-existing medical conditions
The presence of central nervous system disorders or kidney disease may increase the impact of mercury toxicity. People sensitized to mercury and those with genetic susceptibility to mercury-induced hypersensitivity are also at higher risk.

Mercury poisoning is preventable

Limit consumption of fish and shellfish
Although it is generally considered healthy to eat fish, mercury is concentrated through the food chain and may be present at high levels in the flesh of predatory fish, mainly shark (Flake), billfish (Broadbill, Swordfish and Marlin), Orange Roughy (Deep Sea Perch) and Catfish. Therefore it is advisable for at risk groups to avoid or limit their ingestion of such fish in order to minimise exposure of methyl mercury.

All other fish species are safe to eat at the recommended level of 2 to 3 times per week.

Food Standards Australia and New Zealand provides guidance on fish consumption to minimise exposure to mercury, at:
http://www.foodstandards.gov.au/_srcfiles/mercury_in_fish_brochure_lowres.pdf
In waters where there is evidence that mercury contamination may lead to harmful levels of mercury in fish, authorities may ban the catching of fish.

Other ways to reduce potential mercury exposure
If there is concern regarding contamination of soil, frequently wash children's hands, and regularly wash or wet-mop floors, stairs, and window sills to reduce dust. Move play areas away from bare soil.

Products that contain mercury, such as thermometers, fluorescent light bulbs and older medications should be handled and disposed of carefully. Do not vacuum up spilled mercury or broken mercury-containing devices as it increases the level of mercury vapour in the air. For further information see:
http://www.climatechange.gov.au/what-you-need-to-know/lighting/resources/fs.aspx

Are there Australian limits for human exposure to mercury?

Drinking water
The Australian National Health & Medical Research Council has set a health-related limit for total mercury in drinking water of 0.001mg/L.
http://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/eh52_aust_drinking_water_guidelines_update_120710_0.pdf

Air
As a guideline for long-term exposure, NSW Health uses the World Health Organisation recommendation for a tolerable daily level in air of 0.2 µg/m^3.

Soil
The current National Environment Protection (Assessment of Site Contamination) Measure, approved by the Council of Australian Governments Standing Council on Environment and Water, recommends health-based investigation levels for mercury in soil in different residential scenarios. The investigation level for residences with garden/accessible soil (also applicable to childcare centres, preschools and primary schools) is 10mg/kg for methyl mercury and 40mg/kg for inorganic mercury; for residences with minimal opportunity for soil access (which includes dwellings with fully and permanently paved yard space) the level is 30mg/kg for methyl mercury and 120mg/kg for inorganic mercury.

It should be noted that where there is significant **metallic** mercury contamination of soil, the document recommends management on a case-by-case basis because assessment of human exposure may require measurement of mercury vapour released from soil. Uptake of metallic or inorganic mercury by food plants is at a level of approximately 1 in 1000 to 3 in 1000 of the levels in the soil, so that food plants grown in residential gardens are very unlikely to accumulate harmful levels of mercury.

What to do if you are concerned about mercury exposure
If you suspect you or your child's health has been affected by exposure to mercury, contact your doctor regarding the need for clinical assessment. Telephone advice may also be sought from the NSW Poisons Information Centre on 13 11 66.

If you need to clean up a mercury spill in your home, or if you are concerned about the likelihood of human mercury exposure from the environment, you may obtain advice from members of the environmental health team at the Public Health Unit on 9382 8333 for south eastern Sydney residents, or if you are elsewhere in NSW, by phoning the state-wide public health unit call number 1300 066 055.

Prepared by South Eastern Sydney Public Health Unit

7 May 2013; review date 31 October 2013.

Appendix G - Summaries EPA Documents

Document 1

Reviewer: Katarina

The document includes:

- Various notices from 1991 – groundwater leakage noted into Springvale Drain – no mercury mentioned
- Old licence files

Document 2

Reviewer: Loek

Letter EPA to Nancy Hillier (Botany Environmental Watch Committee) regarding complaint/questions ICI (February 1993)

- Public concerns 1989 over chlorinated hydrocarbons EPA initiated Phase 1 of the assessment (7 Sept 1990)
- No immediate threat was found to the public
- Actions undertaken by SPCC (now EPA): fencing, signs at boatramp, letters to groundwater users and information meetings
- 1992 Oysters were tested. No Hg found in them
- Vegie garden tested: No VOCls found
- Pump and treat seems not succesfull
- Comprehensive brief for Phase 2 prepared with Technical Advisory Committee
- ICI will engage consultant, EPA will closely supervise
- No prosecution of ICI is underway as the contamination occurs before the introduction of legislation which prohibitsthe contamination of soil/groundwater

EPA letter to Minister, Subject ICI

- Provided to assist minister with meeting with ICI Chief Executive
- Apart from a small number of relatively minor incidents, the company has an excellent environmental record and co-operates willingly and effectively with the EPA

Anonymous caller (saying old employee of ICI, had to sign a secrecy document) complained about illegal mercury discharges to Botany Bay via underwater pipe and to adjacent ICI owned land (13-Oct-1992) at 2am every day. EPA inspected the property on 14-Oct-1992 and discussed the alleged night-time discharge. No evidence of such a pipe was found as ICI do not front the bay. There is a stormwater overflow pipe that drains to Springvale Drain during storms. This pipe leaks as groundwater infiltrates into it. (*CDMS: I made a copy of this letter*)

13 June 1992 the chlorine compressor in the FCAP tripped and chlorine entered the cell room through the cells. Plant emergency was put in place.

This file contains more complaints and how the EPA dealt with them. None of them were relating to the FCAP

Letter Water Board, 20-June 1990, Malabar plant (ICI is the only identified and approved discharger of Hg in the catchment) have suppied Water Board with monitoring data (figure provided by ICI) from Jan 1987 to May 1990. Hg concentrations dropped from 98 ug/L to 35 ug/L. (*CDMS: The total mass is unknown. I made a copy of this figure)* .

State Pollution Control Commission, submission for meeting 22/2/91, Questions regarding disposal of sewerage sludge contaminated by mercury from ICI to landfill at Menai:

- Actual form of Mercury was not determined as the criteria takes into account Hg in its most toxic form
- Treated sludge was disposed of at Menai landfill between 14 and 25 September 1990. A total of 840 tonnes was accepted for disposal, Hg levels were monitored *(CDMS : levels are unknown)*
- Hg was immobilised using cement/lime kiln dust
- *CDMS the sludge mentioned in this letter is sludge from the Malabar sewer treatment plan*

Letter from ICI to SPCC (now EPA) 12 march 1990

- Existing sludge filtration and handling facilities are approaching the end of their useful life (sludge must be double handled now before disposal);
- Project involves installation of new filtration equipment;
- Sludge collected onto sludge pad are regularly loaded directly into a truck for disposal;
- Closed circuit drainage system

Document 3

Reviewer: Katarina

The document includes:

- Incident at Olefines plant cracking furnace in 1992
- Dust monitoring equipment installed
- Response to EPA on CAP operation – the usage of fresh mercury is approximately 1.5 m3 per year , it is recovered as thick and contaminated mercury and used for reprocessing.
- Brine waste and sulphided solids from effluent treatment are stabilised by addition of NaS, followed by mixing with cement and casting into large blocks
- Brine waste filter cake , underflow from effluent treatment vessel contains mercury sulphide from the process
- Contaminated carbon containing mercury was stored in storage pending further processing
- Removal of mercury from hydrogen which is not sold , produces hydrogen steam
- High testing frequency ensures that product has no more than 3 mg/m3 of mercury
- Variation of licence condition in 1991

Document 4

Reviewer: Katarina

The document includes:

- Safety data sheets for hydrocarbons
- Further licence conditions
- Responses to operation of CAP response to State pollution control commission – fresh mercury usage record will be kept ,
- Filter cake from the brine is the major source of the sludge to be stabilised , stabilised brine waste includes sodium sulphide added to brine waste at 50 kg for each batch of 12 te of the waste , and then cement added to form a block
- Explanation of the operation of the ICI chloride plant
- Hg levels in the hydrogen feed to the hydrogen chloride synthesis unit shall not exceed 5 ug / m3. Samples to be collected monthly to check on this condition

Document 5

Reviewer: Katarina

The document includes:

- Licence conditions from 1995
- Fire incident in the refrigerated catalyst store
- Comments of GW report Stage 2 Woodward Clyde
- Incident investigation reports on release of ethylene oxide , PVC
- Copy of the EPA licence 1993
- Report on ethylene oxide storage tanks

Document 6

Reviewer: Katarina

The document includes:

- Copy of the EPA licence 1994-1995

Document 7

Reviewer: Katarina

The document includes:

- Copy of EPA licence 1990 specifying Mercury levels as 0.5 ug/L
- Discussion about practicality of 35 ppb guideline for mercury
- Total Hg calculated as being discharged from the plant via SS005 S and N, pumped rew and settled effluent is about 11 kg/day of Hg exported
- Mean Hg content for 1989 was 66 ppb Hg average daily output

Letter from State Pollution Control Commission (15/8/1989) minutes from meeting with water board officers and ICI:

- 80% of the mercury (effectively 325 grams/day) that the board is allowed to dispose of in their effluent comes from ICI.

Letter Water Board to ICI (17 July 1989)

- "*for the time being, sludge* [from the Malabar treatment facility] *will continue to be discharged to the marine environment*"

Document 8

Reviewer: Katarina

The document includes:

- Copy of letter from water board in 1990 indicating concern that Orica will not be able to limit the Hg in discharge water below 35 ppb (as per Orica's proposal)
- Reot from united nations env program in 1988 re environmental health criteria for methylmercury
- State pollution control commission 1989- issued report acceptable levels of environmental contaminants with particular info on mercury
- Improvement proposed for liquid effluent from the chlorine plant: dedicated cooling system, replacement of brine sludge filter and treatment of chlorine plant effluent
- Water resources commission issued a GW resources report on the Botany Basin

Document 9

Reviewer: Loek

Letter Orica to EPA, 12 March 1998, review of waste management activities on botany Site

- N170: 600 tonnes per annum generated in the Chlorine Plant >> disposal to landfill
- D120 was not mentioned in this waste review
- Clorine Plant: Spent activated carbon containing mercury, accumulating at 4,4 m^3 per annum. Current stockpile: 37 m^3
- Mercury-rich sludges from stella filters, maintenance of caustic tank as well as cells and brine sumps, accumulating at 5,7 m^3 per annum. Current stockpile: 68m^3

Copy of EPA licence 006901, Waste Minimisation And Management Act, 1995. In force until 1 April 2000

- Limited condition 2.1: mercury waste may be accepted at this facility

Document 10

Reviewer: Loek

Woodward-Clyde, 22 September 1994 Groundwater Survey, Stage II, Technical Advisory Committee meeting:

- Soil program Block 1; surficial material mainly boiler ash: variable Hg concentrations <0.1 to 70.5 mg/kg
- Phase 2/C3: Groundwater model, solute transport model, MT3D, Modflow

Woodward-Clyde, 14 February 1994 Groundwater Survey, Stage II, Technical Advisory Committee meeting:

- Mercury in shallow groundwater Plant Site (WG65): 0.0035 mg/L (Depp GW no Hg, Southland and Foreshore Road: no Hg in groundwater)

Minutes of Meeting 5th Technical Advisory and tender Review Committee for Stage 2 ICI Botany Survey, 10 August 1993

Community Liaison Committee (CLC) Meeting minutes, 10th meeting:

- Dredging of Penrhyn Estuary was discussed. Will be undertaken shortly. 15,000 m3 dredge material possible to be placed under third runway construction
- Veggies from a nearby ICI Chinees veggie garden were sampled: no chlorinated hydrocarbons were found >> roots probably above contaminated aquifer and watering was with reticulated water

CLC meeting minutes 12th meeting (14 March 1994)

- There is not much fishing in Penrhyn Estuary and the levels of contamination in fish are below health based limits

Minutes of Meeting 7th Technical Advisory and tender Review Committee for Stage 2 ICI Botany Survey, 3 March 1994

- Mercyry in fish was found in small quantities
- Application has been received by EPA to place dewatered dredge from Penrhyn Estuary on the western side under a suitable cover. Meeting scheduled to discuss
- Copied map with location old boat-ramp and biota results
- Proposed collection of fish for second phase of Stage 2 study

Minutes of Meeting 6th Technical Advisory and tender Review Committee for Stage 2 ICI Botany Survey, 14 February 1994

- Dredging penrhyn estuary: two disposal sites: western bank (site have to be licensed as landfill) and in the bay. Offsite disposal to expensive. Disposal on Southlands not possible. *CDM Smith: It should be noted that these works were undertaken by the Department of Public Works and were NOT related to Orica/ICI*.

Folder contains older minutes of CLC meetings. Also a Scope/Contract for Phase 2/C1-6

Document 12

Reviewer: Loek

Woodward-Clyde, 13 June 1995 Groundwater Survey, Stage II, Technical Advisory Committee meeting No11 (13 June 1995):

- Soil program Block 1: surficial material mainly boiler ash; variable Hg concentrations <0.1 to 70.5 mg/kg. Block 2: Hg concentrations <1 to 66 mg/kg at Test pit TP8)
- Sediment ponds, Springvale Drain mercury resampling >100 mg/kg over 20+m
- Threshold hazard index approach has been choosen for Mercury
- Receptors included children and adult residents and recreational users
- Phase 2/C5: 10 sites in key receptor areas were sampled using flux chambers (air quality)

Minutes of Meeting 11th Technical Advisory and tender Review Committee for Stage 2 ICI Botany Survey, 13 June 1995

- *CDMS: Minutes are confidential and no community reps are in that meeting*
- 10 air samples to be collected. Results will inform the HRE

Document 13

Reviewer: Loek

Several (~25) reports of call to pollution line

Letter Freight Rail regarding Chlorine gas emissions

Letter with EPA comments on the Stage 2 Groundwater Survey (Contract C6). Actually the EPA reviewed the entire Stage 2 Survey. NSW EPA sought advice (remediation technologies) from US EPA Region IX staff (Levine and Opalski) and their comments are endorsed by NSW EPA.

- Offsite impacts are of primary concern to EPA
- EPA wants to address additional concerns in Stage 3 (ecology Penrhyn Estuary, other contaminants such as dioxins and furans and northern extent ICI groundwater plume
- US EPA reviewers state that the Stage 2 report is biased towards passive remediation technologies. These do not have an established performance record
- *CDM Smith: We refer to document 88 which is the same review document (Opalski and Levine)*

News articles (May-June 1996)

- ICI told to clean up or close
- ICI put on notice
- Second Gas leak
- ICI to feel EPA heat over gas leaks

Minutes of meeting Technical Advisory Committee Meeting No. 12, Sept 1995 (EPA, Botany Council, ICI, AGC Woodward-Clyde.

- Preliminairy results of Risk Assesment presented by Woodward Clyde to the committee. Calculated risks (for all receptors, including residents, children) fall within criteria commonly accepted by regulatory agencies. Chlorinated compounds were assessed. *CDM Smith: mercury not assessed*

Letter ICI to EPA, 9-9-1994 regarding closure vinyl plant early 1997

Document 14

Reviewer: Loek

Soil sample collected at new silo site at Alkathene. Mercury was detected in top layer (2ppm), mid layer 2ppm (2m) and <2ppm in bottom layer (2.5m)

Document 15

Reviewer: Loek

Audit by Cooper&Lybrand Consultants of the ICI Australia Operations P/L of the SH$E management system, August 1997.

- 3 plants were audited (including Clorine)
- Four main areas of improvement identified:
    - Increase the inclusion of and emphasis on environmental issues
    - Ensure "closure" of systems from a due diligence perspective
    - Improve documentation that currently exists in a variety of forms
    - Undertake improvements to the SH&E system itself to clarify some issues, remove ambiguities and ensure all relevant topics are included
- Records of housekeeping inspections of Chlorine plant and sparse
- Chlorine would only report a mercury spill if it occurred outside otherwise the spill would just be cleaned up
- Chlorine has processes which bypass direct lines to Malabar, ie their processes are directed via the 14th Av effluent treatment system. Fort this reason Chlorine doesn't not use the procedure: incident communication with SWC's Malabar sewage treatment plant
- Environmental Impact Assessment: Chlorine has seen this procedure as a site procedure and has not addressed it at plant level. However the Site Environment section indicated that it has seen a copy of the beginnings of an EIA from Chlorine

Stormwater Drainage Conditions – CAD drawing July 1990: Chlorine Plant and surroundings drain direct discharge on storm drain.

Document 16

Reviewer: Loek

Presentation new botany chlor-alkali plant, 29/1/1998. Current operation: 70,000 tonnes/annum of chlorine from mercury cell process. New plant: 30,000 tonnes / annum chlorine

Position Paper Conceptual Design for Realignment of Springvale Drain Through Southlands, Woodward Clyde, November 1997.

- Current drain capacity is 8 m3/s prior to overtopping

Letter ICI to EPA regarding name change to Orica Limited on 2 February 1998 but will work under same CAN (004117828)

- ICI has the following licences at 16-20 Beauchamp Road, Mattraville
    - 2148 under the Pollution Control Act
    - P10290 under the Waste Recycling and Processing Service Act
    - 26 under the Environmentally Hazardous Chemicals Act

Letter EPA to ICI (500755A46/4) regarding the Coopers&Lybrand Audit report (see document 15). "EPA finds it encouraging that the auditors founds that your SH&E system is generally robust however it is noted that there are some areas that could be improved". EPA asks for a schedule of implementation of the recommendations

Letter ICI to EPA (22/12/1997) responding EPAs request as above: ICI acknolegde that "Environment" has not been tacked onto safety and health. The site environmental improvement team has accepted the task to implement the recommendations

Document 17

Reviewer: Loek

Adjustment of licence 2148

Report on emissions By products Recycler Plant

- PCDF is included in analytes (emission rate is 0.85 ng/min)

No other relevant mercury information in this file

Document 18

Reviewer: Katarina

The document includes:

- Documents from 1998
- Dames and Moore report on replacement of chlor-alkali plant –EIS- mercury cell technology will be replaced by modern membrane cell technology to produce chlorine
- The modernisation of the plant will result in improved wastewater quality and there will be no mercury in process water
- Existing CAP described in detail along with the process of producing chlorine . Mercury sludge form the system is directed to sludge filter and wastewater to effluent system .
- Usage of raw mercury material in CAP is 11.2 tonnes/year
- The volume of wastewater produced per year is 120 million tonnes . The sewage discharge point is equipped with online mercury analyser. When mercury exceeds 200ug/L the system shuts off
- Approximately 25 tonnes of mercury sludge is waste is generated per year . The waste is stored on site
- Concrete blocks which have been stabilised contain up to 1000mg/kg of mercury and these have been leachate tested prior to disposal to landfill. Around 1000 tonnes /y of this waste is generated
- Potential air emissions: from mercury cell area the vapour is directed to carbon adsorber to remove mercury and the air is vented to atmosphere. Hg vapour can not exceed 50ug/m3
- Mercury waste is proposed to be relocated to Vinyls plant for temp storage
- Mercury contamination associated with caustic soda spills
- Analytical results of gw samples in shallow gw are below 0.0005 for Hg and 0.038 for deep gw (below 15m)

Document 19

Reviewer: Katarina

The document includes:

- Document on disposal of the building wastes from the removal of solvents plant 1998
- No mercury is associated with this process

Document 20

Reviewer: Katarina/Loek

The document includes:

- Complaint was made re illegal discharge of waste (ferric acid and mercury) via valved pipe to the bay on demand. The anonymous complaint was discussed with Orica in the quarterly meeting on 27 October 1998 and Orica provided a letter refuting the allegation and provided EPA with a reasonable explanation. Ingress of groundwater occurred into stormwater as a result of rising gw level and defects in stormwater system
- Complaints regarding noise and emissions
- Statement of env effect 1998 prepared by Woodward Clyde – to combine all entities and lot numbers into one

Document 21

Reviewer: Katarina

The document includes:

- Subdivision application document prepared by Woodward Clyde in 1998
- Odour and gas emission complaints

Document 22

Reviewer: Katarina

The document includes:

- Discussion on granular iron permeable reactive barrier for remediation of halogenated organic compounds in groundwater in 1999
- Progress in isolating sections of the Springvale Drain for remediation of sediment
- Upgrade of stormwater pipes
- Shallow gw remediation for Southlands area using reactive iron barrier , test studies completed in 1997
- Bioremediation program was being developed in 1999
- Construction of pilot scale test in Feb 1999
- Stormwater pipes upgrade and Springvale drain realignment in Nov 1999

Document 23

Reviewer: Katarina

The document includes:

- EPA copy of licence from 1998-1999
- Incident report on ruptured disc at alkathene plant , resulting in discharge of ethylene and polymer to atmosphere
- Reactive barrier wall to be installed to 8m depth to intercept shallow gw
- High rainfall events in second half of 1998 resulted in gw entering the stormwater drain , subsequently Springvale drain and estuary.
- Stored waste on site includes mercury rich sludge accumulating at 5.7m3 per annum , the then current stockpile as at March 1998 was 68m3

Document 24

Reviewer: Loek

No relevant mercury information was found in this document

Document 25

Reviewer: Loek

Realigment Springvale drain, SHE Plan, June 1999:

- Expected Mercury in soil <10 mg/kg
- Expected Mercury in sediments <200 mg/kg (in base of Springvale Drain
- Overall objective is to ensure no soil sediment leaves the site.
- Sediment stockpile (assumed to be 30m3) shall be sampled by SHE Pacific and covered with plastic sheet

Letter EPA CH772/24 // CHF31880: EPA approves the "Speciation: Realigment of Springvale Drain, Orica Australia, Botany Industrial Park". EPA refers to the waste classification guidelines.

City of Botany informed EPA that it has concerns of surface water quality at the interceptor linking Springvale Drain and Floodvale Drain. Council sent CH2MHill report Site Remediation Works John Fletcher International to EPA. 4 GW wells were sampled on this Site and mercury was non-detect in all four wells (I made a copy of the map and results)

Document 26

Reviewer: Loek

Letter from EPA regarding Realignment of Springvale Drain

- All excavated materials must be stockpiled and sampled in a statistically valid manner. This will determine reuse for access roads on Southlands Block 2 or storage awaiting remediation in a purpose build area on Block 1
- Botany Bay CC has requested a CEMP to be prepared

Draft letter EPA to Orica re Voluntary Investigation and Remediation Proposal: EPA Agreement.

- Mercury has been identified as a specific Orica sourced contamination
- Orica's objective is to achieve a 50% reduction in contaminant load in the shallow aquifer
- EPA will not issue an investigation or remediation order against Orica
- An email with questions raised by several EPA people is included. Concerns about deep aquifer not being remediated and 50% reduction goal. Is that set in concrete?

Meeting minutes CLC – No. 7, 21 Sept 1999:

- EPA suggested Orica to summarise the re-calculated Health Risk Assessment. SHE Pacific (consultant from Orica) explained that the only receptor showing a change was the hypothetical child swimming in Penryhn Estuary. Chance of cancer rose from 10^{-7} to 10^{-4}.
- Mitigation actions have been undertaken (e.g., removal of facilities at the old boat ramp, and installation of warning signs)
- Situation of someone swimming in the Estuary is unlikely due to siltation

Email EPA Sept 1999:

- EPA requested Orica to recalculate HRA they did in stage 2 in light of newer, more extensive monitoring results: increase in risk for children swimming in Penrhyn Estuary.
- Reality check: water level is extremely low and HRA says kids must swim for a couple of hours once a week every week of the year = unlikely

Annual report Orica (letter Orica from 24 August 1999)

- Orica commenced re-lining ungrouted stormwater pipes
- Report mentioned ingress of contaminated groundwater into stormwater drains

Report" Progress in the management & destruction of scheduled HCB Chemical Waste, EPA 11/08/99

- No mention of mercury in this report
- There is an laboratory certificate attached to this report: BPR Emissions 10 May 1999
    - Not analysed for mercury

- A result was provided for 2,3,7,8 substituted PCDFs (0.024 ng/Sm^3) and other PCDD and PCDF congeners

Document 27

Reviewer: Loek

Letter from Botany Industrial Park P/L)

- EPA Identification No 1 and 2 (label on Orica drawing B93211 is 7 resp. 5). Both to be analysed for Hg (100 percentile limit is 3 mg/m^3)

Letter from Orica (11 April 2000), Condition 19 CEMP

- Condition 20 (i) – for inclusion in B5; "mercury monitoring above the construction site did not detect any mercury in the atmosphere above the site. However, there will be ongoing monitoring for mercury in excavations…."

Minutes CLC Meeting 29 March 2000

- Springvale Drain Realigment completed in March 2000 having commenced in January. See photos presentation CLC Committee Meeting No.9 (29 march 2000). Not sure if the old drain has been remediated? Still in place? I have not found an evaluation report yet.

Letter from the Minister for the Environment to the Member for Coogee (Bob Debus) regarding concerns Ms June Moore (10 Kent Street, Waverly) that Orica emits 2,75 millions kg of waste a year into the atmosphere: Orica will replace anode technique with membrane technique (early 2001) and will reduce mercury emissions dramatically.

CEMP for the new Chlor Alkali Plant.

Letter from Botany Industrial Park P/L

- Period 1/10/99 to 31/12/99
    - Solid Brine Blocks (N170) 72 tonnes to Pacific Waste Management, Kemps Creek

Article Syndey Morning Herald 29/01/2000: 230 kg Hg of mercury is being released into the skies annually. Neither Orica or EPA were aware of this number until last year.

Document 28

Reviewer: Loek

Quaterly waste report (on letter head from Botany Industrial Park P/L)

- Period 1/4/00 to 30/6/00
    - Solid mercury waste (D120) 30 tonnes to Pacific Waste Management, Kemps Creek
    - Solid Brine Blocks (N170) 96 tonnes to Pacific Waste Management, Kemps Creek
    - Solid mercury waste (D120) 1514 tonnes to Penrith Waste, Mulgoa
- This report mentions 165 tonnes solid mercury waste (D120) from Qenos P/L disposed off at Penrith Waste, Mulgoa

Licence Orica 2148 (POEO 1997 Act)

- Monthly mercury air sampling is required at points 1 and 2. EPA metod 12, 13 & 14 (US EPA Method 29). Limit is 3 mg/m^3. Analytical method use to be Cold Vapour AAS.

Licence Orica 26 (Environmental Hazardous Chemicals Act 1985)

- Condition 26.2: 2,3,7,8, furans must be analysed individually

Orica Botany Environmental Survey, Stage 3 – Remediation Proposed Shallow EDC Plume Containment, Woodward-Clyde, 5 May 2000

- Pumptest undertaken: hydraulic conductivity of 15m/day (transmissivity ~ 50 m^2/day). URS undertook an independent review and concluded the results as valid.
- Mercury was not analysed for in this report
- New Springvale date alignment was visible in drawings

Returns?? from Orica (Statement in Support of Application for Environment Protection Licence)

- Hg vents/stack emission coordinates discharge points Hg to Air
- 2 discharge points of mercury to water (point 10 and 12)
- Annual production hydrochloric acid is 44,000 te/annum
- Hg waste generated at: Brine (sludge containing mercury), Clorine Production (fugitive Hg), Hydrogen plant (fugitive Hg in vented hydrogen and mercury contaminated carbon (stored pending Hg recovery))
- Pollutant loads: 0.23 te per year atmospheric emissions
- An overview with waste streams has been provided by Orica. However waste codes D120 (mercury waste) has not been mentioned.
- Waste code N170 (Stabilised brine waste blocks). March 1999: 2709 tonnes per annum.

Archived Document, Pollution Control Act, 1970, licence 2148:

- special condition: commission the rebuilding or repair of the ungrouted stormwater pipes between Site proper (8^{th} Avenue) and Springvale Drain.
- Condition 83: approval from EPA must be obtained for removal of sludge from the site

Waste Minimisation and Management Act, 1995 (licence 6901)

- Condition 2.1: ….and mercury waste (as agreed to in writing with the EPA) may be accepted at this facility.

Document 29

Reviewer: Loek

Stage 3 – Remediation Air Emissions Report (27 October 2000, URS (Woodward-Clyde), prepared for SHE Pacific P/L). No Mercury was sampled/analysed for. Recommendations were to do air emission sampling once a year where the main groundwater plume is but also at residential areas

Letter EPA (13 Oct 2000) to Orica that EPA amended their licence so that Orica can store waste temporarily from Lidcome Liquid Waste Plant at their location during the Paralympics (16-30 Oct 2000)

Minutes CLC Meeting 10 (2/8/2000):

- Groundwater gradient is app 1:flowing at around 1 to 2 m/day

Letter EPA (4 Sept 2000) to Orica that EPA amended their licence so that Orica can store waste temporarily from Lidcome Liquid Waste Plant at their location during the Olympics (starting 1 Sept 2000 for 5 weeks)

Annual report (Orica, 7 August 2000) for licence No. 26: Mercury not mentioned in this report. It focuses on HCB and CPWE.

Emission report for the BPR Unit (Orica, 9 August 2000). Results include PCDFs (condition 13/14 licence No. 26)

Document 30

Reviewer: Loek

CLC Meeting no11 – Minutes

- 1000 $m^3$of sediments will be excavated from the bed of the bypass. Sediments will be relocated to a sediment containment structure adjacent to Nant Street pending sampling and analyses to determine treatment and disposal

Botany Industrial Park Pty Ltd (15 December 2000) – Annual Report on Environmental Performance and Compliance

- Implementation of a computerised waste tracking system

Botany Industrial Park Pty Ltd (22 November 2000) – Report on Compliance with Pollution Reduction Programs 1999-2000

- Stormwater PRP: Orica has retained the responsibility for its legacy issues, even on those portions of land being sold to Qenos and Huntsman
- Two major stormwater drainage systems were completely religned to prevent ingress of contaminated groundwater
- During 2000 Orica commenced construction of the new CAP
- Orica has constructed a temporary diversion of Springvale Drain as it passes through its McPherson Street to enable the removal of contaminated sediments from the course of the old drain. This will mean that historic deposits of mercury will no longer be carried downstream to Botany Bay
- No mention of Mercury emissions/monitoring

Botany Industrial Park Pty Ltd (6 November 2000) – Fourth quarterly Waste Report (Orica Licence 2148; Qenos Licence 10000, Huntsman Licence 007513), period 1/7/00 – 30/9/00

- N170: 188 tonnes to Kemps Creek
- D120: 513 tonnes to Penrith Waste, Mulgoa (from Orica)
- D120: 50 tonnes to Penrith Waste, Mulgoa (from Qenos)

Botany Industrial Park Pty Ltd, 22-11-2000. BIP proposes to use their own mercury analytical method for stack emissions. Licence required method 12,13,14 to be used (similar to US-EPA method 29)For point 2 (the End Box Vent, the specification is 3 mg/m3) between 18/8/1999 to 21/7/2000 the highest level measured was 0.7 mg/m3 with all but one reading well less than half this value (monthly readings).

Document 31

Reviewer: Loek

Letter EPA re approval of natural immobilisation mercury in sediments Springvale Drain

- Oricia needs to provide a more scientifical evidence why the Hg is immobilised naturally in the sediments. TCLP tests alone is not enough. EPA has asked for XRD or SEM results

Letter from Orica (15 December 2000) to Premier of Victoria (Steve Bracks) that Orica supports the call for a Commission of Inquiry to be held regarding the HCB Waste (10,000 tonnes stored in 60,000 drums, remediation costs in the order of $80 million, preferred technique is GeoMelt). Also Orica recognises that Community Engagement is very important.

Document 32

Reviewer: Loek

Springvale realignment Development Application (Both EPA and Botany Council say that the other is the competent Authority)

Project Specification Springvale Drain Sediment Removal & Drain Reconstruction, 16 November 2000. Prepared for Orica. Prepared by Orica Engineering:

- Remediation of existing stormwater drain to prevent ingress of potentially contaminated groundwater was completed in April 2000
- Diversion of a section of the Drain – completed in March 2000
- Remediation/removal of contaminated sediments in the bypassed section of the drain and reconstruction/recommissioning of that section within 5 years of the completion of Program Scope Item 2 (diversion as above)
- The temporarily drain needs to be used for recharge/infiltration trench for extracted groundwater (EDC Plume) after air stripping
- Sediments will be disposed of as naturally immobilised solid waste (*note CDMS: this was not approved by EPA*) or stored onsite

Draft minutes CRC meeting no. 12. Minutes prepared by Orica for review for EPA/Dept Health/UNSW/DLWC/BBCC

Orica Botany Groundwater remediation Project, Annual Report to the NSW EPA, Revision 1, 26 February 2001

- Gives good overview of all groundwater contaminations at Orica's site
- Marine biota: baselines levels for mercury in fish were established by Dr Roger Drew (toxicologist)
- Repair of Orica's stormwater pipes was completed in March 2000. Project completion report was issued to EPA on 29 June 2000
- Springvale Drain was remediated and completed in Feb 2000. Project completion report was issued to EPA on 29 June 2000
- App 1 is a URS report prepared for Orica to meet the requirements of the Voluntary Remediation Agreement (VAR):
    - Mercury in marine biota (Stage 2 S2/C4 Woodward-Clyde 1996) were below National Health and Medical Research Council (NHMRC) Maximum Residue levels (MRLs)
    - Stage 3 survey: fish was collected from Penrhyn Estuary and two reference sites. Mercury was detected
    - Emissions from contaminated groundwater to air were assessed during 1995-1999. Residents and recreational users were identified as main receptors and samples were collected off site and onsite (*Note CDMS: no mercury was sampled for)*
    - Update of the HHERA (Stage 2) is described in this document. Since the original HHERA (date unknown) the risks for children (5-12 years) who may swim or wade in the Penrhyn Estuary have increased with a factor of 1000 (non-threshold

carcinogenic risks 5*10-7 to 5*10-4 and from 0.27 to 1.6 for the threshold hazard index). The original HHERA was updated due to increased levels of EDC in groundwater.
    - The May 1999 surface water quality results are generally the highest that have been recorded since monitoring commenced in 1995
    - Recommendations:
        - More data, weekly at high and low tide and at old and new boatramp needs to be collected
        - Warning signs at old boat ramp to be placed in a more prominent spot to warn people not to use old boat ramp (closer to Springvale Drain outlet) for swimming
- Springvale drain and estuary investigations. Mercury in sediments samples in Southland with max concentrations of several hundred mg/kg and in Estuary sediments in the range of 0.2 to 5.2 mg/kg
    - primary mechanisms for mercury migration to Southlands were trade waste discharges prior to connection to sewer in 1958, historical leaks and spills on the CAP then migration via surface water and boiler ash migration to drain
- SHE Pacific is now called Orica Engineering
- In the appendix is a report from Toxikos (Roger Drew) on mercury in fish caught in the Penrhyn Estuary and reference sites. It is considered that mercury (and HCB) levels found in fish from the 1998 survey (and 1993/1994/1994/1996/1996) do not pose a health risk to humans.
- Dr David Major from GeoSyntec Consultants provided expert advice on bioremediation of EDC (Ethylene DiChloride) groundwater contamination

CLC meeting No 11 (22 November 2000)

- Porst 2000, Sydney Port Corporation: Penrhyn Estuary would be significantly affected by the expansion. Sydney Ports has a number of options in mind for the Estuary

Document 33

Reviewer: Loek

HCB Environmental Impact Statement refers to mercury in Chapter 8 and appendix D where soil analysis are presented in detail. *(CDMS: we haven't seen the EIS <yet>).*

Letter URS to EPA (7 September 2001), proposed HCB waste Destruction Facility at Orica

- Mercury criteria in EIS: 1.8 ug/m3, EPA criteria 0.93 ug/m3 (approved methods and guidance for the modelling and assessment of air pollutants in NSW, NSW EPA, August 2001), maximum predicted concentration incl background is 0.09 ug/m3
- Discussion about Mercury in soil stockpile No. 1 (2,400 tonnes). Orica wants to use this stockpile in the GeoMelt process.

Annual return licence 2148, Orica letter to EPA (16 August 2001): 21/7/2000 to 21/7/2001

- Outlet of final mercury absorber in waste hydrogen: Monitoring point 1 (point 7 on drawing B93211): mercury lowest-mean-highest: 0.1-0.62-1.2 (mg/m3), 10 samples analysed (not 12, explanation provided), in-house monitoring method, now being discussed with EPA
- End Box vent: Monitoring point 2 (point 5 on drawing B93211: mercury lowest-mean-highest: 0.1-0.13-0.4 (mg/m3), 11 samples analysed (not 12, explanation provided), in-house monitoring method, now being discussed with EPA
- 16 complaints received. Most noise and odour
- I made a copy of the map provided

Botany Industrial Park P/L, letter with quarterly waste reports (period 1/4/01 to 30/06/01), Orica

- D120, 798 tonnes (flexible excavation was the transporter) >> Penrith Waste Mulgoa
- D120, 25 tonnes (mulgoa quarries was the transporter) >> Penrith Waste Mulgoa
- N170, 6 tonnes >> Kemps Creek
- N170, 98 tonnes> Kemps Creek
- Qenos P/L: D120, 5.04 tonnes (Penrith Waste)

Advice from EPA on HCB EIS stack emission discharge limits

- USEPA Emission limits for Mercury : 45 ug/m3
- Ground level concentrations (GLC) Mercury (organic) : 0.00003 ppm (0.0003 mg/m3)
- Ground level concentrations Mercury (inorganic) : 0.0017 mg/m3
- GLC must be reported on an averaging period of 3 minutes

Report on Encapsulation Groundwater Monitoring, Round 5, May 2001 as required by condition 18.2 for Orica EHC Licence No. 26

- Wells were not analysed for Mercury.
- Inferred flow direction September 1999: SW
- Inferred flow direction May 2001 : W (groundwater levels are 1m lower than in 1999)

Annual return licence 2148, Orica letter to EPA (11 September 2000): 21/7/1999 to 20/7/2000

- Outlet of final mercury absorber in waste hydrogen: Monitoring point 1 (point 7 on drawing B93211): mercury lowest-mean-highest: 0.01-0.41-1.7 (mg/m3), 9 samples analysed (not 12, explanation provided), in-house monitoring method, now being discussed with EPA
- End Box vent: Monitoring point 2 (point 5 on drawing B93211: mercury lowest-mean-highest: 0.01-0.14-0.93 (mg/m3), 11 samples analysed (not 12, explanation provided), in-house monitoring method, now being discussed with EPA
- Mass Monitoring was NOT required (condition R1.1 and M6)
- 2 complaints received. Noise related

Phone record (Robert Evans/Orica with EPA on 14 June 2001)

- Mercury levels at monitoring point 1 was max 9.6 mg/m3 however this was when there was NO gas flow in the vent. Two readings were excluded from the annual returns (now 9 and not 11);
- Orica proposed new waste category: ""filter cake" is currently produced from the system but is turned into concrete blocks to immobilise the Hg. Hg will no longer be used in the new system and the filter cake produced will not need to be immobilised"

Letter Botany Industrial Park P/L (30 May 2001)

- Orica request to remove mercury monitoring at points 1 and 2 from its 2148 licence as the new CAP will not use mercury

Letter Botany Industrial Park P/L (29 May 2001)

- Orica provides information on their method used to derive Mercury concentrations in the Stack Emissions.

Document 34

Reviewer: Loek

Copy of the ESA for the Proposed HCB Waste Destruction Facility, Volume 1 Main report, July 2001.

Not relevant for this review

Document 35

Reviewer: Loek

File contains only documentation on the proposed HCB Waste Destruction Facility

File is not relevant for this review

Document 36

Reviewer: Loek

900 public submissions were received in response to the HCB destruction facility. Majority of the concerns was that the EIS didn't consider alternative technologies and alternative treatment sites.

EPA submission to the commission of inquiry of the HCB waste destruction plant, 11 February 2001

- Mercury: there is a potential it will be emitted from the proposal. The emission limit 0.1 mg/m3 is 10 times as stringent as the maximum emission limit of 1 mg/m3 specified by the Clean Air (Plant and Equipment) Regulations 1997

Licence 2148: L4 Volume and mass limits: L4.1 Not applicable

Revised Modelling: One Stack Only, Orica HCB Waste Destruction Facility, URS, 11 October 2001

- Ausplume 5.2 was used. Mercury was also modelled.

Document 37

Reviewer: Loek

Project completion report to EPA, NSW, 18 December 2001, Springvale Drain Sediment Removal and Drain Reconstruction

- 1000 m3 of sediments from basement of the drain have been stockpiled on site
- Photo (in colour) compilation provided in report

Orica Botany Groundwater Remediation Project, Annual Report to NSW EPA, 27 February 2002

- 8 November 1996, Orica issued a proposed Stage 3 RAP (the Five-year RAP). The RAP was based on pollution reduction strategy. February 2000 Orica entered in a Voluntary Investigation and Remediation Agreement (VRA3) with the EPA (ended December 2001). In December 2001 Orica submitted the VRA4 which was issued by EPA in January 2002
- *CDM Smith: Mercury contamination in groundwater has not been recognised as a COC in the VAR*
- Repair of Orica stormwater pipes undertaken to prevent groundwater ingress into the stormwater system (and subsequently in Springvale drain). Ingress ceased after the works
- 420 tonnes of soil and sediment were excavated from the Springvale drain and was stored onsite/sampled and classified as Industrial Waste. **Material was transported to the SITA Industrial Landfill in December 2001**
- In section 4.3.1. it is mentioned that NSW EPA has grant approval for the classification of the waste material as Industrial

Commission of Inquiry into proposed HCB Destruction facility at Orica Botany – Response to Questions (20 March 2002)

- Mercury emission concentration of 0.1 mg/m3 (glc, ground level concentration) is based on the application of best practice
- Air Scientist from the NSW EPA answered that they don't have ambient air data for mercury and advice to contact people involve in the inventory of air toxics
- The EPA does not have background air quality data for mercury

Document 38

Reviewer: Katarina

Document contains the info on human health risk assessment related to HCB soil encapsulation at Orica. Sampled analytes do not include Hg.

Chemicals analysed as part of Car park gw monitoring program do not include Hg.

Document 39

Reviewer: Katarina

EPA letter to Orica re proposed HCB waste destruction facility and discharges to air and water. Discharges to air at EPA point 8 should not exceed 0.1 mg/m3 Hg at 100% concentration. EPA point 9 is required to be monitored at quarterly intervals for mercury when facility is operating.

Document includes the reference to proposal to construct and operate HCB waste destruction facility. Major environmental aspects relating to this proposal are air emissions, hazards and risks and health aspects. Mercury is named as one of the pollotants that may be present in the facility discharge. Regulatory emission limit for Hg is 1 mg/m3 (NSW EPA), however the proposed consent Orica's limit is 0.1 mg/m3. It was stated that no background ambient air quality existed for the Botany area for mercury. Air modelling (in 2002) assumed 0.006 ug/m3 per 1-hour average based on the Vic EPA and review of Australian and international studies. . A conservative estimate of fugitive emission of mercury from the then decommissioned Orica ChlorAlkali Plant were used – 0.0004 g/s. Air modelling predictions indicate that estimated background conc of mercury is 0.005 *(1 h average) with 0.46 maximum predicted conc and 0.46toal maximum conc.

Mercury was identified as one of the components with low levels of conc. That is present in contaminated soi which will be used in the melt cells (Geomelt).

Air quarterly monitoring at point 9 is required for Hg.

Document 40

Reviewer: Katarina

Document includes bioremediation field trials with DCA remediation and papers on natural attenuation of DCA. As part of bioremediation trials mercury was sampled during baseline collection and during week 12, 24 and 36 of the trial.

Document 41

Reviewer: Katarina

Document includes annual report for groundwater remediation project (2003)

Groundwater monitoring report 2003 (URS) summarises the records of shallow and deep , northern (EDC storage areas), central (main EDC under Block 2) and southern (under Block 1 contains CTC, PCE, TCEand VCM)plume. Surface and gw monitoring of EDC, CTC, PCE,PCA and VC. No change in conc from 1999-2002.

Air emisssions sampling undertaken in 5 programs between 1995-2001. Four offsite locations were sampled.

2002 reactive iron barrier technology performance after 39 months of trial operation

Full scale iron barrier planned for 2003.

Offsite piezometers samples for chlorinated hydrocarbons.

Bioremediation field trials in shallow and deep aquifer. Sampling program includes dissolved metals incl mercury, anions, degradation products (methane, ethane ect) .

EPA licence in 2001 – mercury allowed in the air <0.1mgm3

Document 42

Reviewer: Katarina

Typical analysis of Hg given for different waste types: asbestos sheeting, fibre glass, plastic, brine, sludge, concrete, timber. Hg conc vary from 90mg/kg for sludge to 3000 and 4300 mg/kg for asbestos sheeting and timber respectively. Attached scanned document with this file.

Waste disposal records for the period from 1 July to Sept 2003, indicate Collex Powerclean disposed of 42 solid mercury and Mulgoa Quarries 362.7 solid mercury. Out of this 387.7 solid mercury went to Collex Landfill and 17 went to Collec Powerclean.

The document mainly contains notes on community meetings and presentations, complaints, dicholorethane (EDC) found in gw bore and no reference is made to mercury.

Document 43

Reviewer: Katarina

Reference is made in the document to atmospheric monitoring for Chlorine. Gas detectors are reviewed for Chlorine.

Document 44

Reviewer: Katarina

Document contains no relevance to mercury, only hexachlorobenzene.

Document 45

Reviewer: Katarina

Document contains no relevance to mercury,

Tanker loading facility and stream stripping unit

Details of passive bioremediation barrier on Foreshore rd

Installation of pipeline to transfer contaminated groundwater

Document 46

Reviewer: Katarina

Document contains no relevance to mercury.

Hydraulic containment – secondary containment area

GW modelling – gw abstraction rates for hydraulic containment of contaminant plumes and source areas

Document 47

Reviewer: Katarina

The doc includes:

- The report on air emission modelling report (excl Hg) and emergency release emission management plan in relation to Stream Stripping unit to treat contaminated gw. Stream stripping modelling report is included.
- EDC seeping into Penrhyn estuary
- REF for Stream Stripping unit - Mercury not mentioned
- REF Appendix F has hazard analysis report on groundwater Phase 2 project - Mercury not mentioned

Document 48

Reviewer: Katarina

The doc includes:

- Stormwater and spill management plan and drawings prepared by KBR, 2004 as a result of the operation of the Botany Groundwater Clean-up Project Phase 2- includes primary pipeline and stream stripping unit- Mercury not mentioned
- Progress reports on Stream stripping unit – H2S in groundwater originally then adsorbed by the carbon , conc of EDC and VCM relevant, high methane in gw
- Health risk assessment - no mercury info
- Health risk assessment for GWTP, air quality impact assessment – no mercury data
- GWTP EIS (2004)

Document 49

Reviewer: Katarina

The document includes:

- Best practice benchmarking report – no mercury info
- EPL licence variation Point 11- lowest limits contested , detection limit for Hg is 0.005 mg/L
- Progress report for car park waste encapsulation- no mercury data 2005
- Reports on special licence conditions E2.1
- Extension of Groundwater extraction exclusion area due to chlorinate hydrocarbons in gw at 12m depth
- GW clean-up project REF for Excess treated water discharge 2005 – for treated water pipeline to stormwater channel – no mercury info
- Risk assessment for prioritising env improvements- HCB issues 2005
- Report of results of pilot trial of air stripping

Document 50

Reviewer: Katarina

The document includes:

- EPA licence variation point 14 and 18 – no mercury
- Additional points suggested 20,21,22 at Springvale Drain and Penrhyn estuary 2005

Document 51

Reviewer: Katarina

Info on waste movement from January 2006- March 2006, 30 solid mercury waste moved off-site

In 2006 KBR prepared the report for the demolition of CAP. The report identifies power house (northern wall) to be heavy contaminated with mercury .

H cells block area, MK1 cell block area B2 cells block area – heavily contaminated with Hg , proposed for demolition and removal

Dangerous goods depot no 60 – used to be cooling water pond, then bund area for material, the proposal involves removal of material from the bund, sucking the liquid mercury from the bottom of the pond and replacing it with clean fill

Daily monitoring of atmospheric Hg required during works within and outside of the area

Mercury ongoing emissions impregnate the structures at a rate of 4000mg/kg

Annual LPI report quotes loss of Hg to atmosphere of some 340kg for the year ending 30 June 2005.

Photographs of CAP Hg contaminated bulidings.

Letter by SITA specifies that a separate cell would be constructed at Kempsey landfill for Hg disposal of waste from Orica.

Air emissions from EDC, VOC, VCM, not mercury.

Change in EPA 2148 licence conditions in 2005 , Hg monitoring discharge to waters GTP labelled site 11(0.0005 % conc), SSU and discharging to Springvale drain site 20

Document 52

Reviewer: Katarina

Review of EPA licence July 2006 – Hg now monitored in Site 11 – Discharge to waters from drain GTP site, and Site 14 effluent monitoring at drain outlet weekly monitoring , removed point 18 monitoring which had Hg, point 20 retained in the licence

Information and modification of Thermal Oxidiser and dioxin emission GWTP closed temporarily

Application for discharge to air during demolition of the HCB, EPA has not granted the application

Document 53

Reviewer: Katarina

Document contains no relevance to mercury, apart from mentioning it in the EPA licence.

Document 54

Reviewer: Katarina

EPA licence(issued Feb 2005) has added point 11, which represents discharge to water –effluent quality , which is drain outlet into Bunnerong Canal (with further flow to Botany Bay). This point has limit imposed on it with Hg conc limit of 0.0001 mg/L. This is based on the ANZECC (2000) guidelines for protection of aquatic ecosystems. Weekly sampling is required at this point. Mercury compounds can be treated , processed on premises, and stored on premises.

Orica has added the value of mercury to Point 11 of 0.0006mg/L being ANZECC for freshwater ecosystems. No EPA licence required if discharge water satisfies ANZECC limits. Orica suggested monthly sampling for Hg at this point.

Document 55

Reviewer: Katarina

Report for voluntary remediation agreement (Feb 2005) states that:

- Conc of Hg in fish and oyster tissue (samples from 2003 and 2004) is less than maximum residue limit(MRL)- this is max conc of an agricultural or veterinary chemical recommended as acceptable max conc in food
- Hg in oyster tissue was lower than that measured in 1996

NSW-EPA - Orica Botany Mercury Independent Review		
Name reviewer	Loek	
Document Number	56	
Document ID	500755A48/01	
Document Title	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - Orica Pty Ltd - 16-20 Beauchamp Road Matraville - EHC Act Licence No 26	
Box Number / E-folder	EPA 10/15	
Location of the Site as described in the document (include a with bore locations in this excel tab)	Not Included	
Location of the Site as described in the document added to the aerial photo	Yes	
Overall relevancy to the project to address human and environmental impacts of mercury	Nil	

Conceptual Site Model, F&T, Site Characterisation (input)	Yes/No	
Analysed for Mercury	Yes	20 samples (representing 20% of the total amount of samples)
Historical practises and releases	No	
Known releases and releases points	No	
Landuse (historic)	No	
Landuse (current)	Yes	Filled Embankment beside public street (Corish Circle)
Fate and transport considerations	No	
Media: Soil (mg/kg)	Yes	maximum value of Hg was 0.3 mg/kg
Media: Groundwater (ug/L)	No	
Media: Sediment (mg/kg)	No	
Media: Air (ug/m3)	No	
Describe analytical methode used	Yes	ET-035T
Groundwater depth (mBGL)	Yes	between 9-11 mBGL (July 2004 assessment)
Groundwater flow direction	No	
Velocity (m/d)	No	
Borelogs provided in report	No	
Statigraphy encountered	Yes	2m boreholes, dand fine to medium grained
Aerial Photos (and year)	No	

Mercury Toxicology (HHRA)	
Impact from inhalation of elemetal mercury	No
historical ingestion of methyl mercury via local seafood	No

Mercury Exposure (HHRA)	
Atmospheric release of vapours	No
(in)appropriate disposal of sludge form the mercury cells	No
Dumping activities	No
Accidental spills	No
Upset conditions during operations	No
Historical releases	No
Ongoing releases	No
Groundwater extraction techniques	No

Vapour Intrusion and Air (HHRA)
Emission from the Chlor Alkali Plant
Flux and Concentrations
Emission points, stack height

Mercury cell electrolysis	
polychlorinated dibenzofurans assessed (2,3,7,8 substituted PCDFs)	No

Site Waste Handling and Disposal Practices	
Historical records available	No
Historic Events/accidents recorded	No

Conclusions and Recommendations

Type here the recommendations as per the report
Additional investigation works below 2m recommended
these have been undertaken in July 2004. During that assessment soil samples were not analysed for Mercury. 11 Boreholes were drilled up to 11m BGL in the same area

Additional Relevant Information

Type here any relevant information
HCBD Further Delineation Sampling

Location (in purple) where the Assessment took place. (Location in red is the former CAP)

NSW-EPA - Orica Botany Mercury Independent Review		
Name reviewer	Loek	
Document Number	57	
Document ID	500755A48/02	
Document Title	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - Orica Pty Ltd - 16-20 Beauchamp Road Matraville - EHC Act Licence No 27	
Box Number / E-folder	EPA 10/15	
Location of the Site as described in the document (include a with bore locations in this excel tab)	Not Included	
Location of the Site as described in the document added to the aerial photo	Yes	
Overall relevancy to the project to address human and environmental impacts of mercury	Nil	

Conceptual Site Model, F&T, Site Characterisation (input)	Yes/No	
Analysed for Mercury	No	Mercury not identified as a CoC
Historical practises and releases	No	
Known releases and releases points	No	
Landuse (historic)	No	
Landuse (current)	No	
Fate and transport considerations	No	
Media: Soil (mg/kg)	No	
Media: Groundwater (ug/L)	No	
Media: Sediment (mg/kg)	No	
Media: Air (ug/m3)	No	
Describe analytical methode used	No	
Groundwater depth (mBGL)	No	
Groundwater flow direction	No	
Velocity (m/d)	No	
Borelogs provided in report	No	
Statigraphy encountered	No	
Aerial Photos (and year)	No	
Mercury Toxicology (HHRA)		
Impact from inhalation of elemetal mercury	No	
historical ingestion of methyl mercury via local seafood	No	
Mercury Exposure (HHRA)		
Atmospheric release of vapours	No	
(in)appropriate disposal of sludge form the mercury cells	No	
Dumping activities	No	
Accidental spills	No	
Upset conditions during operations	No	
Historical releases	No	
Ongoing releases	No	
Groundwater extraction techniques	No	
Vapour Intrusion and Air (HHRA)		
Emission from the Chlor Alkali Plant		
Flux and Concentrations		
Emission points, stack height		
Mercury cell electrolysis		
polychlorinated dibenzofurans assessed (2,3,7,8 substituted PCDFs)	No	
Site Waste Handling and Disposal Practices		
Historical records available	No	
Historic Events/accidents recorded	No	

Conclusions and Recommendations

Type here the recommendations as per the report

Additional Relevant Information

Type here any relevant information
HCBD Car Park Air Emissions Sampling Program, October 2004

Location (in purple) where the Assessment took place. (Location in red is the former CAP)

NSW-EPA - Orica Botany Mercury Independent Review		
Name reviewer	Loek	
Document Number	58	
Document ID	500755A48/03	
Document Title	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - Orica Pty Ltd - 16-20 Beauchamp Road Matraville - EHC Act Licence No 28	
Box Number / E-folder	EPA 10/15	
Location of the Site as described in the document (include a with bore locations in this excel tab)	Not Included	
Location of the Site as described in the document added to the aerial photo	Yes	
Overall relevancy to the project to address human and environmental impacts of mercury	Nil	
Conceptual Site Model, F&T, Site Characterisation (input)	Yes/No	
Analysed for Mercury	No	Mercury not identified as a CoC
Historical practises and releases	No	
Known releases and releases points	No	
Landuse (historic)	No	
Landuse (current)	No	
Fate and transport considerations	No	
Media: Soil (mg/kg)	No	
Media: Groundwater (ug/L)	No	
Media: Sediment (mg/kg)	No	
Media: Air (ug/m3)	No	
Describe analytical methode used	No	
Groundwater depth (mBGL)	Yes	9 - 10 mAHD
Groundwater flow direction	Yes	South East
Velocity (m/d)	No	
Borelogs provided in report	Yes	
Statigraphy encountered	No	
Aerial Photos (and year)	No	
Mercury Toxicology (HHRA)		
Impact from inhalation of elemetal mercury	No	
historical ingestion of methyl mercury via local seafood	No	
Mercury Exposure (HHRA)		
Atmospheric release of vapours	No	
(in)appropriate disposal of sludge form the mercury cells	No	
Dumping activities	No	
Accidental spills	No	
Upset conditions during operations	No	
Historical releases	No	
Ongoing releases	No	
Groundwater extraction techniques	No	
Vapour Intrusion and Air (HHRA)		
Emission from the Chlor Alkali Plant		4 ambient air samples were collected but not analysed on Mercury
Flux and Concentrations		
Emission points, stack height		
Mercury cell electrolysis		
polychlorinated dibenzofurans assessed (2,3,7,8 substituted PCDFs)	No	
Site Waste Handling and Disposal Practices		
Historical records available	No	
Historic Events/accidents recorded	No	
Conclusions and Recommendations		Type here the recommendations as per the report measure waterlevels and pumping flow rates in production bores to better understand the effect of the local inferred groundwater flow direction collect groundwater samples from production bores and sample on TPH/MAH/SVOC/VOC install additional monitoring wells
Additional Relevant Information		Type here any relevant information

Location (in purple) where the Assessment took place. (Location in red is the former CAP)

Document 59

Reviewer: Katarina

Document contains no relevance to mercury.

Non related discussions:

Discussion on HCB soil encapsulation and liner integrity

Issues with elevated levels of HCBD in air

HCB waste destruction by GeoMelt

Document 60

Reviewer: Katarina

Document contains no relevance to mercury.

Non related discussions:

- Issues with encapsulation of hexachlorobutadiene (HCBCD) and contamination of gw
- Technology review of remediation and risk assessment matrix for different methods

Document 61

Reviewer: Katarina

Document contains no relevance to mercury.

Non related discussions:

- Groundwater cleanup plan presented (Oct 2003)

Document 62

Reviewer: Loek

Document contains no relevance to mercury from the Orica Botany Plant.

Document is about total Catchment Management - Cooks River - Joint Meetings of Councils

Document 63

Reviewer: Loek

Document contains no relevance to mercury from the Orica Botany Plant.

Document is about total Catchment Management - Cooks River - Joint Meetings of Councils

Document 64

Reviewer: Loek

Document contains no relevance to mercury from the Orica Botany Plant.

Document is about total Catchment Management - Cooks River - Joint Meetings of Councils

Document 65

Reviewer: Loek

Document contains no relevance to mercury from the Orica Botany Plant.

Document is about total Catchment Management - Cooks River - Joint Meetings of Councils

Document 66

Reviewer: Loek

Document contains no relevance to mercury from the Orica Botany Plant.

Document is about total Catchment Management - Cooks River - Joint Meetings of Councils

Document 67

Reviewer: Loek

SPCC, Environmental Control Study of Botany Bay - Summary Report - For Discussion and Comment - December 1980

- This document does not contain much valuable information for the independent mercury-Orica review project

Document 68

Reviewer: Loek

Sediments in Penrhyn Estuary: 31-50% is Silt+Clay

Sampling Point *	Gravel %	Sand %	Silt %
127	-	27	73
128	-	28	72
129	-	42	58
130	-	53	47

*: Increasing distance from the Springvale Drain Inlet

Document 69

Reviewer: Loek

SPCC, Toxic Chemicals, Environmental Control Study of Botany Bay

- Study undertaken in 1979
- In this report, information on metal and orchanochlorine concentrations in fish and shellfish caught or grown in Botany Bay, Georges River and Cooks River has been surveyed.
- Hg in Botany Bay (or George River) Oysters (1973 – 1976) ranges between 0.03-0.08 mg/kg wet basis
- Hg Inorg in Oysters collected at 5 different sites in the Bay were between 0.02 – 0.03 mg/kg wet basis (April 1987)
- Hg Org in Oysters collected at 5 different sites in the Bay were between 0.02 – 0.05 mg/kg wet basis (April 1987)
- Hg Total in Oysters collected at 5 different sites in the Bay were between 0.04 – 0.07 mg/kg wet basis (April 1987)
- Hg Inorg in Praws/Crabs collected in the Bay (1978) were 0.02 mg/kg wet basis
- Hg Org in Praws/Crabs collected in the Bay (1978) were 0.06 mg/kg wet basis
- Hg Total in Praws/Crabs collected in the Bay (1978) were 0.08 mg/kg wet basis
- Hg in edible muscle tissue of small numbers of fish caught in the Bay have been analysed. Mean levels are below NHMRC maximum level (0.5 mg/kg) for all collected seven species (72 fish were sampled):
    - Inorganic Hg: mean ranges between 0.01 – 0.03 mg/kg (max is 0.04 mg/kg)
    - Organic Hg: mean ranges between 0.06 – 0.26 mg/kg (max is 0.35 mg/kg)
    - Total Hg: mean ranges between 0.04 – 0.29 mg/kg (max is 0.67 mg/kg)
- Mercury is the only metal whose maximum concentration in any fish has been greater than half of the recommended limit.

Document 70

Reviewer: Loek

SPCC – ICI Botany Environmental Survey Stage 1 Plerliminairy Investigations, May 1990 by A G Environmental Engineers in association with Woodward-Clyde Consultants INC. (USA)

- Steering committee oversaw these works
- No hydrolic conducting tested for
- Limitations with purge & trap
- ICI info: prior to 1958 effluent disposal was via Springvale
- Southlands (open to the public) was owned by Australia paper manufactures prior to 1980
- ICI bought Southlands in 1980 from APM
- Effluent treatment plant started operation in 1958
- Treatment in early 1970's at Malabar plant
- In 1989 contamination was found in a stormwater pipe that discharged into springvale drain contam water originated from groundwater seepages into drain at joints along section of the pipe
- Groundwater flow westerly / south westerly
- Groundwater velocity (site) 80-260 m/year
- Groundwater velocity (Southlands) 40-80 m/year
- Gw flow changes late 1960's – pumping in the north and in 1977 (Davis/Gelatine area, Swinbourne Rd, Anderson Street) + 1982 >> below average rain fall
- Boiler ash fill material present 0-1.0/1.5 mbgl
- Soil: Hg soil up to 1104mg/kg - WG 40, north of the heavy ends drums storage
- Soil: Boiler ash fill contain elevated Hg levels up to 20 mg/kg
- Shallow gw: Southland Hg in shallow groundwater < 2.5 ug/L
- Hg near chlorine plant slightly elevated 0.8 – 3.0 ug/L
- Deep gw: Hg? <0.1 ugl – 0.6 ug/l no obvious patern
- Surface water : Hg 0.4-2.0 ug/L Penhryn Estuary
- Surface water: 0.4-0.8 ug/l spingvale drain
- Sediments in Springvale drain: 0.2 -5.0 mg/kg (upstream)
- Surface sediments in Penrhyn Estuary 1.0 – 3.0 mg/kg
- Biota – Hg 0.2 – 1.3 mg/l – recommended NH&MRC guidelines were 0.5mg/l (for human consumption is (shell)fish
- In mussel / oyster Hg were <0.5
- Groundwater change: During the 1960's /1977-1982 the flow at Matraville was towards N-HW towards pumping on Anderson street
- No groundwater flow from ICI site was in the direction of residential
- Phase 1 was limited by NSW state pollution control commission (SPCC)
- 1944 CAP, carbon anodes / Hg cells
- Chlorine (Cl2 strong oxidizing agent), sodium hydroxide(NaOH caustic soda) and hydrogen (H2)
- Major ion-chemistry of groundwater is presented
- Detection limit Hg (groundwater) 1.0 ug/L

- Analytical method : cold vapour AAS
- Surface water: Hg Springvale drain all < 1.0 ug/l; in estuary entry 1.0 ug/l
- Water in ICI stormwater pipe: 700 ug/l
- Foration of mercuric sulphide (low solubility)
- Wells (WG-13, 14, 18, 30, 32, 33, 34, 40 and 60) between 0.3 – 3 ug/l
- Results on sediment samples in Drain & Estuary max Hg sediment 5.1 mg/l
- Good discussion about movement of contaminations in groundwater, local boxes , rainfall
- Gw levels in southland area fluctuate pending rain
- Biota: concentrations observed in 3 edible species tested in the study area within acceptable limits and pose either hazard to human health.
- Page 9 (phase 1): task 2: detailed Plant history not taken into account with sampling rationale
- Page 28: all effluent or spring vale drain prior to 1958 + discharge on ground in vicinity of present effluent treatment plant
- Page 153: backgound levels Hg in sandy spoils + boiler ash

Document 71

Reviewer: Loek

Position Paper, March 1990, Author unknown

- Approximately 100,000 tonnes of chlorine produced per year
- 105,000 tonnes per year of caustic soda
- Hg discharged to sewer in the waste stream from the CAP.
- Workers reported Hg spills hosed down to drain
- Hg was banned from sewer (old trade waste policy, 1972-1988) however ICI had a dispensation. When new policy came in place (June 1988) Hg was permitted
- Several people /employees reported that ICI used Springvale drain for disposal of a production waste stream
- Writer doubts if the ICI video from inside the drain showing ingress of groundwater through cracks is a video from the actual drain
- Spills were kept quiet from management
- Reference: ICO Australia (1989) Unusual Incidents Reports, May-July

Document 72

Reviewer: Loek

Report is not relevant for this review

Document 73

Reviewer: Loek

Document not relevant for this review

Document 74

Reviewer: Loek

This is the same document as document 70. Please refer to this document

Document 75

Reviewer: Loek

This document (March 1990) presents finding of the ICI investigations on 2,3,7,8, tetrachlorodibenzo dioxin (TCDD) and 2,3,7,8 tetrachlorodibenzo furan (TCDF). TCDF/TCDD may be by products of herbicides produced at the site.

- 45 soil samples collected >> 8 composite samples were prepared
- 2 biota samples collected from Penrhyn Estuary
- TCDD in soil were below <0.001 ng/gr (ppb)
- TCDD in sediments (Springvale Drain) were below <0.003 ppb
- TCDD is biota <3 ppt (pictograms/gr)
- TCDF in soils were between 0.0027 – 2.3 ng/gr (ppb)
- TCDF in sediments (Springvale Drain) were between 0.41 – 1.6 nanogram/gr (ppb)
- TCDF is biota <3 ppt (pictograms/gr)

No soil samples were collected at or near the FCAP.

NSW-EPA - Orica Botany Mercury Independent Review

Document Number	76
Reviewer	K. David
Document ID	LH 363.179/ICI
Document Title	ICI Botany groundwater Stage 2: Survey. Contract S2/C6, overview report / prepared for ICI Australia Engineering Pty. Ltd. Author: ICI Australia Engineering Pty. Ltd. Woodward-Clyde Consultants. New South Wales. State Pollution Control Commission. Publication Date: 1996
Box Number / E-folder	13/15
Location of the Site as described in the document (include a with bore locations in this excel tab)	Included
Location of the Site as described in the document added to the aerial photo	Yes
Overall relevancy to the project to address human and environmental impacts of mercury	High

Conceptual Site Model, F&T, Site Characterisation (input)	Yes/No	This is summary report for Stage 2 combining all works incl health risk assessment, gw , soil and sediments contamination with Hg
Analysed for Mercury	Yes	
Historical practises and releases	Yes	Hg associated with paints
Known releases and releases points	Yes	
Landuse (historic)	Yes	
Landuse (current)	Yes	
Fate and transport considerations	Yes	advection, dispersion, sorption and degradation. Geochem model: shallow and deep gw have anaerobic conditions, redox conditions in surface water , shallow and deep gw have high organic carbon content , solute transport moedl used to model EDC and CTC
Media: Soil (mg/kg)	Yes	
Media: Groundwater (ug/L)	Yes	Shallow gw historically contaminated with Hg,
Media: Sediment (mg/kg)	Yes	Hg identified in Penhryn Estuary in Stage 1 and 2 surveys
Media: Air (ug/m3)	Yes	
Describe analytical methode used		
Groundwater depth (mBGL)	Yes	35mAHD at Centennial Park , 9m AHD at the northeastern part of the plant site and 0mAHD at Botany Bay, gradient 1:120. Deep groundwater is confined , gradient is flatter than shallow system 1:350, flow is in a southwest direction, Springvale drain does not influence deep gw flow, shallow gw dischargeds to the drain,
Groundwater flow direction	Yes	southwest
Velocity (m/d)	Yes	AGEE 1990 report gw velocity at 80-260m/year, Stage2 reports 70-80m/year, in the upper layers and 3-4 m/year in the basal layer (Layer 3)
Borelogs provided in report	No	Provided in gw specific report
Statigraphy encountered	Yes	Reported and cross sections presented, details in the gw specific report
Aerial Photos (and year)	No	
Mercury Toxicology (HHRA)	NA	
Impact from inhalation of elemetal mercury		
historical ingestion of methyl mercury via local seafood		
Mercury Exposure (HHRA)	NA	
Atmospheric release of vapours		
(in)appropriate dosposal of sludge form the mercury cells		
Dumping activities		
Accidental spills		
Upset conditions during operations		
Historical releases		
Ongoing releases		
Groundwater extraction techniques		
Vapour Intrusion and Air (HHRA)	NA	
Emission from the Chlor Alkali Plant		
Flux and Concentrations		
Emission points, stack height		
Mercury cell electrolysis	NA	
polychlorinated dibenzofurans assessed (2,3,7,8 substituted PCDFs)		
Site Waste Handling and Disposal Practices	NA	
Historical records available		
Historic Events/accidents recorded		

Conclusions and Recommendations

Report provides summary of all Stage 2 results. Hg has been detected in seeps (up to 0.008mg/L) entering Springvale Drain and Southlands, and in two shallow wells near Solvents Plant. Hg was found in sediments in Springvale Drain, highest conc 260 mg/kg, and decrease in conc downstream of Southlands. Literature review was undertaken to assess remediation technologies and two phase remediation strategies were recommended: pollution reduction and groundwater remediation. Future investigations to include delineation of DNAPL xtent, and source area containment, pumping and seconadry recovery /in situ treatment. For shallow gw remediation preferred technology is passive technology. For long term funnel and gate is most suitable. Future investigations to include depth of influence of Springvale Drain on shallow gw in Southlands , understanding of the connction between shallow groundwater and surface water in the south of Southlands, west of Floodvale Drain, between McPherson Street and Penrhyn estuary. Recommendations for more investigations into degradation processes, changes in deep gw plume and quality of deep gw dischrge to Penrhyn Estuary , assessment of mechanism for mercury migration to Springvale Drain

Additional Relevant Information

Hg one of the target chemicals assessed based on risk

Location (in purple) where the Assessment took place. (Location in red is the former CAP)

Document 77

Reviewer: Katarina

The document includes:

- Biota study in 1996 by Woodward Clyde, to see amongst other chemicals Hg in invertebrate species in Penrhyn estuary
- Follow on from Stage 1 where Hg was detected in a number of species , no conclusions could be drawn from that study due to naturally occurring Hg in the fish
- In 1994 sampling of fish undertaken with mercury detected in higher conc in Penrhyn estuary than elsewhere
- Based on the above and the detection of Hg in invertebrates , mudcrabs it was concluded that Estuary may be significant source of bioavailable Hg in the species

Document 78

Reviewer: Katarina

The document includes:

- Study on Springvale Drain – Stage 1
- History of the Southlands provided in the report 1996– used for paper manufacturing prior to ICI, a series of pits and ponds were dug, and mercury based fungicides may have been used. Furnace ash was used to fill the site. Effluent disposal prior to 1958 was via a stormwater pipe directly to Springvale drain and direct discharge to ground close to effluent treatment plant.
- Mercury is contained in coal ash
- Sediment investigation undertaken by Woodward Clyde found that contaminated sediment discharged from Springvale and Floodvale drains into the Penrhyn estuary and the head of estuary has got highest conc
- Mercury detected in all sediments taken from the drain 0.05 to 260 mg/kg
- Stage 2 detected overall higher Hg conc than Stage 1 in sediments
- Hg conc in boiler ash samples range from 1-20mh/kg , and the sediment sampling from Penrhyn estuary found Hg 0.29-28.1 mg/kg
- Upstream of heavy drum store and downstream of stormwater pipe and tank farm area Hg 0.24 to 8.1 mg/kg , highest in the Southlands area 18-112 mg/kg
- Surface water samples from the drain did not have detectable mercury
- Hg in the drain from boiler ash, paper wastes, other sites and historical practices on site
- Anaerobic conditions but fluctuating redox , low Hg mobility under highly reducing conditions , formation of HgS
- High Hg levels maybe due to flushing of soluble mercury under favourable redox conditions following recharge event
- No Hg in surface water
- Hg in sediments and soils , without exception decrease in Hg with depth

Document 79

Reviewer: Katarina

The document includes:

- Health risk assessment 1996 Appendices
- No appendix relevant to Hg
-

NSW-EPA - Orica Botany Mercury Independent Review

Document Number	79
Reviewer	K. David
Document ID	LH 363.179/ICI
Document Title	ICI Botany groundwater Stage 2: Survey. Contract S2/C5, Health risk assessment / prepared for ICI Australia Engineering Pty Ltd. Author: ICI Australia Engineering Pty. Ltd. Woodward-Clyde Consultants. New South Wales. State Pollution Control Commission. Publication Date: 1996
Box Number / E-folder	14/15
Location of the Site as described in the document (include a with bore locations in this excel tab)	Included
Location of the Site as described in the document added to the aerial photo	Yes
Overall relevancy to the project to address human and environmental impacts of mercury	Moderate

Conceptual Site Model, F&T, Site Characterisation (input)	Yes/No	This is report fis health assessment report for chemicals of which one is mercury
Analysed for Mercury	Yes	
Historical practises and releases	Yes	
Known releases and releases points	Yes	Summary of events
Landuse (historic)	Yes	Summary of events
Landuse (current)	Yes	Summary of events
Fate and transport considerations	Yes	
Media: Soil (mg/kg)	Yes	
Media: Groundwater (ug/L)	Yes	Shallow gw historically contaminated with Hg, in the seeps near Springvale Drain
Media: Sediment (mg/kg)	Yes	Hg identified in Penhryn Estuary in Stage 1 and 2 surveys
Media: Air (ug/m3)	Yes	
Describe analytical methode used		
Groundwater depth (mBGL)	Yes	
Groundwater flow direction	Yes	southwest
Velocity (m/d)	Yes	
Borelogs provided in report	No	
Statigraphy encountered	No	
Aerial Photos (and year)	No	
Mercury Toxicology (HHRA)	NA	
Impact from inhalation of elemetal mercury	Yes	Risk assessment provided , Appendix A contains toxicity profile for Hg ,
historical ingestion of methyl mercury via local seafood		
Mercury Exposure (HHRA)	NA	
Atmospheric release of vapours		
(in)appropriate dosposal of sludge form the mercury cells		
Dumping activities		
Accidental spills		
Upset conditions during operations		
Historical releases		
Ongoing releases		
Groundwater extraction techniques		
Vapour Intrusion and Air (HHRA)	NA	
Emission from the Chlor Alkali Plant		
Flux and Concentrations		
Emission points, stack height		
Mercury cell electrolysis	NA	
polychlorinated dibenzofurans assessed (2,3,7,8 substituted PCDFs)		
Site Waste Handling and Disposal Practices	NA	
Historical records available		
Historic Events/accidents recorded		

Conclusions and Recommendations

Mercury was detected in blue swimmer crab, but not in Sydney rock oysters.Risk assessment was undertaken to understand the toxicity of parameters on the potential receptors. Mercury was considered target chemical for groundwater, surface water, soil biota, Different receptor populations and chemical intake were considered, and risk was calculated. The report concluded that the risks associated with exposure to the target chemicals fall within acceptable criteria. Uncertainty analysis was undertaken

Additional Relevant Information

Hg one of the target chemicals assessed based on risk

Location (in purple) where the Assessment took place. (Location in red is the former CAP)

NSW-EPA - Orica Botany Mercury Independent Review		
Name reviewer	Katarina	
Document Number	80	
Document ID	LH 363.179/ICI	
Document Title	ICI Botany Groundwater Stage 2 Survey , Contract S2/C2, Water /Soil phase 1	
Box Number / E-folder	EPA 15/15	
Location of the Site as described in the document (include a with bore locations in this excel tab)	Included	
Location of the Site as described in the document added to the aerial photo	No	
Overall relevancy to the project to address human and environmental impacts of mercury	Moderate	This document described stratigraphy of Botany Sands, electrical conductivity of the aquifer using geophysical testing , and downhole geophysics, results of EC and seismic geophysical survey can be used in the fate and transport assessment of Hg
Conceptual Site Model, F&T, Site Characterisation (input)	Yes/No	
Analysed for Mercury	No	
Historical practises and releases	Yes	
Known releases and releases points	No	
Landuse (historic)	Yes	
Landuse (current)	Yes	
Fate and transport considerations		
Media: Soil (mg/kg)	No	
Media: Groundwater (mg/L)	Yes	EC and seismic geophysical survey and stratigraphy , small number of gw bores sampled, in shallow aquifer Hg conc 0.0035mg/L, <0.0005 mg/L in deep
Media: Sediment (mg/kg)	No	
Media: Air (ug/m3)	No	
Describe analytical methode used		
Groundwater depth (mBGL)		
Groundwater flow direction	Yes	westerly to southwesterly direction
Velocity (m/d)	Yes	80-260 m/year under ICI Botany site , in the Southland 40-80 m/year
Borelogs provided in report	No	
Statigraphy encountered	Yes	Detailed CPT test, three gw bores, and surface geophysical data is available to provide detailed stratigraphy
Aerial Photos (and year)	No	
Mercury Toxicology (HHRA)	No	C5 contract talks about human health risk assessment
Impact from inhalation of elemetal mercury		
historical ingestion of methyl mercury via local seafood		
Mercury Exposure (HHRA)	No	
Atmospheric release of vapours		
(in)appropriate disposal of sludge form the mercury cells		
Dumping activities		
Accidental spills		
Upset conditions during operations		
Historical releases		
Ongoing releases		
Groundwater extraction techniques		
Vapour Intrusion and Air (HHRA)	No	
Emission from the Chlor Alkali Plant		
Flux and Concentrations		
Emission points, stack height		
Mercury cell electrolysis	No	
polychlorinated dibenzofurans assessed (2,3,7,8 substituted PCDFs)		
Site Waste Handling and Disposal Practices	No	
Historical records available		
Historic Events/accidents recorded		

Conclusions and Recommendations

The extent of deep gw contamination to the south of the plant may be more extensive then orrigianlly thought when C3 was prepared. Proposed scope for C3 : 3D extent of list of contaminanats in gw , flow and fluctuations of contaminanats, define southern and western margin of gw contamination, recommend remadial action for ponds and soils in Southlands. Recommendations were made realting to odours upstream of PWP .Any health risk assessment should precede remediation option work

Additional Relevant Information

Recharge is in the north and east , heavy pumping during 1960s and between 1977 and 1982 induce reversed gradient . The isopach map of Hawkesbury ss has been prepoared based on surveys.

Location (in purple) where the Assessment took place. (Location in red is the former CAP)

NSW-EPA - Orica Botany Mercury Independent Review

Document Number	81
Document ID	LH 363.179/ICI
Document Title	ICI Botany Groundwater Stage 2 survey
Box Number / E-folder	15/15
Location of the Site as described in the document (include a with bore locations in this excel tab)	Included
Location of the Site as described in the document added to the aerial photo	Yes
Overall relevancy to the project to address human and environmental impacts of mercury	Moderate

Conceptual Site Model, F&T, Site Characterisation (input)	Yes/No	Provide details
Analysed for Mercury	Yes	detected in shallow and deep gw near solvent plants Boiler ash on Southlands , paper wastes (Hg as fungicide) , other industrial sites in Springvale
Historical practises and releases	Yes	Draincatchemnt, possible ICI
Known releases and releases points	Yes	From Stage 1 report
Landuse (historic)	Yes	
Landuse (current)	Yes	
Fate and transport considerations	Yes	EDC and CTC only modelled
Media: Soil (mg/kg)	Yes	Hg detected in most soil samples up to 1 mg/kg, one high conc sample 66 mg/kg
Media: Groundwater (ug/L)	Yes	Shallow gw conc 0.001mg/l, near Solvents Plant, , in deep gw at the Southlands boundary generally less than 10mg/kg, two isolated locations 50-60mg/kg, Springvale Drain sediments had 100 mg/kg conc for 20m long seciton of the channel, surficial sediments had higher Hg conc then samples
Media: Sediment (mg/kg)	Yes	taken from 0.5m depth
Media: Air (ug/m3)	No	
Describe analytical methode used		
Groundwater depth (mBGL)	Yes	From 9mAHD at the eastern side to 0mAHD at Botany Bay
Groundwater flow direction	Yes	groundwater flow to the southwest
Velocity (m/d)	Yes	
Borelogs provided in report	Yes	Appendix B
Statigraphy encountered	Yes	Figure 7.3 in the main report, sand, with peat lenses
Aerial Photos (and year)	No	

Mercury Toxicology (HHRA)	
Impact from inhalation of elemetal mercury	No
historical ingestion of methyl mercury via local seafood	No

Mercury Exposure (HHRA)		
Atmospheric release of vapours	Yes	Odours notified, linked to reduced site conditions, and groundwater,
(in)appropriate dosposal of sludge form the mercury cells		NA
Dumping activities		NA
Accidental spills		NA
Upset conditions during operations		NA
Historical releases		NA
Ongoing releases		NA
Groundwater extraction techniques		NA

Vapour Intrusion and Air (HHRA)	
Emission from the Chlor Alkali Plant	No
Flux and Concentrations	NO
Emission points, stack height	No

Mercury cell electrolysis	
polychlorinated dibenzofurans assessed (2,3,7,8 substituted PCDFs)	No

Site Waste Handling and Disposal Practices		
Historical records available	Yes	Brief decscription given
Historic Events/accidents recorded	Yes	

Conclusions and Recommendations

This report altereed the potential sources of contamination from previous Stage 1 works. Additioanl sources identified during this program are former EDC storage tanks, former 300t Vinyl chloride sphere and Heavy Ends Redrumming. Groundwater flow model was developed , for solute transport two compounds were selected EDC and CTC. EDC plume is steady, CTC wil migrate towards Botany Bay. ZContaminated surface water and sediments in Penhryn Estuary is a result of deep gw dischrge, and transpoert of contaminanats down Springvale Drain and Floodvale Drain. The soil Hg contamination is higher in the Block 2 western side of Springvale drain than in the eastern part. Resampling of Hg anomaly in sediments confirmed the presence >100 mg/kg concentations over 20m lng section of the channel
There are no recommendations in the report

Additional Relevant Information

27 gw bores have been driled and their details and locations are in the Appendices. All bores were sampled.Flow and transport modelling was undertaken. Soil and sediments samples were collected (69 samples in total)

Location (in purple) where the Assessment took place. (Location in red is the former CAP)

NSW-EPA - Orica Botany Mercury Independent Review

Name reviewer	Katarina	
Document Number	82	
Document ID	LH 363.179/ICI	
	Appendix A to Appendix N	
Document Title		
Box Number / E-folder	15/15	
Location of the Site as described in the document (include a with bore locations in this excel tab)	Included	as per doc ID80
Location of the Site as described in the document added to the aerial photo	Yes	
Overall relevancy to the project to address human and environmental impacts of mercury	Moderate	

Conceptual Site Model, F&T, Site Characterisation (input)	Yes/No	Provide details
Analysed for Mercury		All items below as per doc number 80
Historical practises and releases		
Known releases and releases points		
Landuse (historic)		
Landuse (current)		
Fate and transport considerations		
Media: Soil (mg/kg)		
Media: Groundwater (ug/L)		
Media: Sediment (mg/kg)		
Media: Air (ug/m3)		
Describe analytical methode used		
Groundwater depth (mBGL)		
Groundwater flow direction		
Velocity (m/d)		
Borelogs provided in report		
Statigraphy encountered		
Aerial Photos (and year)		
Mercury Toxicology (HHRA)		
Impact from inhalation of elemetal mercury		
historical ingestion of methyl mercury via local seafood		
Mercury Exposure (HHRA)		
Atmospheric release of vapours		
(in)appropriate disposal of sludge form the mercury cells		
Dumping activities		
Accidental spills		
Upset conditions during operations		
Historical releases		
Ongoing releases		
Groundwater extraction techniques		
Vapour Intrusion and Air (HHRA)		
Emission from the Chlor Alkali Plant		
Flux and Concentrations		
Emission points, stack height		
Mercury cell electrolysis		
polychlorinated dibenzofurans assessed (2,3,7,8 substituted PCDFs)		
Site Waste Handling and Disposal Practices		
Historical records available		
Historic Events/accidents recorded		
Conclusions and Recommendations		No recommendations these are Appendices
Additional Relevant Information		Contains borelog info

Location (in purple) where the Assessment took place. (Location in red is the former CAP)

Document 83

Reviewer: Loek

Document contains ~35 expressions of interest / requests to receive consultant brief for the ICI Stage 2 Assessment

State Pollution Control Commission (SPCC), memo

- As a result of public concern in early 1989 over chlorinated hydrocarbons and mercury contamination emanating from ICI, the SPCC initiated a three stage survey of this petrochemical complex. First stage was released on 7 september 1990 and provided preliminary data on the hature, extent and degree of chemical contamination of the ICI site and neighbouring areas.
- Immediate actions after Stage 1 were:
    - Erection of warning signs, fencing, sending letter to groundwater users, organising information meetings with the community liaison committee (CLC)
- Stage 2 quantification of contamination in more detail
- Stage 3 is the remedial strategy

State Pollution Control Commission (SPCC), letter from 11/11/1991

- Summary of meeting. It was also decided to hold a public meeting on the subject of the ICI-Botany contamination

Photos of Springvale Drain, Southlands, Floodvale Drain and Penrhyn Estuary

Draft Deed of agreement between ICI (now Orica) and SPCC (now EPA)

Communication about gas masks for train drivers and chlorine leak incidents

ICI Solvents plant is being decommissioned in 1991

Proposed Botany Pipeline and terminal earthworks, Letter from AGC Woodward-Clyde to SPCC on 12th of March 1991

Meeting minutes of meetings between ICI/SRA/SPCC

Document 84

Reviewer: Loek

Follow-up on document 83

Minutes and communication in regards to evaluation of the Stage 2 tenders. There was a steering committee (ICI/SPCC (now EPA)/independent experts, prof M Knight) involved in this entire process.

No documents found on the February 1992 meeting of the tender evaluation committee. *CDMS: It is likely that in this meeting the committee members agreed upon engaging Woodward Clyde as the consultant for all 6 contracts for the Stage 2 works*

Document 85

Reviewer: Loek

Public Works Department appointed AG Environmental Engineers (now AGC Woodward-Clyde) to conduct sediment sampling of the Penrhyn Estuary. July 1992

- Report speaks about early sediment testing done by AG Environmental Engineers in 1990. Contaminated sediments were found during this assessment
- EPA ordered the 1992 assessment to be undertaken while dredging had already been undertaken.
- USEPA 74171 method, APHA 3112B, cold vapour AAS (detection limit 0.005 mg/kg)
- Hg levels in dumping area: 0.28 mg/kg (after dumping)
- Sediment close to Floodvale Drain: 13.9 – 28.1 mg/kg (above Dutch C-level)
- Hg levels within dredge channel: 0.12 – 8.2 mg/kg
- Highest levels of Hg within the surface sediments
- Levels decrease with increasing distance from the drain (Floodvale and Springvale) discharge points
- 2000 m3 of surface sediments have been removed
- AG concluded that contaminated sediment has been dredged and moved to the dumping ground but no excessive accumulation of contamination has occurred due to mixing/deposited/dispersed processes
- I copied map
- *(CDMS: PWD used same consultant as Orica)*

Memo EPA, 19 March 1992:

- Botany Council is now concerned about public liability possibilities and is considering putting up warning signs

Letter EPA to PWD, 10.3.92

- Unauthorized dredging must stop immediately, testing is required
- EPA suggested to use AGC Woodward Clyde (as they did Stage 1 ICI Botany review)
- There is talk about dredging undertaken in this area in 1988 and EPA askes for more historical details, prior to 1988

PWD did the maintenance dredging on behalf on Botany Council who leased the boat ramp from Sydney Port Authority

Letter EPA to PWD from 24 Sept 1993: Dredging can continue but approval from EPA is required. Also biota sampling Stage 2 ICI assessment needs to be planned in conjunction with dredging works

A total of 15000 m3 of contaminated sediments must be dredged to allow the boatramp to be used by the public. A report must be provided to make recommendations on the most appropriate relocation of dredged spoil

Document contains also information on the proposed third runway dredging program.

Document 86

Reviewer: Loek

This documents flows up to document 85

Additional sampling of the sediments near the existing boatramp was undertaken by Johnstone Environmental Technology (November 1993):

- Mercury present in surface and depth sediments
- Mercury is related to fine black silty sediments
- Levels of mercury are higher further upstream (towards the Springvale/Floodvale drains) to the estuary
- Mercury analysed in the sediments up to 36.2 mg/kg
- Mercury in the clean sands at the entrance channel was 0.1 mg/kg
- Sediments were analysed for mercury, chromium and HCB. Also TCLP testing was undertaken. Mercury was not leachable
- No elevated mercury found in sandy (natural) materials
- Disposing dredged materials elsewhere in Botany Bay was not recommended
- On shore disposal opposite the existing boat ramp was the preferred option
- *CDMS: I made a copy of the map*

Discussion between EPA and Public Works resulted in a few other options.

On 17 June 1994 Public Works decided to build a new boat ramp because no suitable disposal location could be found.

Document 87

Reviewer: Loek

"Groundwater Interception Potential Impacts on Migratory and Threatened Shorebird Communities in Botany Bay, October 2004, Avifauna Research&Services"

- Report prepared for URS on behalf of Orica
- Refers to *URS, 2004b HCB and mercury in Sediment and Biota, Penrhyn Estuary, NSW, August 2004*
- In the report it is mentioned in Section 2.2 that mercury concentrations in the Estuary were measured up to 183 mg/kg (samples collected in December 2003). *CDM Smith: This must have been reported on in the URS 2004b report*

Document 88

Reviewer: Loek

Review of the ICI Stage 2 Soil and Groundwater Survey by Herbert Levine and Daniel Opalski (both USEPA.

- *CDM Smith: Mercury was not mentioned in this review*
- It is strongly recommended that groundwater containment technologies involving physical barriers as well as hydraulic controls be considered
- The Stage 2 investigation performed by ICI was well conducted
- Passive remedial systems are promising but more investigation is required. In the short term conventional technologies must be considered to contain the contamination and reduce mass

Letter EPA to Botany Bay CC to inform CLC committee on the review done by Golder on the Phase 2 Health Risk Assessment component

Letter from EPA to Orica/ICI: Orica/ICI pays a 'fee for service' ($8150/quarter) to the EPA for the EPA officer involved in the Stage 2 assessment. EPA asks for an extension of the period

Letter 14 April 1991 from State Pollution Control Commission to Users of Groundwater in Botany Area.

- Commission warns those living or working in the area not to use groundwater for human/animal consumption/food processing or irrigation of potential foods

Memo from Cathy Dyer (Contam land manager EPA Sydney) from 5/3/96 regarding the Stage 1 and Stage 2 assessments and review by USEPA (*CDMS: copy made*)

- Good overview of relevant Stages
- ICI/Orica payed for the consultants (incl USEPA) the NSW EPA had to use
- EPA had negative comments on the draft S2/C5 report (HRA)
- *CDM Smith: Mercury was not mentioned*

NSW EPA raised a number of issues which must be addressed before the Stage2/C5 report (HRA) can be endorsed. The EPA cannot endorse the Consultants conclusion that there are no unacceptable human health risks associated with the contamination. Additional work may be required by ICI to address EPA's concerns

Memorandum US-EPA Region IX (14 February 1996). Review of the Stage 2/C4 report (Biota report).

- Reviewer (Sophia Serda, Ph.D) has concerns. A number of fish exceed action levels for HCB and Mercury but these species were not consumed by humans. Therefore the reviewer recommends analyses on species that are commonly consumed by humans
- Also concerns about sampling program/choice of sampling months

NSW-EPA - Orica Botany Mercury Independent Review

Document Number	92	
Document ID		Stage 3 Groundwater Survey, ICI Botany Springvale Drain Investigation – HCB and Mercury Study in Sediments, Surface Water and Groundwater, Woodward-Clyde, March 1997
Document Title	Stage 3 Groundwa	
Box Number / E-folder	Reports from Orica	
Location of the Site as described in the document (include a with bore locations in this excel tab)	Included	
Location of the Site as described in the document added to the aerial photo	Yes	
Overall relevancy to the project to address human and environmental impacts of mercury	Moderate	

Conceptual Site Model, F&T, Site Characterisation (input)	Yes/No	Provide details
Analysed for Mercury	Yes	sediments in the Springvale Drain area in southland and Penhryn estuary and surface water and shallow gw in the same area
Historical practises and releases	No	Trade waste discharge prior to 1958 has been the main source of mercury cont and transport , Boiler ash at Southlands, paper waste, ICI historical practic
Known releases and releases points		
Landuse (historic)		
Landuse (current)		
Fate and transport considerations		
Media: Soil (mg/kg)	Yes	Sampling undertaken along the Springvale drain up to 0,5 m depth. Conc of mercury typicaly higher in deeper zones as opposed to shallow 0.3m depth. Below 0.5 m dpeth mercury concentration decreases,
Media: Groundwater (ug/L)	Yes	SW quality- no Hg detected from samples disharging from property , conc 0.0001 to 0.0005 mh/L. Gw contains free mercury seeps to Springvale Drain , m
Media: Sediment (mg/kg)	Yes	Highest Hg conc in fine grain particles in which boiler ash is present as dominant fraction. Mercury is present in boiler ash naturally. Upstream sediments mercuy concentration is 1mg/kg, but d/s near McPheason. str. 220 mg/kg, at Penhryn estuary 2.6 mg/kg. Conc of mercury from 9.9 to 418 mg/kg. Over the period from 1993 to 1996 the conc of mercury in sediment has incereased in shallow and deep sediment samples. Volume of sediment with mercury is estimated at 1400 kg.
Media: Air (ug/m3)	No	
Describe analytical methode used		APHA 18h edition 3500-Hg
Groundwater depth (mBGL)		Gw seepage to Springvale drain through Southlands
Groundwater flow direction		
Velocity (m/d)		
Borelogs provided in report		
Statigraphy encountered		
Aerial Photos (and year)		

Mercury Toxicology (HHRA)

Impact from inhalation of elemetal mercury
historical ingestion of methyl mercury via local seafood

Mercury Exposure (HHRA)

Atmospheric release of vapours
(in)appropriate dosposal of sludge form the mercury cells
Dumping activities
Accidental spills
Upset conditions during operations
Historical releases
Ongoing releases
Groundwater extraction techniques

Vapour Intrusion and Air (HHRA)

Emission from the Chlor Alkali Plant
Flux and Concentrations
Emission points, stack height

Mercury cell electrolysis

polychlorinated dibenzofurans assessed (2,3,7,8 substituted PCDFs)

Site Waste Handling and Disposal Practices

Historical records available
Historic Events/accidents recorded

Summary of investigations at Springvale Drain/Southlands and Penrhyn Estuary in particular sediment contamination and distribution of HCB and mercury. Extensive sediment sampling was undertaken and smercury detected at Southlands and Penhryn estuary but not downstream of drains and at the moth of estuary. Stormwater drain had high Hg concentration. Hg detected in surface water samples at from Springvale Drain within Southlands and in shallow gw near paper waste pond, Sediments are contaminated from shallow gw in Springvale drain area. Migration of mercury is a result of former discharge to sewer, historical leaks and spills and boiler ash migration to drain. migration in sediment via stormwater drain and shallow gw discharge to stormwater system and migration of sulble Hg via sw to Springvale drain.Four remediation options are given.

Conclusions and Recommendations

Additional Relevant Information

Mass of mercury in Springvale Drain has been calculatedat 309kg.

Location (in purple) where the Assessment took place. (Location in red is the former CAP)

Document 107-108-109-110-114

Reviewer: James Lavelle, 17/10/2013

Orica Historical HHRA Summaries and Observations

Summary

Two risk assessments were completed that have some relevance to the FCAP that is the subject of the independent review. Risk assessments are summarized briefly below and their utility for helping to address community concerns is discussed below.

The risk assessment completed for Mutch Park (2006) was focused exclusively on organic chemicals in the Mutch Park bore. This water supply well provided water for non-potable uses such as irrigation. Some chemicals found in groundwater are associated generally with wastes produced by chlor-alkali plants, but the risk assessment did not include information that would implicate the Orica FCAP as the source of these chemicals. The site is apparently up-gradient of the major source of Hg in soil and in groundwater.

The focus of this risk assessment was on non-potable uses of groundwater, and thus addressed a limited possible exposure for workers or park visitors that might sporadically contact water from the well. This limited focus does not provide insight into other sources of exposure of community concern.

The assessment does provide some indirect evidence of a local source of organic chemicals that are often associated with electrolysis of brine at chlor-alkali plants (e.g. hexachlorobutadiene), chlorinated phenols). Given this information, stage two efforts might include a search for sources -- at the site and/or in off-site disposal or release locations. This effort might also consider further fate and transport characterization for organic chemicals, including collection of additional groundwater data if indicated.

The Mutch Park risk assessment does not provide information that can be used to evaluate historical releases of mercury vapors into the community, and thus cannot assist in developing estimates for inhalation exposure in the past. Neither does it provide any information on deposition of Hg onto community soils where direct contact with these soils could result in exposure.

Results from the Mutch Park risk assessment may provide some indication of worker and park-user risks during the time that the Mutch Park bore was used for irrigation. Limited and relatively recent data from this well make extrapolation of results into the past difficult. As an example, if concentrations of vinyl chloride in groundwater used for irrigation were higher in the past, the finding in the risk assessment that long-term exposure to this water might exceed “safe” thresholds would become more worrisome.

The source of contaminants in GW in the Mutch Park bore was not examined critically in the report. Given the nature of these contaminants, a search for a connection with the FCAP (e.g. inappropriate disposal?) would be prudent. Such a search could be include request for and review of Orica records, interviews with former workers, additional sampling for organic chemicals and Hg, etc.

A human health risk assessment was also produced in 2008 to address a limited set of issues. The main focus of the assessment was releases of Hg to soil within the FCAP and in bordering industrial properties, and releases of and subsequent transport in shallow groundwater. These issues are not ones of great concern to the community at this time. Soil within the industrial area is of little direct concern for community residents and groundwater is apparently not used as a source of either potable or non-potable water for nearby residents.

The 2008 risk assessment was updated in 2012, but it again focused exclusively on soil within the industrial areas (the FCAP and adjacent properties) and on the Hg plume in shallow groundwater.

Observations

The utility of risk assessments performed to address impacts of releases of mercury and other chemicals in the vicinity of the FCAP appears limited to some understanding of Hg releases at the FCAP and fate and transport of this Hg in shallow groundwater. The assessments also suggest several gaps in knowledge of activities, processes and releases associated with historical FCAP operations. These gap may be filled by review of other information currently available or, possibly, by collection of additional data in a second stage of the project

1. Substantial amounts of Hg escaped containment during historical FCAP operations. Residual Hg is present in soils in the industrial area, including properties adjacent to the FCAP. This observation indicates that releases of Hg were not simply spills onto soils on the plant site. Other possibilities will need to be considered -- inappropriate disposal, releases of Hg vapors and/or other Hg forms to air, overland flow during precipitation events, historical waste dumping and perhaps others. Data from Mutch Park indicates presence of chemicals commonly associated with CAPs.

   Data gaps -- transport pathway data; historical soil data (prior to 1992); disposal practices; details of plant operations and waste disposal; waste characterization data; soil and groundwater data for chemicals in addition to H; other?.

2. No substantive assessment of impacts to residents living adjacent to the FCAP has been developed. For such an assessment to be performed, several pathways not covered in available evaluations of risk require consideration: inhalation of Hg vapors released during operations; deposition of Hg onto community soils; releases to community soils from inappropriate disposal and/or waste dumping

   Data gaps -- Data to support air dispersion and deposition modeling, including meteorological data; residential soil data for Hg and other chemicals of concern, if any; ongoing sources of Hg and/or other chemicals, if any; other?

3. Indirect evidence of release in the community (Mutch Park bore contamination) suggests that effort will be needed to ferret out source(s) of this contamination.

   Data gaps – Historical information on disposal/dumping; worker interviews; forensic soil sampling (e.g. Hg “sniffing”); forensic GW sampling (source tracing); other?

4. No substantive assessment of impacts of spills, leaks, dumping, etc. to storm drains/surface water is available. Recreational use, if any, of local SW resources could be a source of childhood exposure; water is always and attraction.

    Data gaps – Information on use of SW (direct observation, community discussion); data for SW and sediments to support risk assessment.

5. No substantive assessment of Orica contributions to Hg and/or other chemicals to Botany Bay has been developed. A minority of comments from the community continues to express concern for more general environmental impacts[1].

    Data gaps – Information on spills, leaks, disposal to support source tracing; forensic sediment sampling data to connect sediment Hg to the site; additional investigation if any substantive impacts to sediments are indicated; other?

[1111] We need to come to a consensus on if and how to deal with Botany Bay sediments in Stage 2.

Document 111

Reviewer: Loek

Site Audit Statement relating to the Amcor Dam Wall at the corner of Botany Rd and Beauchamp Rd.

In WM02 a level of mercury has been measured of 22 ug/L in Nov 2004. In 2003 the level was NE, in Oct 2004 it was 0.6 ug/L and in 2006 it was NE (No Exceedance). The site was declared suitable for commercial/residential use and groundwater abstraction is not recommended (site is within Orica Plume designated area)

Document 119 – 120

Reviewer: Loek

119:

Relating a mercury spike during the CPWE remediation. Professor Brian Priestly agrees with the EPA that there are no significant health risks associated with these emissions

120:

Advice Priestly relating to mercury emissions DTD plant and URS HHRA relating these emissions. Priestly considers that no any additional controls over mercury emissions appear to be necessary as the stack emissions are well within those forecasted in the HHRA report (the HHRA indicate no significant health risks)

Document 128

Reviewer: Loek

Position Paper, March 1990, Author unknown

- Approximately 100,000 tonnes of chlorine produced per year
- 105,000 tonnes per year of caustic soda
- Hg discharged to sewer in the waste stream from the CAP.
- Workers reported Hg spills hosed down to drain
- Hg was banned from sewer (old trade waste policy, 1972-1988) however ICI had a dispensation. When new policy came in place (June 1988) Hg was permitted
- Several people /employees reported that ICI used Springvale drain for disposal of a production waste stream
- Writer doubts if the ICI video from inside the drain showing ingress of groundwater through cracks is a video from the actual drain
- Spills were kept quiet from management
- Reference: ICO Australia (1989) Unusual Incidents Reports, May-July

Document 171

Reviewer: Loek

Period 2006-2007

Risk Analysis of the Botany Groundwater Treatment Plant – Report of Findings, Ernst&Young, 29 September 2006. Prepared for Orica

Independent Audit Report, Botany Groundwater Remediation Program, prepared for Orica. September 2006.

Orica submitted the independent audit report to DECC (now EPA) in September 2006.

Annual Return – Licence 2148, reporting period July-2005 to July 2006

- No Mercury to air analysed (not required)
- Water discharge composition: 7 samples required and collected, lowest <0.0001 mg/L, highest 0.0002 mg/L

Orica Waste Activities from 1 July 2006 to 30 September 2006

- D120, Solid, 35 tonnes (14 tonnes transported by Skipmaster and 21 tonnes transported by Thiess) was disposed of at Sita

Groundwater Treatment Plant – Dioxin Emissions _URS report1 Sept. 2006, Human Health Risk Assessment for the EIS of the treatment plan. Update of the HHRE was required as levels of dioxins and furans was 2-3 times higher than calculated in the EIS under normal operations.

FCAP demolished between Sept-Dec 2006

Orica Waste Activities from 1 April 2006 to 30 June 2006

- No D120 or N170 disposed of in this period

Document 172

Reviewer: Loek

Licence 2148, from July 1996-July 1997

- Section (H) Clorine Plant
- H 1.: amount of mercury added to the plant inventory and the time at which the addition was made must be recorded
- Mercury in brine waste to be immobilised with sulphide and casted into concrete blocks. To be tested on TCLP (must be <0.2 mg/L), testing once per 3 months or 200 tonnes
- Mercury waste to be held in sealed drums in a roofed and sealed area. Record must be maintained of all materials transferred to this store
- Hg in air emissions < 3 mg/m3
- Records of the above must be kept for 2 years and made available to EPA upon request

Letter of the minister of Environment on major crackdown of the Orica Plant (7 June 1996)

- Three major leaks over the last three weeks
- ICI can expect surprise Environmental audits by the EPA compliance teams
- *"the government is determined to get ICI back on track in relation to its environmental performance"*

Document 173

Reviewer: Loek

Letter ICI to EPA, 14 March 1997, Review of waste management activities on Botany Site.

- Provided to EPA to assist in reviewing the licence Waste Minimisation and Management Regulation, 1996. Describes waste generated at all ICI plants on site
- 1500 tonnes/annum of stabilised brine waste (consent number 10290/73/OS) . Inorganic filter cake containing trace mercury. Stabilised with sulphide an Portland cement. Disposed to landfill with impervious liner and leachate management
- Spent activated carbon containing mercury sulphide, sorted onsite, 30m^3 per annum (no consent, not registered with EPA)
- Demolition waste and soil containing less than 50 mg/kg HCB, 50 tonnes/annum (2300 tonnes during 1994-1995), new projects on lightly contaminated areas
- Stored Waste:
    - Spent activated carbon accumulating at 4.4m^3, current stockpile: 37 m^3
    - Mercury rich sludge from Stella filters, maintenance of caustic tank as well as cells and brine sumps, accumulating at 5.7 m^3 per annum, current stockpile: 68 m^3

EDC Heaviest management, EPA became aware that ICI was storing 2,400 tonnes of waste at ACR, waste is called EDC heaviest and formed as part of ICI vinyl chloride monomer operations at Botany. The waste contains about 1200 mg/kg of scheduled chemicals (most is HCB).

Letter EPA to ICI, 6/3/97, Stage 3 – Remediation project

- EPA has stressed in recent letters to ICI that it wishes to have an input to the planning of fieldwork activities during Stage 3. EPA has concerns that several assessments have been completed without discussions with EPA which could potentially mean that EPA cannot endorse them.

Draft licence 002148, 7/3/97

- Section (G) Clorine Plant
- G 1.: amount of mercury added to the plant inventory and the time at which the addition was made must be recorded
- Mercury in brine waste to be immobilised with sulphide and casted into concrete blocks. To be tested on TCLP (must be <0.2 mg/L), testing once per 3 months or 200 tonnes
- Mercury waste to be held in sealed drums in a roofed and sealed area. Record must be maintained of all materials transferred to this store
- Hg in air emissions < 3 mg/m3
- Records of the above must be kept for 2 years and made available to EPA upon request

EPA letter to Botany Council (17/2/97) regarding groundwater use restrictions near ICI

Document 174

Reviewer: Loek

I read this entire document (1996) but there was no information which was relevant for the independent mercury review.

Document 175

Reviewer: Loek

CDM Smith requested and received the 2004 Phase 1 (MPL Health, Safety and Environment, project N200118.01) from Randwick Council. MPL concluded the following:

- A review of the aerial photographs for Heffron Park indicated that significant historical filling or earthworks at the site is unlikely to have occurred;
- 1943: No obvious filling, the site comprises clear open sandy ground cover;
- Between 1947 – early 1970's. Naval or Defence stores or detention centre buildings. Up to 31 larger buildings and numerous smaller buildings cover majority of the site. No obvious filling;
- 1975: majority of the buildings removed from the site development of recreation areas and facilities progressing;
- 1978 – 1982: pool installed, tennis courts installed;
- There is no information available relating to the operational activities regarding filling at the site, nor redevelopment, environmental management or capping of the site. The site was more likely to have been filled for the purposes of landscaping, as opposed to waste disposal, and the materials are likely to be limited to soils or demolition wastes;
- The vegetation observed on the site indicated no visual signs of stress;
- Information contained within the Council property file outlined that the site previously used as a major military storage facility, later for migrant detention and has been officially used as a recreation reserve since 1959;
- The site observations and historical photography indicate that any filling was most likely undertaken for landscaping purposes. The Plan of Management (1997) indicates that the landscaping mounds comprised compacted clean fill;
- Based on the available information it is unlikely that the site would present a significant risk of harm to users of the site or the environment in regard to contamination;
- At this stage, no additional investigations or monitoring is recommended;
- MPL identified 18 potential landfill sites in the Local Government Area of Randwick (See report: Identification of Closed Landfill Sites – Randwick Local Government Area, July 2004 by MPL);
- This Phase 1 ESA did not identify any evidence that the site would present a Significant Risk of Harm in its' present condition; and
- Based on the available information and the site observations, the site in its' present condition would be suitable for its continued recreational use.

NSW-EPA - Orica Botany Mercury Independent Review

Document Number	
Document ID	
Document Title	Electronic Docume Final report - Stage 1 and 2 investigations- Formaer chlor-alkali plant , consolodated investigation report , URS 2006
Box Number / E-folder	USB folder
Location of the Site as described in the document (include a with bore locations in this excel tab)	Included
Location of the Site as described in the document added to the aerial photo	Yes
Overall relevancy to the project to address human and environmental impacts of mercury	Moderate

Conceptual Site Model, F&T, Site Characterisation (input)	Yes/No	
Analysed for Mercury	Yes	
Historical practises and releases	No	Literature review of previous studies for Stage 1 and 2
Known releases and releases points		Appendix A- history of site and CAP, Block L , G and M and potentially A. Previous mercury in soil found in the Southlands was attributed to contaminated fill when Australian pulp services owned
Landuse (historic)	Yes	The soil contamination in Springvale drain was not found to be groundwater related.
Landuse (current)		
Fate and transport considerations	Yes	Mercury mobility in groundwater and soils discussed. The study indicates that it is unlikely that elemental Hg would move down through soil profile to deeper hydrostratigraphic unit , mostly due to surface tension. In any other form Hg would be more soluble and tend to move easily. Mercury would have sorbed to peat/clay layer and it is not likely that it has travelled further below this layer.
Media: Soil (mg/kg)	Yes	Undertaken to provide screening assessment of soil contamination, 16 samples taken , XRF analysis (protable), at each loaction two samples taken for inorganic mercury analysis
Media: Groundwater (ug/L)	Yes	Additonal wells were installed around the CAP based on the results of sampleing of existing wells (not offsite), 11 shallow wells to 9m, 11 intermediate depth wells to 12m and 12 deep wells to 20m depth. 34 gw samples taken from wells installed in this program and analysed for mercury and pH. Previous investigations in 1990 and 1996 found out limited mercury contamination in shallow wells only.
Media: Sediment (mg/kg)	No	
Media: Air (ug/m3)	No	
Describe analytical methode used		
Groundwater depth (mBGL)		
Groundwater flow direction		
Velocity (m/d)		
Borelogs provided in report		
Statigraphy encountered		
Aerial Photos (and year)		

Mercury Toxicology (HHRA)

Impact from inhalation of elemetal mercury
historical ingestion of methyl mercury via local seafood

Mercury Exposure (HHRA)

Atmospheric release of vapours
(in)appropriate dosposal of sludge form the mercury cells
Dumping activities
Accidental spills
Upset conditions during operations
Historical releases
Ongoing releases
Groundwater extraction techniques

Vapour Intrusion and Air (HHRA)

Emission from the Chlor Alkali Plant
Flux and Concentrations
Emission points, stack height

Mercury cell electrolysis

polychlorinated dibenzofurans assessed (2,3,7,8 substituted PCDFs)

Site Waste Handling and Disposal Practices

Historical records available
Historic Events/accidents recorded

Conclusions and Recommendations

Additional Relevant Information

Location (in purple) where the Assessment took place. (Location in red is the former CAP)

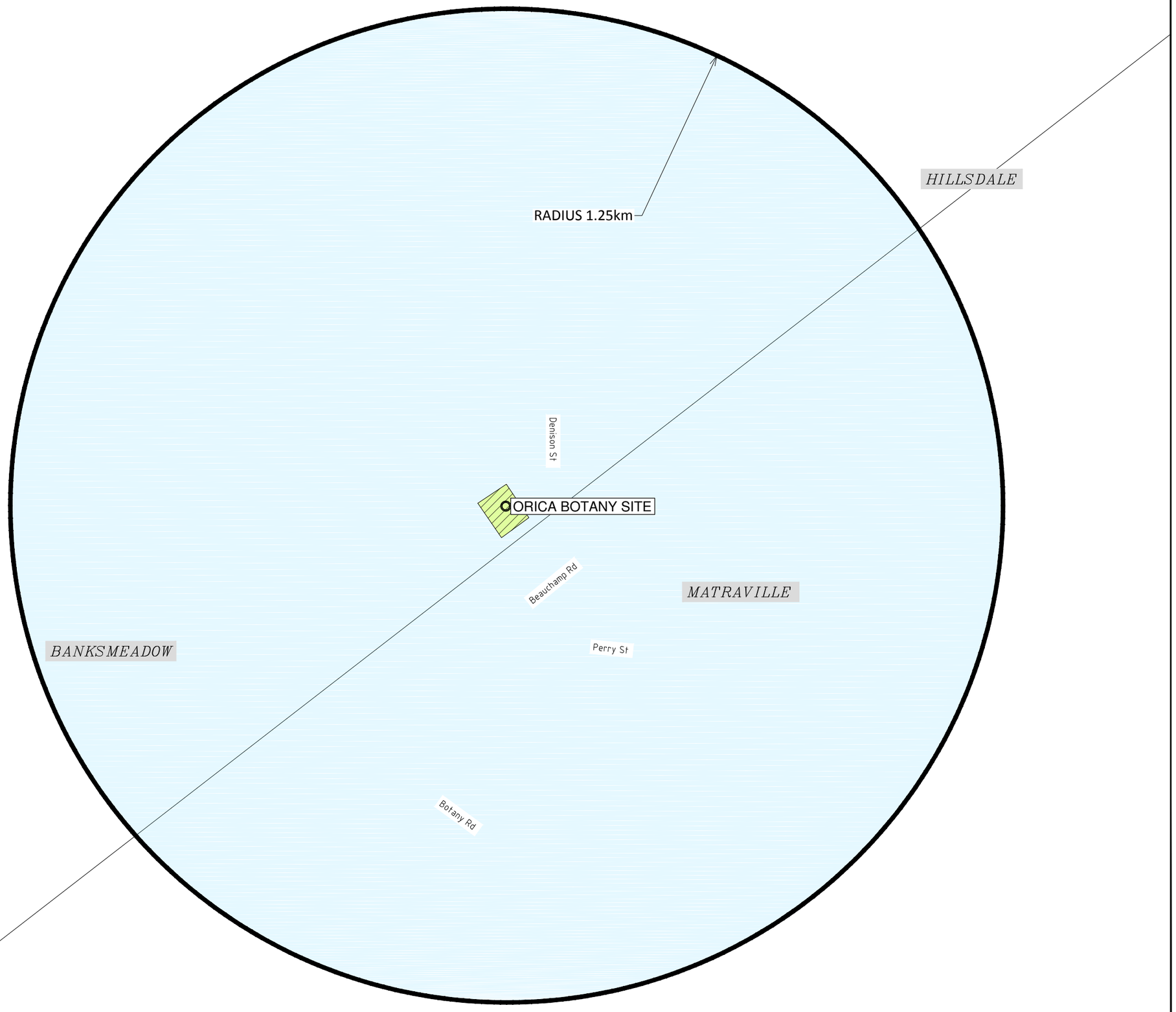
Appendix H - Study Area

0 100 200 300 400 500m

SCALE 1:10,000 AT A3 SHEET SIZE

CDM Smith
cdmsmith.com

SCL130051.01
EPA- INDEPENDENT MERCURY
REVIEW ORICA BOTANY
1.25km RADIUS AROUND SITE



Appendix I - EPA – Orica/ICI Document Registry

	B	C	D	E	F	G
1			**Orica - ICI Document Registry**			
2						
3	**Number**	**ID code**	**Title**	**Item type**	**Home Location**	**Box No/E-Folder**
4	1	500755B1 ORIGINAL	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - SCHEDULED PREMISES - ICI AUST OPERATONS PTY LTD 16-20 BEAUCHAMP RD MATRAVILLE LICENCE NO 2148	File	Government Records Depository	K549884
5	2	500755A42	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - SCHEDULED PREMISES - CHEMICAL WORKS ICI AUST OPERATIONS PTY LTD 16-20 BEAUCHAMP RD MATRAVILLE ROUTINE MATTERS	File	Government Records Depository	EPA 12/15
6	3	500755B1/01	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - 500755B1 SCHEDULED PREMISES - ICI AUST OPERATONS PTY LTD 16-20 BEAUCHAMP RD MATRAVILLE LICENCE NO 2148 (500755B1)	File	Government Records Depository	K549884
7	4	500755B1/02	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - 500755B1 SCHEDULED PREMISES - ICI AUST OPERATONS PTY LTD 16-20 BEAUCHAMP RD MATRAVILLE LICENCE NO 2148 (500755B1)	File	Government Records Depository	K549884
8	5	500755B1/03	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - 500755B1 SCHEDULED PREMISES - ICI AUST OPERATONS PTY LTD 16-20 BEAUCHAMP RD MATRAVILLE LICENCE NO 2148 (500755B1)	File	Government Records Depository	K549884
9	6	500755B1/04	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - 500755B1 SCHEDULED PREMISES - ICI AUST OPERATONS PTY LTD 16-20 BEAUCHAMP RD MATRAVILLE LICENCE NO 2148 (500755B1)	File	Government Records Depository	K549884
10	7	709978PT2	ICI INPUTS TO SEWER ESPECIALLY ORGANOCHLORINES OCS AND MERCURY CHEMICALS BRANCH FILE	File	Government Records Depository	K0496346
11	8	709978	ICI INPUTS TO SEWER ESPECIALLY ORGANOCHLORINES (OCS)AND MERCURY CHEMICALS BRANCH FILE	File	Government Records Depository	K0496346
12	9	500755A47	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - SCHEDULED ACTIVITIES - ORICA AUSTRALIA PTY LTD - 16-20 BEAUCHAMP ROAD MATRAVILLE 2036 - PREMISES - SYDNEY REGION WASTE ACTIVITY	File	Government Records Depository	EPA 12/15
13	10	BA639	ENVIRONMENTAL REVIEWS AND INQUIRIES - CHEMICAL INDUSTRY - ICI BOTANY - ENVIRONMENTAL SURVEY MEETINGS 7/09/1992 In Container 'EPABOX99/1120 (At Home Location: Government Records Repository (GRR))' 18/10/2012 at 10:37 AM	File	Government Records Depository	EPA 12/15
14	11	BA639/01	BA639 ENVIRONMENTAL REVIEWS AND INQUIRIES - CHEMICAL INDUSTRY - ICI BOTANY - ENVIRONMENTAL SURVEY MEETINGS (BA639) 22/03/1995 In Container 'EPABOX99/1120 (At Home Location: Government Records Repository (GRR))' 16/09/2003 at 4:31 PM	File	Government Records Depository	EPA 12/15
15	12	BA639/02	BA639 ENVIRONMENTAL REVIEWS AND INQUIRIES - CHEMICAL INDUSTRY - ICI BOTANY - ENVIRONMENTAL SURVEY MEETINGS (BA639) 28/08/1995 In Container 'EPABOX99/1120 (At Home Location: Government Records Repository (GRR))' 22/10/2012 at 12:25 PM	File	Government Records Depository	EPA 12/15
16	13	500755A46/01	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - 500755A46 SCHEDULED PREMISES - ICI AUSTRALIA OPERATIONS PTY LTD - 16-20 BEAUCHAMP RD - MATRAVILLE - PREMISES (500755A46)	File	Government Records Depository	K0376555
17	14	500755A46/04	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - 500755A46 SCHEDULED PREMISES - ICI AUSTRALIA OPERATIONS PTY LTD - 16-20 BEAUCHAMP RD - MATRAVILLE - PREMISES (500755A46)	File	Government Records Depository	K0376555
18	15	500755A46/05	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - 500755A46 SCHEDULED PREMISES - ICI AUSTRALIA OPERATIONS PTY LTD - 16-20 BEAUCHAMP RD - MATRAVILLE - PREMISES (500755A46)	File	Government Records Depository	K0376555
19	16	500755A46/06	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - 500755A46 SCHEDULED PREMISES - ICI AUSTRALIA OPERATIONS PTY LTD - 16-20 BEAUCHAMP RD - MATRAVILLE - PREMISES (500755A46)	File	Government Records Depository	K0376555
20	17	500755A46/07	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - 500755A46 - SCHEDULED PREMISES - ORICA PTY LTD - 16-20 BEAUCHAMP RD - MATRAVILLE - PREMISES (500755A46)	File	Government Records Depository	K0376555
21	18	500755A46/08	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - 500755A46 - SCHEDULED PREMISES - ORICA PTY LTD - 16-20 BEAUCHAMP RD - MATRAVILLE - PREMISES (500755A46)	File	Government Records Depository	K299052
22	19	500755A46/09	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - 500755A46 - SCHEDULED PREMISES - ORICA PTY LTD - 16-20 BEAUCHAMP RD - MATRAVILLE - PREMISES (500755A46)	File	Government Records Depository	K299052
23	20	500755A46/10	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - 500755A46 - SCHEDULED PREMISES - ORICA PTY LTD - 16-20 BEAUCHAMP RD - MATRAVILLE - PREMISES (500755A46)	File	Government Records Depository	K299052
24	21	500755A46/11	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - 500755A46 - SCHEDULED PREMISES - ORICA PTY LTD - 16-20 BEAUCHAMP RD - MATRAVILLE - PREMISES (500755A46)	File	Government Records Depository	K299052
25	22	500755A46/12	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - 500755A46 - SCHEDULED PREMISES - ORICA PTY LTD - 16-20 BEAUCHAMP RD - MATRAVILLE - PREMISES (500755A46)	File	Government Records Depository	K299052
26	23	500755A46/13	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - 500755A46 - SCHEDULED PREMISES - ORICA PTY LTD - 16-20 BEAUCHAMP RD - MATRAVILLE - PREMISES (500755A46)	File	Government Records Depository	K299052
27	24	500755A46/14	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - 500755A46 - SCHEDULED PREMISES - ORICA PTY LTD - 16-20 BEAUCHAMP RD - MATRAVILLE - PREMISES (500755A46)	File	Government Records Depository	EPA 1/15
28	25	500755A46/15	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - 500755A46 - SCHEDULED PREMISES - ORICA PTY LTD - 16-20 BEAUCHAMP RD - MATRAVILLE - PREMISES (500755A46)	File	Government Records Depository	EPA 1/15
29	26	500755A46/16	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - 500755A46 - SCHEDULED PREMISES - ORICA PTY LTD - 16-20 BEAUCHAMP RD - MATRAVILLE - PREMISES (500755A46)	File	Government Records Depository	EPA 1/15
30	27	500755A46/17	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - 500755A46 - SCHEDULED PREMISES - ORICA PTY LTD - 16-20 BEAUCHAMP RD - MATRAVILLE - PREMISES (500755A46)	File	Government Records Depository	EPA 1/15
31	28	500755A46/18	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - 500755A46 - SCHEDULED PREMISES - ORICA PTY LTD - 16-20 BEAUCHAMP RD - MATRAVILLE - PREMISES (500755A46)	File	Government Records Depository	EPA 1/15
32	29	500755A46/19	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - 500755A46 - SCHEDULED PREMISES - ORICA PTY LTD - 16-20 BEAUCHAMP RD - MATRAVILLE - PREMISES (500755A46)	File	Metro Basement Compactus	EPA 2/15
33	30	500755A46/20	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - 500755A46 - SCHEDULED PREMISES - ORICA PTY LTD - 16-20 BEAUCHAMP RD - MATRAVILLE - PREMISES (500755A46)	File	Metro Basement Compactus	EPA 2/15
34	31	500755A46/21	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - 500755A46 - SCHEDULED PREMISES - ORICA PTY LTD - 16-20 BEAUCHAMP RD - MATRAVILLE - PREMISES (500755A46)	File	Metro Basement Compactus	EPA 2/15
35	32	500755A46/22	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - 500755A46 - SCHEDULED PREMISES - ORICA PTY LTD - 16-20 BEAUCHAMP RD - MATRAVILLE - PREMISES (500755A46)	File	Metro Basement Compactus	EPA 2/15
36	33	500755A46/23	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - 500755A46 - SCHEDULED PREMISES - ORICA PTY LTD - 16-20 BEAUCHAMP RD - MATRAVILLE - PREMISES (500755A46)	File	Metro Basement Compactus	EPA 2/15
37	34	500755A46/24	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - 500755A46 - SCHEDULED PREMISES - ORICA PTY LTD - 16-20 BEAUCHAMP RD - MATRAVILLE - PREMISES (500755A46)	File	Metro Basement Compactus	EPA 3/15
38	35	500755A46/25	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - 500755A46 - SCHEDULED PREMISES - ORICA PTY LTD - 16-20 BEAUCHAMP RD - MATRAVILLE - PREMISES (500755A46)	File	Metro Basement Compactus	EPA 3/15
39	36	500755A46/26	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - 500755A46 - SCHEDULED PREMISES - ORICA PTY LTD - 16-20 BEAUCHAMP RD - MATRAVILLE - PREMISES (500755A46)	File	Metro Basement Compactus	EPA 3/15
40	37	500755A46/27	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - 500755A46 - SCHEDULED PREMISES - ORICA PTY LTD - 16-20 BEAUCHAMP RD - MATRAVILLE - PREMISES (500755A46)	File	Metro Basement Compactus	EPA 3/15
41	38	500755A46/28	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - 500755A46 - SCHEDULED PREMISES - ORICA PTY LTD - 16-20 BEAUCHAMP RD - MATRAVILLE - PREMISES (500755A46)	File	Metro Basement Compactus	EPA 4/15
42	39	500755A46/29	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - 500755A46 - SCHEDULED PREMISES - ORICA PTY LTD - 16-20 BEAUCHAMP RD - MATRAVILLE - PREMISES (500755A46)	File	Metro Basement Compactus	EPA 4/15
43	40	500755A46/30	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - 500755A46 - SCHEDULED PREMISES - ORICA PTY LTD - 16-20 BEAUCHAMP RD - MATRAVILLE - PREMISES (500755A46)	File	Metro Basement Compactus	EPA 4/15
44	41	500755A46/31	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - 500755A46 - SCHEDULED PREMISES - ORICA PTY LTD - 16-20 BEAUCHAMP RD - MATRAVILLE - PREMISES (500755A46)	File	Metro Basement Compactus	EPA 4/15
45	42	500755A46/32	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - 500755A46 - SCHEDULED PREMISES - ORICA PTY LTD - 16-20 BEAUCHAMP RD - MATRAVILLE - PREMISES (500755A46)	File	Metro Basement Compactus	EPA 5/15
46	43	500755A46/33	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - Orica Pty Ltd - 16-20 Beauchamp Road Matraville	File	Metro Basement Compactus	EPA 5/15
47	44	500755A46/34	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - Orica Pty Ltd - 16-20 Beauchamp Road Matraville - Licence 2148	File	Metro Basement Compactus	EPA 6/15
48	45	500755A46/35	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - Orica Pty Ltd - 16-20 Beauchamp Road Matraville - Licence 2148	File	Metro Basement Compactus	EPA 6/15
49	46	500755A46/36	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - Orica Pty Ltd - 16-20 Beauchamp Road Matraville - Licence 2148	File	Metro Basement Compactus	EPA 6/15
50	47	500755A46/37	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - Orica Pty Ltd - 16-20 Beauchamp Road Matraville - Licence 2148	File	Metro Basement Compactus	EPA 7/15
51	48	500755A46/38	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - Orica Pty Ltd - 16-20 Beauchamp Road Matraville - Licence 2148	File	Metro Basement Compactus	EPA 7/15
52	49	500755A46/39	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - Orica Pty Ltd - 16-20 Beauchamp Road Matraville - Licence 2148	File	Metro Basement Compactus	EPA 7/15
53	50	500755A46/40	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - Orica Pty Ltd - 16-20 Beauchamp Road Matraville - Licence 2148	File	Metro Basement Compactus	EPA 7/15
54	51	500755A46/41	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - Orica Pty Ltd - 16-20 Beauchamp Road Matraville - Licence 2148	File	Metro Basement Compactus	EPA 8/15
55	52	500755A46/42	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - Orica Pty Ltd - 16-20 Beauchamp Road Matraville - Licence 2148	File	Metro Basement Compactus	EPA 8/15
56	53	500755A49/01	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - Orica Pty Ltd - 16-20 Beauchamp Road Matraville - Orica Groudwater Treatent Project	File	Metro Basement Compactus	EPA 9/15
57	54	500755A49/02	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - Orica Pty Ltd - 16-20 Beauchamp Road Matraville - Orica Groudwater Treatent Project	File	Metro Basement Compactus	EPA 9/15
58	55	500755A49/03	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - Orica Pty Ltd - 16-20 Beauchamp Road Matraville - Orica Groudwater Treatent Project	File	Metro Basement Compactus	EPA 9/15
59	56	500755A48/01	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - Orica Pty Ltd - 16-20 Beauchamp Road Matraville - EHC Act Licence No 26	File	Metro Basement Compactus	EPA 10/15
60	57	500755A48/02	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - Orica Pty Ltd - 16-20 Beauchamp Road Matraville - EHC Act Licence No 27	File	Metro Basement Compactus	EPA 10/15
61	58	500755A48/03	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - Orica Pty Ltd - 16-20 Beauchamp Road Matraville - EHC Act Licence No 28	File	Metro Basement Compactus	EPA 10/15
62	59	500755A48/04	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - Orica Pty Ltd - 16-20 Beauchamp Road Matraville - EHC Act Licence No 29	File	Metro Basement Compactus	EPA 11/15
63	60	500755A48/05	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - Orica Pty Ltd - 16-20 Beauchamp Road Matraville - EHC Act Licence No 30	File	Metro Basement Compactus	EPA 11/15
64	61	500755A48/06	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - Orica Pty Ltd - 16-20 Beauchamp Road Matraville - EHC Act Licence No 31	File	Metro Basement Compactus	EPA 11/15

	B	C	D	E	F	G
3	**Number**	**ID code**	**Title**	**Item type**	**Home Location**	**Box No/E-Folder**
65	62	BA642	Total Catchment Management - Cooks River - Joint Meetings of Councils	File	Metro Basement Compactus	K0190733
66	63	BA642/1	Total Catchment Management - Cooks River - Joint Meetings of Councils	File	Metro Basement Compactus	K0190733
67	64	BA642/2	Total Catchment Management - Cooks River - Joint Meetings of Councils	File	Metro Basement Compactus	K0190733
68	65	BA643	Total Catchment Management - Cooks River - Joint Meetings of Councils	File	Metro Basement Compactus	K0190733
69	66	BA643/1	Total Catchment Management - Cooks River - Joint Meetings of Councils	File	Metro Basement Compactus	K0190733
70	67	State Pollution Control Commisssion (SPCC)	Environmental Control Study of Botany Bay - Summary Report - For Discussion and Comment - December 1980	Publication	Library	EPA 12/15
71	68	State Pollution Control Commisssion (SPCC)	Bottom Sediments of Botany Bay - Environmental Control Study of Botnay Bay - September 1978	Publication	Library	EPA 12/15
72	69	State Pollution Control Commisssion (SPCC)	Toxic Chemicals - Environmental Control Study of Botany Bay - September 1979	Publication	Library	EPA 12/15
73	70	State Pollution Control Commisssion (SPCC)	ICI Botany environmental study Stage 1, Preliminary investigations - May 1990	Publication	Library	EPA 12/15
74	71	State Pollution Control Commisssion (SPCC)		Publication	Library	EPA 12/15
75	72	State Pollution Control Commisssion (SPCC)	Botany Bay environmental control study: Phase 1 - Recreation - June 1976	Publication	Library	EPA 12/15
76	73	AGC Woodward-Clyde	Assessment of soil and groundwater contamination at propsed vinyl chloride plant byproducts recovery unit, ICI Botany siteL supplementary report - March 1991	Publication	Library	EPA 12/15
77	74	LH 363.179/AGE	ICI Botany environmental survey. Stage 1. Preliminary investigations. / prepared by A.G. Environmental Engineers in association with Woodward-Clyde Consultants (USA). Author: AG Environmental Engineers. New South Wales. State Pollution Control Commission. Woodward-Clyde Consultants. Publication Date: 1990	Publication	Library	EPA 13/15
78	75	LH 363.179/AGE	ICI Botany environmental survey. Stage 1. Preliminary investigations. Supplementary report on dioxin and furan investigations / prepared by A.G. Environmental Engineers in association with Woodward-Clyde Consultants (USA).Author: AG Environmental Engineers. New South Wales. State Pollution Control Commission. Woodward-Clyde Consultants. Publication Date: 1990	Publication	Library	EPA 13/15
79	76	LH 363.179/ICI	ICI Botany groundwater Stage 2: Survey. Contract S2/C6, overview report / prepared for ICI Australia Engineering Pty. Ltd. Author: IC Australia Engineering Pty. Ltd. Woodward-Clyde Consultants. New South Wales. State Pollution Control Commission. Publication Date: 1996	Publication	Library	EPA 13/15
80	77	LH 363.179/ICI	ICI Botany groundwater Stage 2: Survey. Contract S2/C4, Biota / prepared for ICI Australia Engineering Pty Ltd.Author: ICI Australia Engineering Pty. Ltd. Woodward-Clyde Consultants. New South Wales. State Pollution Control Commission. Publication Date: 1996	Publication	Library	EPA 13/15
81	78	LH 363.179/ICI	ICI Botany groundwater Stage 2: Survey. Contract S2/C1, Springvale drain / prepared for ICI Australia Engineering Pty Ltd. Author: IC Australia Engineering Pty. Ltd. Woodward-Clyde Consultants. New South Wales. State Pollution Control Commission. Publication Date: 1996	Publication	Library	EPA 13/15
82	79	LH 363.179/ICI	ICI Botany groundwater Stage 2: Survey. Contract S2/C5, Health risk assessment / prepared for ICI Australia Engineering Pty Ltd Author: ICI Australia Engineering Pty. Ltd. Woodward-Clyde Consultants. New South Wales. State Pollution Control Commission. Publication Date: 1996	Publication	Library	EPA 14/15
83	80	LH 363.179/ICI	ICI Botany groundwater Stage 2: Survey. Contract S2/C2, Water/soil, phase 1 / prepared for ICI Australia Engineering Pty Ltd. Author: IC Australia Engineering Pty. Ltd. Woodward-Clyde Consultants. New South Wales. State Pollution Control Commission. Publication Date: 1996	Publication	Library	EPA 15/15
84	81	LH 363.179/ICI	ICI Botany groundwater Stage 2: Survey. Contract S2/C3, Water/soil, phase 2 / prepared for ICI Australia Engineering Pty Ltd. Author: IC Australia Engineering Pty. Ltd. Woodward-Clyde Consultants. New South Wales. State Pollution Control Commission. Publication Date: 1996	Publication	Library	EPA 15/15
85	82	LH 363.179/ICI	ICI Botany groundwater Stage 2: Survey. Contract S2/C3, Water/soil, phase 2. Appendices / prepared for ICI Australia Engineering Pty Ltd.Author: ICI Australia Engineering Pty. Ltd. Woodward-Clyde Consultants. New South Wales. State Pollution Control Commission. Publication Date: 1996	Publication	Library	EPA 15/15
86	83	CH772	Contaminated Sites - Chemical Industries - Matraville - ICI Aust Operations Pty Ltd	File	Government Records Depository	K0493184
87	84	CH772/01	Contaminated Sites - Chemical Industries - Matraville - ICI Aust Operations Pty Ltd	File	Government Records Depository	K0493184
88	85	CH771	Contaminated Sites - Botany Bay Penrhyn Estuary - Dredging	File	Government Records Depository	K0493184
89	86	CH771/01	Contaminated Sites - Botany Bay Penrhyn Estuary - Dredging	File	Government Records Depository	K0493184
90	87	Avifauna Research & Se	Groundwater Interception Potential Impacts on Migratory and Threatened Shorebird Communities in Botany Bay - October 2004	Publication	Internet Sourced	EPA 12/15
91	88	CH772/19	US EPA - Review of the ICI Stage 2 Soil and Groundwater Survey by Herbert Levine and Daniel Opalski 1996	Document conta	Government Records Depository	EPA 12/15
92	89		Desktop review to clarify the potential risks to nearby residents from calcine sands at the Liddell's Calcine Sands site. Ravi Dadu and Dav	Other	Other	EPA 12/15
93	90					
94	91		Electronic Documents			
95	92		Stage 3 Groundwater Survey, ICI Botany Springvale Drain Investigation – HCB and Mercury Study in Sediments, Surface Water and Gro	Other	Other	Reports from Orica
96	93		Woodward-Clyde, March 1997 Figures 1.1-3.3[1]	Other	Other	Reports from Orica
97	94		Woodward-Clyde, March 1997 Figures 7.1-7.2[1]	Other	Other	Reports from Orica
98	95		Woodward-Clyde, March 1997 Figures 3.4-5.14[1]	Other	Other	Reports from Orica
99	96		Woodward-Clyde, March 1997 Tables[1]	Other	Other	Reports from Orica
100	97		Woodward-Clyde, March 1997 Plates[1]	Other	Other	Reports from Orica
101	98		Woodward-Clyde, March 1997 Appendix A[1]	Other	Other	Reports from Orica
102	99		Woodward-Clyde, March 1997 Appendix B[1]	Other	Other	Reports from Orica
103	100		Woodward-Clyde, March 1997 Appendix C[1]	Other	Other	Reports from Orica
104	101		Woodward-Clyde, March 1997 Appendix D[1]	Other	Other	Reports from Orica
105	102		Woodward-Clyde, March 1997 Appendix E[1]	Other	Other	Reports from Orica
106	103		Woodward-Clyde, March 1997 Appendix F[1]	Other	Other	Reports from Orica
107	104		Woodward-Clyde, March 1997 Appendix G[1]	Other	Other	Reports from Orica
108	105		A Review of the Mercury Pollution Abatement Program at ICI Operations Botany, W.A Davies and R.G.H Prince, University of Sydney, O	Other	Other	Reports from Orica
109	106		Orica Former ChlorAlkali Plant Mercury in Soil Remediation Delineation Investigation, URS Australia Pty Ltd, 11 August 2010	Other	Other	Reports from Orica
110	107		FCAP_HHERA_final_21Aug08-MUP (3)	Other		HHERA
111	108		FCAP_HHERA_final_21Aug08_text (5)	Other		HHERA
112	109		2013 CAP HHERA Final 20 June 2013	Other	Other	HHERA
113	110		Priestly peer review FCAP HHERA July 2013	Other	Other	HHERA
114	111	SAS EPA-1806201317	Botany Council DA Amcor long dam and subdivide, 1-59 Beauchamp road / 44A McCauley Street Matraville, Site audit by Rod Harwood	Other	Other	Documents
115	112		Andrew Helps and Doug Cameron_Environment and Communications References Committee 20 February 2013	Other	Other	Documents
116	113		Review of Contamination Issues Associated with the Port Botany Expansion 2003 URS App_AA	Publication	Other	Documents
117	114		Mutch Park QRA. URS. Aug, 06	Other		Documents
118	115		Orica CoBB Briefing 4 October 2012 FCAP Presentation	Other		Documents
119	116		Atmospheric Pathways, Transport and Fate of Mercury in the Global Environment PART II_UNEP FT_19112012	Publication		Documents
120	117		UNEP Revised-Waste Management Business-Plan-May2012-Highlighted	Publication		Documents
121	118		UNEP-Hg Guidelines Rev 7	Publication		Documents
122	119		IEP Request 4- B Priestly Response	Other		Documents
123	120		IEP Request 4 2 Feb 2012 website	Other		Documents
124	121		Health-based Soil Investigation Levels env_soil	Publication		Documents
125	122		RAP_R_Rev1 Block A_M RAP	Publication		Documents
126	123		RAP_R_Rev 2_Orica_ Block G_Final[1]	Publication		Documents
127	124		Remediation Options Appraisal Report April 2012	Publication		Documents
128	125		Making Chemicals from Salt at ICI, Botony	Other		Making Chemicals from Salt a
129	126					
130	127		**Public Submissions**			
131	128		Pollution problems from the ICI chemical complex, Botany. Position Paper. March , 1990.	Other	Other	EPA 12/15
132	129		MD12-2228 Final Cover Letter and attachments for filing 08 06 12	Other	Other	Helps
133	130		MD12-3541 final Scanned Copy 18 09 12	Other	Other	Helps
134	131		Email Helps to Clark URS HH+E Risk Assessment report 25 November 2012 Attachment: FCAP_HHERA_final_21Aug08-MUP (3)	Other	Other	Helps
135	132		Letter Helps to C Snell Proposal Letter 27 Nov 2012	Other	Other	Helps
136	133		Email Helps to N Johnston Orica Port Botany 27 November 2012 Attachment: FCAP_HHERA_final_21Aug08_text (5) Attachment: Letter Helps to C Snell Proposal Letter 27 Nov 2012 7219Rev4 Attachment: Orica Port Botany Licence Questions Table 7221Rev2	Other	Other	Helps
137	134		Email Helps to NI RE FCAP HHERA Tue 27 11 2012 541 PM Attachment: FCAP_HHERA_final_21Aug08_text (6)	Other	Other	Helps
138	135		Email Helps to Bill Crowe 13.12.2012	Other	Other	Helps
139	136		Email Helps to E Benker ICI Yarraville 15 January 2013	Other	Other	Helps
140	137		MD13-307 Helps to MO 21 01 13	Other	Other	Helps
141	138		Email Helps to Sheehy Your Enquiry 29 January 2013 Attachment: CV Ian Andrew Brown 15.01.2012 Attachment: US EPA Mercury Study Report to Congress December 1997 Attachment: Highlighted Report Appendix E Mercury Surface Emissions Sampling FCAP Attachment: URS Appendix E Mercury Surface Emissions Sampling FCAP two page	Other	Other	Helps
142	139		Email Helps to GS Anderson St Sample comments. 29 01 2013 1148 AM	Other	Other	Helps

	B	C	D	E	F	G
3	**Number**	**ID code**	**Title**	**Item type**	**Home Location**	**Box No/E-Folder**
143	140		Email Helps to Sheehy Anderson St Sample comments 29 January 2013 Attachment: Helps' sample result from Anderson Street Botany	Other	Other	Helps
144	141		Letter Helps to Sheehy re Orica Port Botany Offsite Mercury Emissions 1.2.13	Other	Other	Helps
145	142		Email Helps to G Sheehy Orica Port Botany Offsite Mercury Releases 1 February 2013 Attachment: Letter Helps to Sheehy re Orica Port Botany Offsite Mercury Emissions 1.2.13 Attachment: USEPA 1971 Atmospheric Emisisons from Chlor-Alkali Manufacture document Attachment: Highlighted Report Appendix E Mercury Surface Emissions Sampling FCAP Attachment: Appendix E URS Report Mercury Surface Emissions Sampling FCAP	Other	Other	Helps
146	143		Email Helps to Gifford 08 03 13 Presentation etc Attachment: Andrew Helps' Presentation 7292Rev4 Attachment: 7292Rev6 Presentation PDF Attacment: 7292Rev6 Presentation annotated Attachment: 120924_BrownIAAustinDW_MaternalTransferOfMercuryToTheDevelopingEmbryo_Fetus_IsThereASafeLevelqustn_ToxicolEnvironment Chem_2012Sep24_online	Other	Other	Helps
147	144		Email Helps to A Kirk Malabar Headland 8 March 2013	Other	Other	Helps
148	145		MD13-1194 Incoming Letter Fed Letter March 2013 inviting submission in response to Helps -Submission 1 Attachment: MD13-1194 BN SENATE SUBMISSION RE Orica Attachment: MD13-1194 Attachment A Hansard Feds Attachment: MD13-1194 Attachment B Senate Help Response final	Other	Other	Helps
149	146		Email G Sheehy to Gifford Telephone conversation with Mr Helps 27 March 2013	Other	Other	Helps
150	147		Email G Sheehy to Helps Mercury Sampling – Matraville 27 March 2013	Other	Other	Helps
151	148		Email Helps to Sheehy Data 28 March 2013	Other	Other	Helps
152	149		Email helps to GS 28 March 2013 FW The community Attachment: Appendix E Mercury Surface Emissions Sampling FCAP	Other	Other	Helps
153	150		Email Helps to Sheehy Testing data 1 attachment 28 March 2013 11.42am Attachment: Soil Analysis results from Helps	Other	Other	Helps
154	151		Email G Sheehy to Helps Testing data 28 March 2013	Other	Other	Helps
155	152		Letter Helps to MO re Orica Botany - Public Health Risks 8.4.13 Attachment: Annexures 1-8 Letter from Orica to MO re Community Concerns Regarding Mercury 21.12.12 Attachment: Annexure #9 Boundary Ambient Air Mercury Monitoring Equipment	Other	Other	Helps
156	153		Email helps to CER 11 april 2013 FW Orica Botany HCB	Other	Other	Helps
157	154		Email Helps to M Gifford - HCB GS Response 12 April 2013	Other	Other	Helps
158	155		MD13-1787 - Hg Recoveries 15 04 13 Attachment: MD13-1787 Letter to Andrew Helps 14 May 2013	Other	Other	Helps
159	156		Email from G Sheehy to M Gifford Orica Botany draft response 15 April 2013	Other	Other	Helps
160	157		Letter Helps to N Johnston re requested comments on draft EPA Management Order 15.5.13	Other	Other	Helps
161	158		MD13-2934 - Orica - Botany issue - Senator B Heffernan 17 06 13 Attachment: MD13-2934 - Signed letter by MO ON 1 July 2013	Other	Other	Helps
162	159		MD13-2995 Mercury contamination at Port Botany - A Helps - MO 21 06 13 Attachment: MD13-2995 spreadsheet	Other	Other	Helps
163	160		Email Helps to MO 27 June 2013	Other	Other	Helps
164	161		Email Gifford to Benker HCB Data 28 June 2013 Attachment: Evaluation of Bioaccumulation Data for HCB Attachment: Persistent organochlorinated pesticides and mechanisms of their toxicity Attachment: ATSDR Tox Profile HCB Attachment: Reductive dechlorination of HCB in wetalnd soils	Other	Other	Helps
165	162		Email Helps to MO 30 June 2013 Attachment: NSW - NEPC HIL's for soil Attachment: SOIL HAZARD CATEGORISATION THRESHOLDS Attachment: Vic EPA Soil Hazard Categorisation	Other	Other	Helps
166	163		Email Helps to MO 1 July 2013	Other	Other	Helps
167	164		Email Helps to MO re Media Watch 28 July 2013 Attachment: Letter Helps to MO re Orica Botany - Public Health Risks 28 07 13 Attachment: NEPM Table 1(A) 1 Attachment: NSW EPA Lamberton Ltr 22-6-12 Attachment: NSW EPA Min Parker Ltr 17-7-13 Attachment: NSW EPA Report 201300114V4 Attachment: NSWEPA PR 16-05-2013 Attachment: SCEW HIL A-calculator	Other	Other	Helps
168	165		Email Helps to ZT Documents for the Mercury enquiry 12 08 13 Attachment: ATSDR HoltraChemHC082106 Attachment: Hg Storage Germany Attachment: USEPA Holtrachem Prosecution Attachment: USEPAChloralkalireport	Other	Other	Helps
169	166		Email submission Jennifer Waller	Other	Other	Public Submissions
170	167		Email submission from Carlos Da Rocha via Chantal Snell Attachment: WHO Mercury disease Attachment: WHO pops at risk for mercury Attachment: WHOCICAD50 Attachment: WHOMercury Advice	Other	Other	Public Submissions
171	168		Submission Charles Abela	Other	Other	Public Submissions
172	169		Email Submission from Len Mahony Attachment: Capitol Hilll -briefing-6-14-11-Final	Other	Other	Public Submissions
173	170		Submission - Denis Muller	Other	Other	Public Submissions
174	171	500755A46/43	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - Orica Pty Ltd - 16-20 Beauchamp Road Matraville - Licence 2148	File	Government Records Depository	K359420 (not original box)
175	172	500755A46/1	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - 500755A46 - SCHEDULED PREMISES - ORICA PTY LTD - 16-20 BEAUCHAMP RD - MATRAVILLE - PREMISES (500755A46)	File	Government Records Depository	K359420
176	173	500755A46/2	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - 500755A46 - SCHEDULED PREMISES - ORICA PTY LTD - 16-20 BEAUCHAMP RD - MATRAVILLE - PREMISES (500755A46)	File	Government Records Depository	K359420
177	174	500755A46/3	ENVIRONMENTAL PROTECTION, COMPLIANCE & REGULATION - LICENSING - Premises - 500755A46 - SCHEDULED PREMISES - ORICA PTY LTD - 16-20 BEAUCHAMP RD - MATRAVILLE - PREMISES (500755A46)	File	Government Records Depository	K359420

Appendix J - Aerial Photos

Project Title - Orica Bo[illegible]Mercury Independent Review: Stage 1 - Data and Information Collection and Review

Figure Title - Aerial Photograph 1930

Site Boundary

N W E S

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Date (11/15/2013)

Project Title - Orica Botany Mercury Independent Review: Stage 1 - Data and Information Collection and Review

Figure Title - Aerial photograph 1941

Site Boundary

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Date (11/15/2013)

Project Title - Orica Botany Mercury Independent Review: Stage 1 - Data and Information Collection and Review

Figure Title - Aerial photograph 1955

Site Boundary

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Date (11/15/2013)

Project Title - Orica Botany Mercury Independent Review: Stage 1 - Data and Information Collection and Review

Figure Title - Aerial photograph 1964

Site Boundary

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Date (11/15/2013)

Project Title - Orica Botany Mercury Independent Review: Stage 1 - Data and Information Collection and Review

Figure Title - Aerial photograph 1970

Site Boundary

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Date (11/15/2013)

Project Title - Orica Botany Mercury Independent Review: Stage 1 - Data and Information Collection and Review

Figure Title - Aerial photograph 1979

Site Boundary

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Date (11/15/2013)

Project Title - Orica Botany Mercury Independent Review: Stage 1 - Data and Information Collection and Review

Figure Title - Aerial photograph 1986

Site Boundary

DISCLAIMER
CDM Smith has endeavoured to ensure accuracy and completeness of the data. CDM Smith assumes no legal liability or responsibility for any decisions or actions resulting from the information contained within this map.

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Date (11/15/2013)

Project Title - Orica Botany Mercury Independent Review: Stage 1 - Data and Information Collection and Review

Figure Title - Aerial photograph 1998

Site Boundary

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Date (11/15/2013)

Project Title - Orica Botany Mercury Independent Review: Stage 1 - Data and Information Collection and Review

Figure Title - Aerial photograph 2011

Site Boundary

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Date (11/15/2013)

Appendix K - Data Sediment and Biota Penrhyn Estuary

This Appendix presents available data (in chronological order) relevant to the assessment of health risks associated with Penrhyn Estuary.

1989 Stage 1 assessment (sediment and biota)

- At 7 locations sediment (3 locations) and surface samples (top 15cm, 4 locations) were collected;
- Mercury levels in sediments were between 0.1 – 3.6 mg/kg;
- Late 1989 indicative biota samples from the benthic zone (bottom of the estuary including the sediments) were collected from 5 locations within the Estuary and 1 location in Botany Bay. Species sampled are summarized in **Error! Reference source not found.**;
- Hg concentrations in prawns collected from in Botany Bay were below detection limit (0.1 mg/kg);
- Mercury was detected in tissue in all fish species collected (between 1.3 – 0.2 mg/kg) and exceeded the recommended NH&MRC guidelines of 0.5 mg/kg in 7 out of 13 species tested. Hg in more commonly tested species (mussel and oyster) were both below the 0.5 mg/kg guideline; and
- Mercury background in biota could not be established for the Bay (no data available).

1992 sediment assessment

- Undertaken by AGC Woodward – Clyde for the Public Works Department;
- Eight sediment samples collected in 1992 showed mercury levels between 0.2 – 15.5 mg/kg;
- Oysters were tested but no mercury above detection limit was found in them;
- Mercury in sediments at the proposed dumping ground (200 m to the north/west of the Estuary) were between 0.24 – 0.28 mg/kg Hg (3 samples collected); and
- Botany Council erected signs at Penrhyn Estuary jetty and car park warning against eating fish caught there. (*CDM Smith: Note that this is the earliest mentioning of a consumption advisory. Also this jetty has now been closed for public access*).

1993 sediment assessment

- Undertaken by Johnstone Environmental Technology (November 1993);
- 14 locations were sampled and a total of 25 samples were analysed;
- Mercury was present in sediment (both surface and depth (0.6m below surface));
- Mercury concentrations were related to fine black silty sediments;
- Levels of mercury are higher further upstream (towards the Springvale/Floodvale drains) to the estuary;
- Mercury analysed in the sediments up to 36.2 mg/kg (0.5-0.6 m below sediment surface);
- Mercury in the clean sands at the entrance channel was 0.1 mg/kg;

- Mercury concentrations in the surface sediments furthest away from the Estuary were 0.18 – 0.43 mg/kg;
- Sediments were analysed for mercury, chromium and HCB. Also TCLP testing was undertaken. Mercury was not leachable;
- No elevated mercury found in sandy (natural) materials;
- Disposing of dredged materials (required to provide access to the old jetty) elsewhere in Botany Bay was not recommended; and
- On shore disposal opposite the existing boat ramp was the preferred option (*CDM Smith: note that on 17 June 1994 Public Works decided to build a new boat ramp because no suitable disposal location could be found. Also during our review we found indications of dredging in/near the Penrhyn Estuary in 1988 (document 85). Since the Port expansion in 2008 the new jetty in not publicly accessible).*

1993/1994 Stage 2 Assessment (sediment and biota)

- Assessment was undertaken by The Ecology Lab and involved evaluation of levels of HCB, HCDB, HCE, mercury and chromium. Beside mercury (the focus of this review) both HCB and chromium were also detected in biota samples collected;
- Biota samples (fish) collected in the Estuary (Oct 1993, Jan 1994, March 1994) and other locations in Botany Bay (March 1994). Invertebrates were only collected in the March 1994 sampling event. Sampled species are summarized in **Error! Reference source not found.**;
- In the Oct 1993 sampling event mercury was not detected in any species of mullet on either sampling occasion, but it occurred in other species (range between 0.1 – 0.2 mg/kg). In a total of 55 fish (from 7 different species) from the Estuary the Hg levels (as high as 0.2 mg/kg) in 15 fish were slightly above the detection limit (0.1 mg/kg);
- Lipid (fat) content was shown to vary significantly over time and between sites. None of the differences could be directly compared to contaminants. Exception is the sea mullet from the estuary in which lipid levels and concentration of HCB showed a significant positive correlation;
- A total of 104 samples were analysed for fish caught in Oct93 and Jan94. Highest level recorded was 0.17 mg/kg;
- In March 1994 mercury was found at all sites for at least one of the tested species (a total of 237 (of which 61 came from Penrhyn Estuary) fish were analysed for mercury and mercury was detected in 22 samples of which 12 were from Penrhyn Estuary). Bream collected at the Estuary had significantly more Hg (mean 0.135 mg/kg, maximum level 0.25 mg/kg) in the muscle tissue than from any other control site (mean <detection limit of 0.045 mg/kg), suggesting that Penrhyn Estuary may provide a source of Hg for this species of fish. None of the other species appeared to show a similar effect. Hg was also detected in all the invertebrates except oysters. The estuary may be a significant source of bioavailable mercury in mud whelks and blue swimmer crabs;
- Note that HCB has been detected in species in levels higher than mercury levels and the NHMRC standard;
- The present study has demonstrated that there is contamination in species from Penrhyn Estuary that are likely to be eaten by humans; and

- Mercury in marina biota (Stage 2 S2/C4 Woodward-Clyde 1996) was found in small quantities and below National Health and medical Research Council (NHMRC) Maximum Residue levels (MRLs).

CDM Smith also reviewed a memorandum on a review done by US-EPA on the stage 2 assessment:

- Memorandum US-EPA Region IX (14 February 1996). Review of the Stage 2/C4 report (Biota report). Reviewer (Sophia Serda, PhD) has concerns. A number of fish exceed action levels for HCBD, HCB and Mercury (HCE was not detected) but these species were not consumed by humans. Therefore the reviewer recommends analyses on species that are commonly consumed by humans; and
- Also concerns about sampling program/choice of sampling months. (note that lipid content was also analysed for).

1996 Stage 3 Assessment (sediments)

- Sediments samples (48 in total) were collected in June 1996 from the mudflats, saltmarshes and sandy beaches near the Springvale Drain outlet and in Penrhyn Estuary. Mercury levels were between 0.2 – 5.2 mg/kg with decreasing levels with increasing distance from the outlet. The highest level was found near the outlet.

1996-1998 Stage 3 Assessment (biota)

Data taken from Toxikos report as CDM Smith does not have the actual data. Ongoing biota monitoring in August 1996, November 1996 and March 1998:

- Six species of fish (see **Error! Reference source not found.**) were collected from Penrhyn Estuary and two new reference locations along the northern shore of Botany Bay;
- For Hg indicator species are silver biddy, dusky flathead and yellow-fin bream;
- Baseline levels for mercury in fish were established by Dr. R. Drew (toxicologist). In the report from Toxicos, Dr. Drew considered that mercury levels in biota caught in 1998 (and in 1993/1994 and 1996) do not pose a health risk;
- Continued biota monitoring at a frequency of every 12-18 months is unlikely to yield information that can be adequately interpreted. Biota monitoring is therefore recommended every 3-5 years;
- Because March 1998 fish levels of HCB and mercury were little different from 1994 it was considered by NSW EPA and the Department of Fisheries that the exceedences (some above the Maximum Residue Limits (MRL) did not constitute a human health risk because:
    - Fish are not taken commercially from the Estuary;
    - Sea mullet (species with highest HCB) are unlikely to be caught in large numbers;
    - Not all fish species have high Hg or HCB levels (in 1998 a total of 35% of all fish caught were above the MRL); and
    - Fish caught from outside the Penrhyn Estuary would form the bulk of that consumed by high fish eaters.

2005 and 2010 Consolidated Human Health Risk Assessment

In the 2010 Consolidated Human Health Environmental Risk Assessment (CHHRA) revised risk assessment and in the 2013 all data on biota was removed by Orica as the Penrhyn Estuary was no longer accessible. However the 2005 CHHRA covered all biota and sediment data. The 2005 CHHRA contains a comprehensive evaluation of sediments, biota and surface water samples collected at the Estuary.

In the 2005 CHHRA it was mentioned that in 2003 NSW DEC did biota sampling on wild oysters collected in Penrhyn Estuary. Mercury was detected at concentrations approximately 10 times higher than DEC's expected background (0.001 mg/kg ww) with concentrations of 0.07 to 0.12 mg/kg ww.

In 2004 USR sampled surface sediments, oysters and fish from the Estuary on three occasions (December 2003 and two occasions in March 2004). The data relevant to mercury indicated that concentrations have not changed significantly from previous sampling conducted in 1994. Concentrations of mercury in fish and oysters were less than the relevant MRL.

In Stage 3 of the ICI assessment between 1996 – 1998 mercury levels in Silver biddy were detected with a maximum of 0.4. In 2004 the maximum was 0.26 mg/kg (with a mean of 0.16 mg/kg). Other species such as the luderick tested for maximum 0.45 mg/kg (mean 0.26 mg/kg).

In Oyster the maximum mercury concentration in 2004 was 0.29 mg/kg.

In 2004 the maximum mercury concentration in sediments was 15.1 mg/kg, collected at Oyster site-1 (in the centre of the Estuary).

In the 2005 CHHRE a table is presented summarizing all available biota data analysed in the edible parts of the fish (i.e. not the liver) for mercury and HCB/MCBD and chromium. This data has been presented in the Table below:

Available biota data (mercury) for Penrhyn estuary (mg/kg)

Stage 1 1989 (range detected)	Stage 2 1993 and 1994 (range detected)	Stage 3 1996 – 1998 (range detected in or near estuary)	URS 2004 mean (max)
	Sea mullet = <0.1 – 0.1	Sea mullet = nd – 0.1	Sea mullet = 0.03 (0.06)
	Sand mullet = <0.1	Sand mullet = nd	
	Silver biddy = <0.1 – 0.1	Silver biddy = nd – 0.4	Silver biddy = 0.16 (0.26)
	Dusky Flat head = <0.1 – 0.1	Dusky flathead = nd – 0.4	
	Yellow fin bream = 0.1 – 0.25	Yellow fin bream = nd – 0.2	
		Flat tail mullet = nd	Flat-tail mullet = 0.04 (0.1)
	Luderick = <0.1 – 0.2		Luderick = 0.26 (0.45)
	Trevally = <0.1 – 0.2		
	Crab = <0.1 – 0.1		
	Mudwhelk = 0.2 – 0.3		
			Tarwhine = 0.07 (0.1)
Oyster 0.2 – 0.3 [1)]	Oyster <0.1 [1)]	Oyster = 0.07 – 0.12	Oyster = 0.21 – 0.2 (0.29)
Polychaete = 0.5 (worm)			
Crab = 1.0			
Bembicium = 1.3 (shellfish, sea snail)			
Pyrazus = 0.9 – 1.2 (shellfish, sea snail)			
Laternula = 0.9 (clam)			

1) Samples collected from location outside of Penrhyn Estuary

SPCC, Toxic Chemicals, Environmental Control Study of Botany Bay 1978

Hg in edible muscle tissue of small numbers of fish caught in the Bay have been analysed. Mean levels are below NHMRC maximum level (0.5 mg/kg) for all collected seven species (72 fish were sampled) during 1973-1978:

- Inorganic Hg: mean for all 7 species ranges between 0.01 – 0.03 mg/kg (max is 0.04 mg/kg)
- Organic Hg: mean for all 7 species ranges between 0.06 – 0.26 mg/kg (max is 0.35 mg/kg)
- Total Hg: mean for all 7 species ranges between 0.04 – 0.29 mg/kg (max is 0.67 mg/kg)

Mercury is the only metal whose maximum concentration in any fish has been greater than half of the recommended limit.

Spoil and Contaminated Materials Management Sub-Plan for Design & Construction of Port Botany Expansion of Sydney Ports Corporation

Based on the results from 4 site investigations (details can be found in the management plan), mercury was identified as a contaminant of concern. Concentrations only marginally exceed the ISQG-Lower value (0.15 mg/kg). Only one sediment sample (E30, 0.0-0.1m, located near the Springvale drain outlet) has a mercury level above the ISQG-High value level (1 mg/kg dry weight). A total of approximately 50 sediment samples were presented on a figure in this document. The area sampled is similar to the area where the port expansion took place including the Penrhyn Estuary.

Environmental Assessment of Botany Bay, Sediments, Sediment Geochemistry & Foraminifera, May 2008

- Port Botany Coastal Catchment Initiative - Sydney Metropolitan Catchment Management Authority;
- This study aims to determine the distribution of the unconsolidated sediments, to assess their geochemical characteristics and to identify and define the ecology of the benthic foraminifera (protozoa) within the Bay;
- Once a complete baseline is available, then the methodology has long term monitoring capabilities; by repeating the study after 10-20 years a clear assessment of the changes that have occurred between the two surveys is obtained. To be effective a baseline must be established within a short period of time;
- A standard set of 11 major elements and 20 trace elements (Pb, Sr, Rb, Y, Zr, Cu, Zn, Ni, Ga, U, Sn, As, Sb, Mo, Cd, Cr, V, Nb, Th, Ce) have been selected for these investigations as many of these are suspected to be toxic to life forms and are likely to be introduced into the area by human activities. This was largely guided by the experience with a similar set of samples from different Australian Estuaries; and
- Maps are provided in this study with the distribution (84 bottom samples) of trace element concentrations within the top 10 cm of (fine) sediments within the Bay.

It surprises CDM Smith that mercury, a known toxic element to life forms was not included in this investigation. A baseline study of mercury in sediments in the Bay would have been a great line of evidence to support our assumption that the mercury introduced to the Estuary is fairly contained. Reviewing data of Botany Bay sediments goes beyond our scope however we would like to recommend mercury to be included in the analytical suite once this study is repeated.

Review of Contamination Issues Associated with the Port Botany Expansion, Prepared for Sydney Ports Corporation, 21 May 2003 (document 113)

- Limited sampling and analysis of biota within Penrhyn Estuary and north-eastern Botany Bay has been conducted. Sampling has been undertaken as part of the environmental investigations for the Orica petrochemical facility to address risks to human health associated with the consumption of fish. These studies have focussed primarily on the concentration of contaminants associated with the Orica petrochemical facility that have the potential to bioaccumulate namely, mercury, chromium and semivolatile halogenated compounds. Biological monitoring has focused on edible species of fish, but has also included a number of invertebrate species. The studies indicate accumulation of HCB in some species at concentrations greater than that found at reference sites elsewhere in Botany Bay (Woodward-Clyde 1996). In contrast, mercury and chromium concentrations in biota have been generally found to be not significantly different from those found at reference sites;

- access to the current boat ramp and the upstream sections of Penrhyn Estuary would be restricted as the current road access to the eastern side of Penrhyn Estuary will be closed to the general public. Access to Penrhyn Estuary would be by foot from Foreshore Beach on controlled access paths. It is conceivable that recreational use of south-eastern Foreshore Beach would be limited to passive activities (i. e. unlikely to involve swimming). This would reduce the potential for exposure to VHCs in the areas having the highest contaminant concentrations, i.e. upper Penrhyn Estuary and could result in a reduction of risks to human health;

- the relocation of the boat ramp to north-west Foreshore Beach may increase active recreational use of this area, which could conceivably including wading or swimming. The concentration of VHCs may increase along the section of Foreshore Beach that forms the constructed channel. However, no significant changes in water quality are predicted for Foreshore Beach west of the constructed channel which, given the open nature of the beach, is the area most likely to be used for swimming; and

- the larger confined area of Penrhyn Estuary would not be expected to result in increased accumulation of contaminants in edible biota. (CDM Smith: changes in habitat and home ranges for fish can be complicated. Changes to these factors is likely given the magnitude of changes in the aerial photos).

2013 HHERA

No additional data have been collected with respect to sediment and biota concentrations in the offsite areas since 2004 (when the last round of sediment samples were collected and considered in the CHHRA). Since mercury concentrations in stormwater runoff from the FCAP are expected to be lower than in the past, it is not expected that the concentrations considered for the assessment of potential exposures in Penrhyn Estuary in the CHHRA are likely to have increased.

Note that we have provided more comments in Section XX from our review of the 2013 HHERA.

Botany Expansion Project

As part of the Port Botany Expansion Project, Sydney Ports has rehabilitated Penrhyn Estuary, located adjacent to the port expansion. The design, methodology and ongoing maintenance for the estuary are outlined within the Penrhyn Estuary Habitat Enhancement Plan (PEHEP).

Appendix L - Modelling approach for former Chlor-Alkali Plant- Orica - Botany

Memorandum

To: *Jim LaVelle*
From: *Gwen Pelletier*

Date: *November 13, 2013*

Subject: *Modeling Approach for Orica Australia*

To evaluate possible impacts from mercury (Hg) releases from the former Orica chlor-alkali plant, screening level air dispersion modeling was completed. Screening models are intended to provide "worst-case" 1-hour concentrations (i.e., higher concentrations than would be obtained using a refined model) without the need to provide actual, hourly meteorological data. This memorandum summarizes the modeling approach, assumptions, and data gaps for the analysis.

Model Selection and Options

Atmospheric dispersion modeling was conducted for Hg using the most recently available version of the EPA's AERMOD modeling system (version 12345). AERMOD has an option to run in a screening mode, which is also known as AERSCREEN. The goal of the modeling was to predict possible worst-case ground-level concentrations of Hg that could have occurred from operation of the facility. As such, it was not necessary to obtain actual meteorological data for the area to complete a refined analysis. AERMOD and AERSCREEN are currently listed as the preferred models in the United States Environmental Protection Agency's (USEPA's) *Guideline on Air Quality Models* (Appendix W to 40 Code of Federal Regulations [CFR] 51). AERMOD View Version 8.2.0 by Lakes Environmental Software was used as the graphical user interface (GUI) to the model.

Regulatory defaults were used with the exception of the screening mode used by the model. Additionally, only 1-hour maximum concentrations can be estimated, thereby warranting the use of a scaling factor to estimate annual average concentrations. Table 1 provides specific information regarding model inputs.

Table 1 Dispersion Modeling Options

Option Description	AERSCREEN Setting
Non-default options	Screening Mode
Dispersion coefficient	Urban
Terrain height options	Elevated
Receptors	▪ Non-uniform polar grid ▪ Distance from origin to rings (m): 25, 50, 59, 100, 127, 150, 200, 250, 300, 350, 400, 450, and 500 ▪ 36 radials
Elevation data	SRTM3 (~90 meter global) map type

The surrounding areas were reviewed to determine the land use of the surrounding areas; the site is considered urban (greater than 50 percent) using the Auer[1] land-use approach to describe the dispersion environment with 3 kilometers of the facility. Terrain data for the site domain was imported using the Shuttle Radar Topography Mission (SRTM) 3 map type. The SRTM3 data provides global coverage of elevation data with a resolution of approximately 90 meters. The AERMOD View GUI automatically selects the proper terrain data to use and assigns elevations to all sources, receptors, and buildings.

Screening Meteorological Data

The MAKEMET utility was used to generate a matrix of meteorological conditions using user-specified surface characteristics, ambient temperatures, minimum wind speeds, and anemometer heights. Default or recommended values from the USEPA were used for all parameters with the exception of temperature. Record temperatures for Sydney, Australia range from a low of 2.1 degrees Celsius (°C) to a high of 45.8 °C[2]; this translates to 275 Kelvin (K) and 319 K for input to MAKEMET. Table 2 summarizes the input data used to generate the screening meteorological data.

Table 2 MAKEMET Utility Input Data

Anemometer Parameters[1]	
Anemometer Height	10 meters
Minimum Wind Speed	0.5 meters per second
Wind Direction Parameters	
No. of Wind Directions	12
Starting Wind Direction	0 degrees
Wind Direction Increment	30 degrees
Temperature and Surface Parameters	
Minimum Temperature	275 K
Maximum Temperature	319 K
Albedo[2,3,4]	0.208
Bowen Ratio[2,3,5]	1.625
Surface Roughness[2,3,6]	1 meter

Notes:

1 USEPA. 2011. *AERSCREEN User's Guide*. EPA-454/B-11-01. March. Available online at: http://www.epa.gov/ttn/scram/models/screen/aerscreen_userguide.pdf [Accessed on November 12, 2013].

2 USEPA. 2004. User's Guide for the AERMOD Meteorological Preprocessor (AERMET). EPA-454/B-03-002. November. Available online at: http://www.epa.gov/ttn/scram/metobsdata_procaccprogs.htm#aermet [Accessed on November 12, 2013].

3 Recommended parameters for urban land use, average weather conditions, and annual average season.

4 The albedo is the fraction of the total incident solar radiation reflected by the surface back to space without absorption.

5 The Bowen ratio, an indicator of surface moisture, is the ratio of the sensible heat flux to the latent heat flux (USEPA 2004).

6 The surface roughness length is related to the height of obstacles to the wind flow and is the height at which the mean horizontal wind speed is zero (USEPA 2004).

[1] Auer, August H. Jr. 1978. Correlation of Land Use and Cover with Meteorological Anomalies. *Journal of Applied Meteorology*. 17: 636-643.

[2] Weatherzone. 2013. Sydney climate, averages and extreme weather records. Available online at: http://www.weatherzone.com.au/climate/station.jsp [Accessed on November 13, 2013].

Emission Sources

Two main sources of Hg emissions were identified in the facility: 1) fugitive emissions from the cell plant and 2) stack emissions from the hydrogen byproduct stream. A building with dimensions of 4,000 square meters by 10 meters high was included as a structure in the dispersion model. Based on historical information, the stack was located approximately 60 meters away from the building. Building downwash was included in the model to account for any influence the building may have on the stack's dispersion. Because the fugitive emissions would emanate from the roof and walls of the cell plant, these emissions were modeled as a volume source. Table 3 summarizes the input parameters for the two emission sources.

Table 3 Input Parameters for Emission Sources (Worst Case Senario)

Parameter	Value	Comments
Fugitive Emissions (Volume Source)		
Release height	5 m	Half the estimated building height
Emission Rate	0.0336 g/s	Estimated emission rate of 1,047 kg/year [4]
Length of side	63 m	Square root of estimated building size (4,000 m^2)
Initial lateral dimension[1]	14.65 m	Length of side divided by 4.3
Initial vertical dimension[1]	4.65 m	Building height (10 m)[2] divided by 2.15
Stack Emissions (Point Source)		
Release height	15 m	Estimated; assumed to be 5 m taller than building
Emission rate	0.0285 g/s	Estimated emission rate of 900 kg/year[4] [5]
Gas exit temperature	180 °F	Estimated from USEPA guidance[3]
Stack diameter	0.5 m	Estimated
Gas exit velocity	3.891 m/s	Estimated using flow rate of 2,750 m^3/h (historical data)

Key:
F = Fahrenheit; g/s = grams per second; kg/d = kilograms per day; m = meter; m^2 = square meters; m^3/h = cubic meters per hour
Notes:

[1] USEPA. 2004. *User's Guide for the AMS/EPA Regulatory Model – AERMOD*. EPA-454/B-03-001. September. Available online at: http://www.epa.gov/ttn/scram/dispersion_prefrec.htm#aermod [Accessed on November 12, 2013].

[2] Building height estimated based on three-level structure.

[3] USEPA. 1976. *Molecular Sieve Mercury Control Process in Chlor-Alkali Plants*. EPA-600/2-76-014. January.

[4] This rate assumes maximum capacity (230 tonnes/day). Prior to 1965 and after 1998 the capacity was less. See Section 5.1 mass balance for estimated capacities.

[5] Since 1979 these emission decreased to 145 kg/year (see section 5.2.4.)

Results

Output from AERSCREEN calculations are not estimates of levels of mercury that may have existed in any locations within the community. These "worst case" estimates only provide justification for additional analysis, using more site-specific data and full dispersion modeling. Such modeling will use local meteorological data, refined emissions information and comparisons with similar chlor-alkali plants elsewhere in the world.

The maximum 1-hour ground-level concentrations for each receptor distance and source was converted to annual averages using a scaling factor of 0.103. Table 4 summarizes the results of the screening model. As shown in the table, the predicted ground-level Hg concentrations range from 0.27 micrograms per cubic meter (µg/m3) to 4.05 µg/m3 for annual averages. These results are depicted in Figure 1 along with screening levels for elemental mercury in air from several sources. Please be aware that a refined analysis would not show similar contours. The reason why the contours on Figure 1 look so round is because the screening met data is in all directions. As such, this should be used for informational purposes only. See Section 7.1 of the main text for an explanation of these screening levels.

Table 4 AERSCREEN Modeling Results

	All		Stack		Fugitive	
Distance (m)	1-Hour ($\mu g/m^3$)	Annual ($\mu g/m^3$)	1-Hour ($\mu g/m^3$)	Annual ($\mu g/m^3$)	1-Hour ($\mu g/m^3$)	Annual ($\mu g/m^3$)
25	35.52	3.55	4.80	0.48	35.16	3.52
50	40.52	4.05	4.44	0.44	38.74	3.87
59	33.80	3.38	3.62	0.36	31.43	3.14
100	15.67	1.57	4.11	0.41	11.57	1.16
127	11.36	1.14	4.34	0.43	7.01	0.70
150	9.30	0.93	4.33	0.43	4.97	0.50
200	6.68	0.67	4.35	0.43	2.90	0.29
250	5.19	0.52	4.00	0.40	2.11	0.21
300	4.39	0.44	3.50	0.35	1.59	0.16
350	3.75	0.37	3.04	0.30	1.23	0.12
400	3.25	0.32	2.67	0.27	0.98	0.10
450	2.89	0.29	2.37	0.24	0.79	0.08
500	2.67	0.27	2.16	0.22	0.66	0.07

Key:
$\mu g/m^3$ = micrograms per cubic meter; m = meter

Next Steps

The screening level modeling that was completed for this analysis does not consider the effects of actual meteorological conditions that could influence the annual average concentrations. Actual meteorological conditions affect the dispersion of the modeled pollutant, which means that maximum annual average ground-level concentrations could occur at locations where there are no sensitive receptors (e.g., residents). It is recommended that refined modeling be completed with actual meteorological data to provide a better understanding of how the Hg emissions could have dispersed. Furthermore, the AERMOD modeling system can be refined to include deposition and decay, which should be considered for further evaluation.

[3] USEPA. 2011. *AERSCREEN User's Guide*. EPA-454/B-11-001. March. Available online at: http://www.epa.gov/ttn/scram/models/screen/aerscreen_userguide.pdf [Accessed on November 13, 2013].

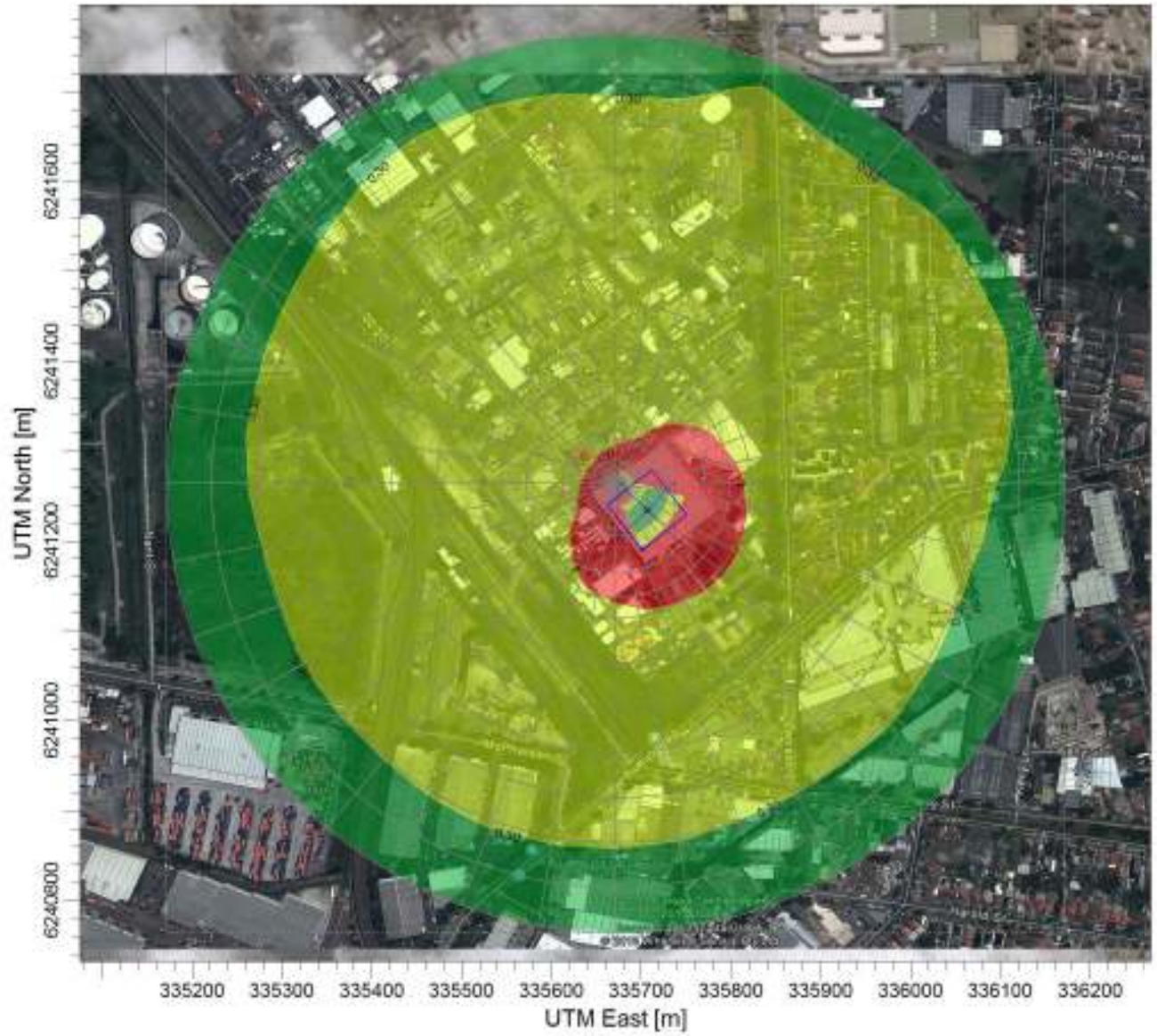
Finally, several parameters, such as the stack diameter, height, and temperature were estimated using professional judgment. Further, changes in chlorine production were not accounted for. Mercury emissions vary according to the amount of chlorine produced. Updating these values with historical data would also affect the modeled results. While it is understood that historical information may be limited, attempting to eliminate data gaps is critical. One means to help put modeling results in perspective will be to use estimates from the literature to model emission rates reported from mercury cell chlor-alkali plants elsewhere in the world.

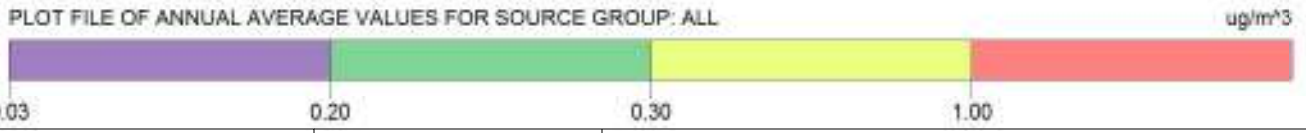
cc: Laura Green
Steve Zemba

Attachment: Figure 1

PROJECT TITLE:

Orica Australia
AERMOD Screening Model





COMMENTS: **Preliminary Draft - For Discussion Purposes Only**	SOURCES: **2**	COMPANY NAME: **CDM Smith**	
	RECEPTORS: **468**	MODELER: **G. Pelletier**	CDM Smith
	OUTPUT TYPE: **Concentration**	SCALE: 1:7,500 (0 — 0.2 km)	
	MAX: **4.1236 ug/m^3**	DATE: **11/19/2013**	PROJECT NO.: **100924.SCL130051.01**

Appendix M - Summary of ICI/Orica Files

Review of documents made available by Orica for the Orica Botany Mercury Independent Review - Stage 1 - Data and Information Collection and Review

Volume	Date on document	Type of Document	Title/Subject	From	To	Content	Reviewer
14	23/02/1942	report		Solvey		Botany works, Design of Brine Plant. Castner-Keller works Botany Clorine Plant is designed for 60 tonnes/week Cl2 output. It will be unique amongst mercury cell plants known to ICI as it will use solar salt whih is of vast inferior quality then industrial salt. all the tanks in the brine plant will require sludging. there is a main concrete 10m3 sludge sump below the lowest sludging cock on the plant. The sump is agitated and emptied through two pump who deliver the sludge to the sludge lagoon. The documents speaks about a working floor for the brine plant level with the 10 foot cell room working floor. The possibility of the plant ultimately extending to three times its present site should be borne in mind when equipment is laid out. On a plan of the plant 21 cells are identified and temperature in the cells is 66 Celcius	Loek
14	5/09/1949	internal memo		ICI	ICI	Imperial chemical industries of Australia and New Zealand Ltd. Botany factory B/57 Effluent segregation at Botany Factory. By PG s and WA K, ICIANZ Library. A scheme is outlined for segregation of the follow-ing plant effluents at Botany factory from the main factory effluent passing into Botany Bay: 1-4) other plants 5). Brine sludges from cell plant it is proposed to run the waste liquors to gravity throug gravity flow stoneware drains into an unused 300' x 50' area situated on that portion of block V beyond the present factory boundary fence. The area will be enclosed by a paling fence to prevent unauthorised trespassing. This action is necessary as the discharge of the materials with the main factory effluent has been forbidden by the Maritime Services Board. Cost savings are anticipated as period cleaning of the existing lime settling pond will no longer be required. The department of public health observed (since 1946) effluent carrying dark suspended matter - This is mostly due to sludges discharged from the brine reactors but may be due to sodium sulphide - ferric chloride combination. This is the present position and it may be summarized as follows: 3) some means of disposing of brine sludge from the cell plant ..... are required. Brine effluent sludges: All magnesium salts and fine insolubale matter ....together with graphite particles from the cell anodes eventually leaves the brine plant in the form of a black sludge. Some of this settles out in the sumps outside the building, but a considerable portion carries on to the drain, which leasd to a sump on the Burma Road corner of the salt store. It is proposed to divert the drain at this sump into a new 6'' stoneware drain leading down Burma Road to the drainage area in Block V. The length of drain concerend is 640' (195 metres).....The average volume of liquor from the brine plant would be about 400 gallons per day (1500 liter/day). A volume of 135,000 cubic feet is therefore available for accumulation of solid matter.	Loek
14	1/05/1956	report		ICI	ICI	Survey of the effluent system at Botany Factory Interim Report: The drainage system can be divided into two separate sections: 1) waste water containing notorious materials, the "noxious effluent" 2) the effluent containing all waste waters, which are not discharged into the noxious effluent. This is often refered to as the "stormwater drain" or "Botany Bay effluent" Attention should be drawn to an apparent lack of adequate drainage planning in the construction stage, as great difficulty was experienced in obtaining a definite picture of the present system *CDM Smith: There is a list of plants/units that discharge to the "noxious effluent" CDM Smith: the FCAP (part of the inorganic section) is not part of this list* Plant wastes not discharging onto the noxious effluent discharge into this general effluent, together with rain water. The wastewaters of the inorganic division may contain the floor washings of the various units and thus may be very acid or alkaline or obtain active chlorine. Generally this is reasonably clean *(note CDM Smith: Mercury is not mentioned here)* Regarding the inorganic Section: The floor beneath the old cells is a (illegible words) at all pools of waters (illegible words) and mud are always present.)elligible words gutter system is needed There a tables in the back of the report which are not very readable. -Sludge from the ex brine plant: weekly discharge, flow to botany bay = ?, estimated analysis: 3.5 tonnes CaCO3, 0.5 tonnes Hg and 0.5 tonnes graphite plus enough water to make fluid -Cell room: Estimated analyses: Alkaline	Loek
8	1/09/1970	other	Hg contetn in effluent	B.B		(Sep 1970) 0.8mg/l – (October 1978) 0.037mg/day CDM Smith Check – 251.6g/day based on 6.8 KL/day	Loek
7	20/03/1972	memo	Hg pollution - air analyses - Research report		Works manager	First results of our pollution survey Deposit gauges – Hg was bound maninly on the sedimented soli particles 4.6-0.017 mgHg/M2 Month (6 tests at different sites) Soil – 7 samples on 8.3.72 (after heavy rains) – 17.6 -0.4ppm Hg backyard of office/Surface salt heap Air samples (3hrs of sampling) – 6.7ug Hg/M3 behind the yard office, 4.2 ug Hg/m3 close to waste water pond Hg can be easily detected in the general area of the plant it is recommended a survey of Hg in air to be carried out.	Loek
5 of 20	1/09/1972	letter	Draft - MWSDB New Policy for Acceptance of Liquid Trade Wastes to Board's Sewerage and Drainage Systems	Presumably ICI. Not stated	MWSDB	Draft of a reply to a letter of 28 August 72 to ICI. Refers to ICI becoming aware of the mercury toxicity issue in 1970, and subsequently spent over $200,000 to reduce Hg in effluent. Refers to losses to effluent of approx 10g/t Hg, which will reduce to 2g/t of Cl produced. NOTE: Refers to extensive fish sampling in conjunction with Health Department and analytical results reported to confirm no evidence in marine life of pollution from industry in local waters.	Andrew

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Volume	Date on document	Type of Document	Title/Subject	From	To	Content	Reviewer
8	9/10/1973	internal memo	Aqueous emissions & Gaseous Emissions	D.E.K.B		Aqueous: Due to time restraints this section hasn't been read Gaseous Emissions: - Clean air Act (Health Department_ - Max emissions from stacks – 20mg/m3 - NHMRC has recommended 3 mg/M3 Present Botany Performance: H2 not being purified and sold, goes in the atmosphere. Contains Hg strength in excess of the saturation levels @ ambient temperature i.e about 15mg/m3. In hot weather it may be above 20mg/M3 Total cell room ventilation is difficult to assess. A measurement in 1969 indicated a total flow of 750.000 cfm for both cell rooms (13.10^6 m3/hr) If it contained 0.05mg/m3 of Hg vapour this would represent an emission of about 1500gram/day	Loek
1 of 20	29/10/1973	report	The Economic Impact of Future Mercury Emission Standards on Chlorine Costs at Botany and Yarraville	Working Party - ICI	osal & Cost Review for Future Compl	$956k in capex required for Botany to upgrade plant to comply with lower Hg limits in effluent. Present performance is 0.5mg/L Hg or 5lb/day based on 50,000gph.. MWS&DB required ICI to reduce Hg to 0.1mg/L by end of 1974 (1lb/day). Installation of sludge filter was proposed. A future requirement by around 1977 of 0.01mg/L (0.1lb/day) was considred likely to be required by ICI. Current maximum air emissions (Clean Air Act) were 20mg/m3, while the NHMRC had just recommended a lower limit of 3 mg/m3. US emissions limit was noted at 2300g/day per facility (in air). H2 stack emission from Botany were approx 15mg/m3 on average, and up to 20mg/m3 on hot days, maybe higher. At peak production in 1973 (260t/day Cl2), 90,500m3 per day of H2 could be vernted at 20mg/m3 equal to 1810g/day. Cell room emissions were assumed to be (based on 1969 measurement) 1500 g/day, based on 750,000 cfm for both cell rooms (1.3x10^6 m3/hr) and 0.05mg/m3 average concentrations.	Andrew
7	29/10/1973	report	The Economic Impact of Future Mercury Emission Standards on Chlorine Costs at Botany and Yarraville	D.E.K.B		Present performance: Hg in effluent ~0.5mg/l >> ~5 lb/day in May 74 it is planned to install a filter which will prevent brine sludge being sewered – expected to lower Hg to 0.05mg/L	Loek
6	29/10/1973	memo	Economic impacts memo	ICI	ICI	Already provided in different volume	Loek
7	6/12/1973	memo	Phone call from water board	water board	ICI	They measures 6mg/l of hg in effluent – board was very upset, 'all hell is likely to break loose'	Loek
7	1973-1974	memo	Several - regarding descussions with water board			-sludge filter was installed by ICI (June 1974) disposal of sludge cake at castlecreagh Hg is filtered between 940-260ppm (dry matter w/w) - mean -1857 ppm Hg – moisture content - 40.5%	Loek
6	11/03/1974	memo	Summary of the current position on the disposal of Hg bearing sludge from botany chloride plant			Present 5 lb/day of Hg is being sewered in association with about 7 tonnes (dry basic)/day of brine purification sludge Issue of regulation by the MWS and DB in 1972 which stated that no Hg could be sewered an undertaking was given to the board to reduce the Hg content of our effluent to 0.1 mg/l (1lb/day) by the end of 1974. In Sept 1974 quantity of sludge produced will be reduced to about half its present rate as barium sulphate will not be present ponding of sludge on site was rejected internally in June 1973.	Loek
1 of 20	1/05/1974	internal memo	Research Dept Progress report March-May 1974, NSW Section. Clariflocculator Sludge and Its Disposal	ICI	Internal Report	Research into potential disposal site selction, and Hg behaviour in soil depending on NaCl concentrations. In Garden Soil and Clay, the % of Hg absorbed based on 0, 0.005, 0.05 and 0.5 % NaCl added is 82/50, 62/15, 44/0 and 18/0 respectively. Hg mobility is highly NaCl dependent.	Andrew
1 of 20	8/05/1974	internal memo	Mercury in Clari Sludge	ICI Organic Laboratory Botany	Members of the Mercury Committee	Total dry solids in Clarifiers approx 45-54% w/w (26-39 % w/w NaCl-free). Hg content in ppm on dry solids basis (NaCl free) 880-945ppm.	Andrew
6	8/05/1974	memo	To the members of the Hg committee	ICI	ICI	Hg in clari flocculate sludge Wet sample 367-232 ppm (w/w) Total dry 674 – 513 ppm On dry solid basis 945 – 880 ppm	Loek
9	16/09/1974	other	Hand written document			Clari sludge filter plant basic operating instructions	Loek
8	1/05/1975	memo	Various	ICI	ICI	Leachability of brine bricks (23*6.5*9cm) = 1.8kg is very low	Loek
1 of 20	15/05/1975	internal memo	Mercury Content in Filter Cake	Research Lab Botany	Chlorine Plant Manager, Botany	14 samples of filtercake analysed and concentrations ranged between 940-2630ppm, with mean of 1857ppm w/w on dry basis. The concentration on a wet basis was 1105ppm Hg based on 40.5% moisture.	Andrew
5 of 20	5/07/1976	letter	No title/subject - relates to Hg in effluent	(Site Planning Manager)	MWSDB (The Secretary)	States Sludge Filter installed September 1974, and since approx 1973 a technical officer and assistance have been employed almost full time on the control of Hg in effluent, which is a continual concern of senior staff. $557,000 spent on capital costs including disposal of sludge to reduce Hg concentrations in effluent.	Andrew
2	8/02/1977	letter		ICI	ICI	2889 (A, 6/55)nd air samples collected and analysed for Hg @ site boundary: 0.2 - 7.6 ppm (levels were greatly reduced after heavy rains) 1.5 - 22 ug/m3 Hg in ambient air within the chlorine plant, particulair near the hydrogen gas holder samples taken in the general atmosphere outside the plant were below 1 ug/m3 which is considered to be acceptable limit	Loek
2	1/05/1977	scientifical publication		not noted	not noted	Article by Dr. M.O. Bouveny (Sweden) for the Chlorine Institute "the Hg based Chlorine Industry and Environmental Survey" Concludes that 90% of the total Hg emissions from mercury cell plants are to the atmosphere ICI Australia has recently completed modernisation programm covering both its mercury cell plants	Loek
2	1/06/1977	scientifical publication		not noted	not noted	Hg wastewater management technology Costs for Hg cell users in the Chlor Alkali Industry by I. Frankel, CIC/ACS Hg replacement for 12 plants: average 0.17 kg Hg / tonne Cl production (0.34 lb/ton) and ranges between 0.09 - 0.41 kg Hg/tonnea from 1975 Small proportion of this lost Hg is discharged via effluents or emissions, most Hg ends up in solids from brine purification, in sulfide sludges, in "in process inventory", or is otherwise lost from the process	Loek
2	16/06/1977	letter		not noted	not noted	Letter ICI to EPA VIC In 1975 - Chlorine by Hg Cell is 110,000 tonnes p.a. Chlorine by Diaphragm cell is 7,000 tonnes p.a. Production increase by 45% over the past 10 years and expected similar increase in the next 10 years Control of Hg losses has tightend considerably since problem was recognised	Loek

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Volume	Date on document	Type of Document	Title/Subject	From	To	Content	Reviewer
2	25/08/1977	letter		SPCC	ICI	SPCC informs ICI it wants to lower the regulation limit on the vented H2 gas stream from 20 to 3 mg/m3 SPCC asked for the following informations (numbers were handwritten on this letter): Daily chlorine production : 230 te/day Daily H2 productions ~7,1 t/d H2 sold: -- H2 vented or lost to atmosphere: 3000 m3/hr; 40,000 ug/m3 Caustic Soda streams : 0.3 g/tonne estimated Hg lost in cell room ventilation, hydrogen gas stream (900 kg/annumn), chlorine and caustic soda stream (57 kg/annumn)	Loek
14	22/09/1977	report		ICI	ICI	Title: Mercury retort explosions at Botany. The mercury retort was commissioned in June/July 1972. Feed materials to the retort include: - sludge and residues from pits in the cell room area, - stellar filter cake(charcoal filter used for filtration of caustic soda), - filter cake from cell effluent filters together with precoat material, floor sweepings, and sludge from cell room floors - miscellaneous deposits which have mercury contamination, thi sincludes Yarraville Stellar filter cake sent by road transport to Botany as well as some deposits from outside pits and drains - denuder balls plant experiment: Hg content (wet basis) before retorting: 4.4% w/w and after retorting 9.4ppm w/w	Loek
8	30/11/1977	letter	Hg emissions CAP	ICI	SPCC	Peak CL2 production is 240 tonne/day which is equivalent to 542 tonnes/day of 50% caustic soda. production of 85% of the max is achieved on a yealy basis (85% from 240 – 74460 tonne/year, caustic side (50%) 168000) Hg in chlorine is 0.04ppm Hgw/w (tested in 1973) 20.1 =10^6um3/annum (55000um3/day) is vented to atmosphere The original cell room was built in 1945. Second cell room was added in 1954 and a third in 1965 – open cell room It is impossible to accurately measure the quality of air moving through out cell rooms. Hg content has been monitored carefully since 1947 (especially at breathing level where people work). Hg in urine was also tested. The Hg content of air in cell room is maintained at less than 50 micrograms/m3 (ug/m3) Hg estimates recovered from the retort plant input stella filter sludge = high Hg residue 1976: 4435kg Hg recovered 1977: 2520 Hg recovered – not fully operational and materials were accumulated Hg inventory budgeted at 0.12kg/tonne of chloride compare to 12 plants in the US, published by chlorine institute. Average makeup of 0.17Kg/tonne (0.09-0.41 kg/tonne) Contains details of the existing Hg emission control measures.	Loek
2	30/03/1978	letter		not noted	not noted	Reduce Hg level in vented H2 gas to below 3 mg/m3 (Canadian NHMRC level) Completion around June 1979 In cell rooms Hg content less then 50 ug/m3 (monitored as a matter of routine) Some brief discussion ensued as to the difficulty of determining actual emissions from our open design cell rooms It was significant that these SPCC officers did not enter into any further discussion on the overall mercury inventory, Question 7 in their correspondence of 25/8/1977	Loek
2	28/08/1978	internal memo		not noted	not noted	Hg emissions ICI already agreed to SPCC proposed reduction in the emission standard from 20 to 3 mg/m3 in line with NHMRC regulations request from SPCC to reduce Hg in strong H2 is considered reasonable by ICI	Loek
2	5/09/1978	internal memo		not noted	not noted	Hg removed from End Box Vents. "the denuder vent may be left untreated"	Loek
2	13/09/1978	internal memo		not noted	not noted	Purpose: discuss matters raised on 29/3/78 and in particular to obtain agreement from SPCC on some aspects on ICI's proposal to reduce the Hg levels in strong hydrogen vented from the CAP. There is talk about an existing vent stack (untreated hydrogen)	Loek
2	21/08/1979	internal memo		not noted	not noted	Purification of waste hydrogen: @present waste hydrogen vents to atmosphere untreated will reduce Hg to below 3 mg/m3 H2 output will be 4,5 te/d (about 2200 m3/hour) absorption with sulphur-impregnated carbon is suggested	Loek
2	30/09/1981	other		unknown	unknown	(Hg * F)/100 : calculated total exposure in cell room Hg in air measurements. Orica calculated the weighted exposure on a weekly basis Avergae weighted exposure 8/7/81 to 30/9/81 is ~30 ug/m3, Av Ambient temp ~28C and Total Load KA ~ 280/week	Loek
9	10/12/1981	internal memo				Testreports on chemical fixation of Hg filter cake	Loek
8	1/01/1982		Environment Council Hg Policy Statement and Background Profile AEC Report no.5, canberra			5 Hg operating cells in Australia - 2 for ICI botany and granville, 3 maller ones APPM wessleyvale, burie, ANM new norfolk, APM Marycale	Loek
8	20/09/1982	memo	Various	MACR	C	Site effluent flow of 6000m3/day Hg content in brine sludge typically = 150ppm +-200oom Hg content in brine liquor = 15ppm +- 24ppm Average Hg in brine sludge = 1000ppm	Loek
8	6/05/1983	memo	Various	ICI	ICI	Preperation on visit FK of the SPCC clean air branch Hg emissions in the Hg report @ botany Flow rate of gasses – 31.6 m3/min, 108oC Hg = 1.15 (14/4/83)-2.62 (4/5/83)mg/m3 = 16608960 m3/yr >>> CDM Smith: 19-43 kg/year	Loek
8	8/06/1983		Hg Emissions from CAP	ICI	ICI	Present – FK from SPCC and ICI Hg usage was 35kg/day of which 15kg/day can be accounted for Approximate of dispersion had been obtained by SPCC assuming 10kg/day emissions of Hg; ambient point source discharge. Graphs presented at different and winds speeds and heights. Commissioning of the end hot venting system was said to be early July 1983 – Hg consumption may increase because of positive ventilation. Matter arising from this examination – alteration of the clean air act limit for Hg to 3mg/m3; possible effect of unaccepted Hg upon local air quality; possible effect of unacceptable Hg upon stormwater runoff and botany bay. approximate estimate of dispersion has been obtained by FK.SPCC office using a procedure described in 'turners work book' which is a standard USA authority	Loek

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Volume	Date on document	Type of Document	Title/Subject	From	To	Content	Reviewer
9	24/06/1983	internal memo				disposal of brine sludge. Solid waste will go to landfill other then Castlereagh it will be a selected landfill but not as sucure as Castlereagh, Brine sludge will be one such waste, leachibility data required to approve disposal.	Loek
8	1/11/1983		Table			Handwritten table regarding Hg (isotope) usage determinations - Sep71-Sep83 Hg usage kg/Tonne varies from 0.064-0.253. Average usage 0.127 kg Mg/Tonne	Loek
8	13/01/1984	memo	Hg content of effluent	ICI	ICI	Grand average - for 1983 was 92ppb, just blow the limit of 100ppb. From 1975 -1983 the Hg in effluent was most of the time <0.1ug/L	Loek
5 of 20	4/10/1985	letter	Mercury Content of Effluent	(Site Environs Manager)	Sewerage and Drainage Board (MW	Average monthly effluent Hg concentrations for 1984/85. Average concentration for 1984 was 0.072mg/L and for 1985 was 0.054mg/L. Only once exceedance of the 0.1mg/L limit was measured, a level of 0.127mg/L	Andrew
1 of 20	1/01/1986	scientifical publication	Potential Health Effects of Mercury in Water Supply Wells	T.R. Stolzenburg, et al.	N/A	Good info of mercury cycling in the environment, solubility, oxidation states etc, and stability field diagram for range of Eh and pH values.	Andrew
6	1/01/1986	scientifical publication	Potential Health Effects of Mercury in Water Supply Wells	TRS		Hg in well water is highly unlikely to be methylated to the toxic methyl mercury form. No shell fish are present in well water	Loek
8	4/02/1986	memo	Various	TMC	ICI	Recommend high priority given to repairs to brine sludge filter (Hg in effluent 210-3300ppb, target is 100ppb)	Loek
8	8/12/1986	other	Incident report	ICI	ICI	Incident: sludge spillage onto pavement 0.5-1m3 equivalent to 100-200ppb Hg in 1 days effluentflow. Cause: inadequate (corroded) sludge chute	Loek
8	10/12/1986	memo	Various	ICI	ICI	Hg cases of brine sludge filter area - substantial spillage occurs + sludge also discharged to MWS&DB sewer (brine) because of poor filtratuib	Loek
1 of 20	11/02/1987	report	Optimization of Mercury Removal from Brine Discharges	ICI	ICI	Highlights that accepted discharge standard is 100ppb Hg. Says typical waste brine and waste water has 20-30 ppm Hg concentrations. Each batch for treatment is about 50m3, and 1-2 batches per day are treated. Each batch takes 1 hour to discharge into about 250m3 of other effluent so maximum Hg conc in the treated batch is 550ppb, but a level of 300ppm is recommended to allow for other Hg sources into the waste stream. Hg precipitation vessel operates at between 110-4680ppb, and up to 10,000ppb on occasions.	Andrew
9	11/02/1987	report		ICI	ICI	Internal report ICI: Optimization of Mercury Removal from Brine Discharges	Loek
8	11/02/1987		ICI Aus Industrial Chem Group, Optimisation of Hg removal from brine discharges	DJM&RCS	ICI	Typical (Hg) in brine is 20-30ppm 1 or 2 batches (50m3 each) treated per day Treatment should achieve aboue 300ppm Hg2+ + S2- Very detailed and comprehensive report	Loek
8	20/02/1987	memo	Various	TMC	ICI	chute has not been repaired. Filtrate tank still full with sludge. Writer appreciates a firm advice about the actions to be taken. Unwise situation in relation to MWS and DB or sPCL and current publicity	Loek
2	1/03/1987	letter		ICI (Doctor)	ICI	Occupational HealthServices, Occupational Hygiene report, Exposure to Hg at Botany Chlorine Plant by G Gately and D Pryor, date: early 1987 area monitoring once weekly (between 1-3pm, hottest part of the day) using a Bacharach (interfers with water vapor and possible some organics > used silica filter) detector in fixed locations. These concentrations are summed using weighting factors (presumable based on average occupancy times in an area to give a "total weighted" exposure. Note CDM SMith: all weighting factors together add up to 108,5 Urine Hg levels measured at Botany are below internal company action limit of 150 ug Hg/g creatinine New toxicological data emerge abd the WHO has set a lower limit of 50 ugHg/g creatinine "the weighted average atmospheric concentration cannot assess individual exposures and may tend to underestimate group exposures" Urine Hg levels are generally regarded as the most reliable guide to occupational exposure: - three monthly - if >150 ug/g then repeat measurement. If still > 150 . remove worker until Hg levels (taken monthly) are below 100 ugHg/g creatinine NH&MRC and NSW Division of Occupational Health levels of 200 ug/g and the Chlorine Institute has a level of 300 ug/g however WHO level was set recently to 50 ug/g H and MKI banks are shelterd from the effect of wind both in the cell room and below, while B1 cells are more open on both levels. General area ventiolation relies on air movement from heat convection, natural wind and electric blowers. It is concluded that the motors not always work together with natural wind (only at eastern wind direction they work together) There are broken concrete floors under the cells which are difficult to hose down completely and which provides traps for mercury. "trench drains in H-banks and MKI basement > "spoon" drains are better as mercury needs to be covered with water layer at all times Repiratory protections should be used when loading, inspection and emptying the retort, when adding Hg to denuders and when steaming Hg-lines @ brine purification: high levels of Hg in air were measured (up to 800 ug/m3). In brine lab it was 65 ug/m3 Bettrer training and Councelling is recommended Respiratorors are not generally worn even for prescribed jobs (range of prescribed jobs needs to be increased)nuder area: pools of Hg are visible in many places Cold Hg in denuders : 200 ug Hg/m3	Loek
2	1/03/1987	letter		ICI (Doctor)	ICI	Occupational HealthServices, Occupational Hygiene report, Exposure to Hg at Botany Chlorine Plant by G Gately and D Pryor, date: early 1987 (followed from previous row) 2 and a half pages of conclusions: there is need for a more stable, reliable direct read-out instument to replace currently one in use 31 recommendations were made. The most important ones: improve ventilation inside cell building unsealed dirt floor under the cells should be sealed more training to cover all operators alternative respirators protection should be considered housekeeping should be improved	Loek
8	3/03/1987	memo	Various	ICI	PAG	Work has been undertaken directly after first memo – tank cleared out In normal operation try not to discharge any brine to the sewer	Loek
8	1/04/1987	Memo	Various	ICI		Long term average Hg in effluent is 72 ppb (1980-1986)	Loek
8	10/04/1987	memo	Samples of sludge			Hg (Dry weight)ppm (ug/g) 2018-275 ppm = 0.2% (CDMS -correct number)	Loek

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Volume	Date on document	Type of Document	Title/Subject	From	To	Content	Reviewer
9	30/06/1987	other	Meeting minutes to review Hg in effluent	ICI	ICI	Objectives: 1) Redirection Hg in effluent in 2 months to within MWS and DB requirements i.e. 100 ppb. 2) Control discharge so that 100 ppm is not exceeded in any one day. Source of Hg pollution: 15 sources were provided i.e - sludge filter carrying over when blocked, about 20 times a year - Brine sludge pad – 1 mil ppb in sludge when hosing down. Graph Attachemnt 2 Hg effluent (ppb - monthly mean) Jan 1981 – June 1987 A total of 10 exceedences (monthly mean) of the 100ppb agreed limit. long term average is 72 ppb.	Loek
8	3/12/1987	letter	Hg waste process	ICI	ICI	Cost for reprocessing Hg waste in Japan Two types of waste: Filter waste (11.57% Hg ~11 tonnes)+ floor sweepings (10.64 % Hg ~ 13 tonnes). Average processing costs $1,500/Tonne of waste	Loek
9	1/02/1988	internal memo				Effluent Treatment Plant Manual (by Retec)	Loek
8	28/07/1988	other	Minutes - Hg in effluent report meeting	ICI	ICI	Background – It was shown in the past, the Botany site has not been able to adequately meet the requirements for the water board… it was agreed that ICI should attempt to improve its performance. 3 main sources of Hg where identified: Site cooling water, brine sludge filter, and precipitation vessel. It was descided in the meeting that the existing report should be renewed. Benefits of recommissioning the existing report were rejected on the basis that it was presently in-operable and the costs to restore it to a safe and workable condition was unjustifiable. Waste to Japan shall be continued as long as Viable	Loek
8	5/08/1988	report	Chlorine plant - Botant - Report - Mercury in Effluent	J.S		Limit set by water board is 100mg/m3 (ppb) the cell room floor drains were connected to the No1 Pre capitation Vessel (PPV) Drains were fitted with Hg traps Sludge from PPV contains 1,000,000ppb (0.1%W/V), pumped across 4th avenue to brine sludge filter where large amount of moisture is removed. The filtrate has about 23,000 ppb Hg, and the filter cake has 3,000,000ppb on a W/V dry basis. Daily production is about 2,5 tonne of filter cake – 7.5kg Hg CDMSmith Inefficiency in the washing process can result in a large amoint of the sludge to wash into effluent and/or stormwater drains Effluent flow rate: 5932Kl/day in 1987 Filter cake form sludge filter is trucked several 100m's down the road to the brine sludge bed behind solvents. Here it is dumped, left to dry before chemically fixed and disposed of at castlecraigh. Effluent overspill tanks are poorly constructed overspill flows to drains (30,000ppb of Hg) Hg losses through hydrogen (grey mercury) = 920 kg p.a. of which 100kg is recovered. Other source is found around the presently defunct mercury retort – adhoc contaminated waste storage. Most is drummer are either spent metasil W-2 from the caustic soda stellar filter. 7 tonnes p.a of caustic soda (stellar filters) or the grey Hg from the lines. Hg content is 30-50 wt% with about 20 tonnes being stored at present. 2 tonnes of floor sweepings with average Hg content of 15% (w/t) Spent metasil has 10% (wt) Hg content and have to be replaced at a rate of 18kg per day Main source of Hg to effluent is the cooling water (half the daily site effluent). Heating chlorinated and will therefore pick up and Hg very easily. Background levels of 50ppb Hg. Cooling water is cheaper than town water and therefore used as wash down water in the plant and other plants around the site. This results in a large amount of Hg going to effluent untreated. Cooling water and sludge filter are main contributors to Hg in effluent. Table with recommendations : Economic: app 9000kg of Hg could be recovered p.p. 12-13$/Kg	Loek
9	15/09/1988	memo	Various	ICI	ICI	Request from CAP to Olefines 1 workshop to temporarily store 200*200Ltr drums containing Hg waste, activated carbon and cell room floor sweepings and steller filters. due to Japanese plant being 'snowed in'.	Loek
9	1/03/1989	internal memo				Mercury waste disposal meeting. App 45te or 18 months of mercury waste are currently stored in the Olefines 1 workshop and this area is not appropriate for such storage of hazardous waste. Three options: 1) install new retort, 2) export to recovery facilities o/s; 3) chemically treat waste within Australia. Up until 1985 the mercury in the waste was recovered by retorting. however the retort had to be taken out of service due to a combination of poor seals, a damaged floor, and frequent blockages, all of which lead to unacceptable high levels of mercury emissions to atmosphere. Installing new retort would reduce mercury consumption. between 1985 - 1988 waste have been exported to Japan. Japan now has decided not to accept waste with Hg content lower then 15% (Botany waste has 10% Hg). Waste from Stellar filters is now drummed and periodically redrummed. A pad is required as last time they had a "disastrous performance". All drums are stored in the open and should be undercover storage even if thsi means hiring a couple of containers. brine sludge pad had no bund and that is unacceptable and during rainfall sludge washes away. A new pad must be build (under cover, drainage and bund) UPdate: Japan has now agreed to accept waste with an extra penalty due to low Hg content	Loek
9	23/04/1989	internal memo					Loek
11	5/05/1989	letter		ICI	anager Pollution Control, Water Boa	discription of improvemnet program. There has been a long standing agreement with the Board to limit discharges into the sewer to 100ppb of Hg. The effluent improvement program will reduce Hg to 35 ppb with a 90 percentile 0f 50 ppb. This is well below the 100ppb. 1) Dedicated Cooling Water System (June 1990) 2) replacement Brine sludge filter (August 1990) 3) Treatment of chlorine plant effluent (Nov 1989) Total costs fro these improvements are 3.53 million	Loek
10	6/06/1989	internal memo		ICI	ICI	Hg in effluent, comparison between Botany and Runcorn. The average Hg in effluent content at Botany in 1988 was 66 ppb with flowrate of 6800 m3/day. The Hg levels in effluent figures are substantiallybetter at Botany compared with Runcorn	Loek
18 of 20	13/10/1989	internal memo	Mercury Consumption	(Technical Manager)	ICI	Memo re increase in Hg consumption post cease of retort at the end of 1986. Contains Chlorine production and Hg consumption between 1981 and 1989. Similar data to that tabulated on a separate tab in this spreadsheet.	Andrew

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Volume	Date on document	Type of Document	Title/Subject	From	To	Content	Reviewer
10	8/11/1989	internal memo		ICI	ICI	Hg Balance, 54 man weeks are required to carry out a comprhensive Hg balance around the cell room. "the past efforts at Hg balance have suffered from lack of analyses and it is unacceptable and unprofessional to conclude that a Hg balance is "impossible". Public's perception justifies a project team be setup and dedicated to performing a Hg balance around the cell room"	Loek
10	14/11/1989	internal memo		ICI	ICI	Hg balance period 1986 to 1989 Input 20,000kg Hg/year Output: Cuastic 200, Effluent 200, Hydrogen 100, Brine sludge 1,000, End box 150, Waste acid 65, Atmosphere 100 (all in kg Hg/yr) Accumulation: Carbon and sludges: 12,850 and Inventory change 220 (kg Hg/yr) comparing before and after retorting in operation: waste streams caustic filter carbon, H2 carbon, end box vent carbon and "sludges" is the difference between Hg consumption with/without retorting accounted" is 5,115 kg/year or 26%. This is probably due to accumulation inside the plant, e.g. denuder balls, spills to floor, Hg in drains and piper etc.	Loek
10	6/12/1989	internal memo		ICI	ICI	handwritten letter, Hg Contaminated sludges Stocktake: Solid Caustic location 192+196 (205 L drums) and 230 (60L) drums (The 196 is from the Spent carbon, (hydrogen)) >> contains 30% Hg Retort location 5 (205 L drums) and 84 (60 L drums, Stellar Filter carbon) >> contains 15% (assumption) Hydrogen Plant 95 (205L drums, spent hydrogen carbon) >> contains 2% Hg Total amount of Hg in the waste is 25,000 kg; 8,500 kg/year which is 34% lower than the figure used by SM in his Hg balance report (14/11/89)	Loek
9	29/12/1989	letter		Waste Management Authority NSW	ICI	letter to inform ICI that mercury waste is no longer acceptable to Castlereagh. Also ICI should consider putting it into blocks. Disposal at regional depot is 35aud/tonne at castlereagh is 50aud/tonne. Lucas Heights is also closer then Castlereagh	Loek
11	1/01/1990	other		ICI		Figure: ICI Australia Operations P/L, 1990 Waste Quantities: Total waste for the period is 1461 tonnes (fluctuates between 25 - 325 tonnes/month)	Loek
10	9/02/1990	internal memo		ICI	ICI	Hg containing carbon from end box venting, H2 adsorption, HCl prification and Caustic Filtration is stored on site. Hg sludges removed from cell and pits are also stored on site. Hg also in caustic (1ppm), hypo (0.25 ppm) and hydrogen (0.05 mg/m3) products	Loek
10	7/03/1990	internal memo		ICI	ICI	proposal ourlining approach to Hg balance on the cell rooms at Botany. More sampling is requested. This will require one person working full time for around 6 month and significant increase in workload for the lab.	Loek
10	11/04/1990	internal memo		ICI	ICI	Hg Balance. "because one of the substantial figures is the mercury inventory in the cell itself only long period measurements are reliable. The exercise truly is a long one and quick results are really not possible"	Loek
10	23/04/1990	internal memo		ICI	ICI	Treatment and control of Stormwater runoff. A consultant (Scott & Furphy, 27/3/1990) adviced on changes to the new treatment plant. The program for the 8th Avenua Treatment Plant has already commenced	Loek
11	30/05/1990	internal memo		ICI	ICI	Brine sludge is to be cemented on site following the closure of the Castlereagh Waste Depot (closure as of 2-July-1990). Currently brine sludge is loaded at Botany into a cement mixer along with fixing chemicals. Thi smixture is transported to Penrith where cement is added prior to disposal in clay lined pit at WMAs facility at Castelreagh	Loek
10	1/07/1990	other		ICI	ICI	ICI Safety Awareness bulletin on mercury. Presents some interesting facts: The amount of Hg in cells is measured using radio isotope anaylsis every 6 months. This can identify areas of significant Hg loss. Employee testing in a regultar monitoring programme to check Hg in urine (maximum level is 150 ug/g Creatine). The mad-hatter story in Alice in Wonderland is an example of severe Hg poisoning	Loek
10	26/07/1990	internal memo		ICI	ICI	Unusual incident report on a Hg spike in effluent (2 pm) during plant maintenance works. 1,688 gr/day were recorded for 26 July 1990 where ~270 is normal. Problem was filters pumping out a pit. Hg was in the form of mercuric chloride CDM Smith: I am not sure if EPA was notified (Malabar STP was definitly notified) however it was apperently in the news as a memo was found from a concerned citizen who rang on the 27/7/1990	Loek
10	27/07/1990	internal memo		Site manager		Clorine Plant - Mercury incident. By Feb 1991 Orica will have colpleted a $10 mio trade waste improvement program in Botany. A further $5 mio will be spent on general improvements on effluent quality	Loek
8	27/07/1990	other	News article			Feb 19990 Orica have completed a $10mil trade waste improvement program at Botany. A further $5Mil will be spent on general improvemnts to effluent quality. Monthly Average Hg Mass (Kg/day) Jan 1986: 0.8 kg/day – Jan 1990: ~0.3 kg/day	Loek
10	1/08/1990	other				malabar Treatment Works: 5 digesters (one doesn't exist (No. 4)). Total capacity is 11,000 m3. The press figure of 20.000 m3 sludge is questionable	Loek
10	3/08/1990	other		ICI	ICI	handwritten calculation that the 160 milligrams Hg (as per newspaper article) in the 20.000 m3 sludge in the Malabar Plant equates to 3200 kg Hg. This is impossible (CDM Smith agrees with this conclusion). It should probably have been 160 micrograms	Loek
10	1/09/1990	other				Fax, author unknown, Draft: Evaluation of current Hg sewerage discharges into the ocean in relation to public health	Loek
10	4/09/1990	other				Hg in effluent monthly report for August 1990. 12 Hg samples per day were collected. Average was 37.6 ppb	Loek
9	21/09/1990	letter		ICI	EPA	prior to 2de July 1990 brine sludge was mixed with cement and sent to landfill (Castlereach depot) in liquid stage. As of Jan 1991 sludge had to fixed in blocks	Loek
10	6/11/1990	internal memo		ICI	ICI	the new trade waste agreements (31/10/1990) has been signed Hg: 0.15 mg/L (95%tile); 0.09 (average, mg/L); Mean 0.2 mg/L; mass (kg/day) 0.6 (concentrations and total mass of Hg will apply until new hg standard is determind. Rate for Hg is 174.45 $/kg	Loek
10	3/12/1990	internal memo		ICI	ICI	handwritten memo about converstations with SPCC to arrange a site visit regarding the July 1990 Hg incident. A letter from ICI's lawyers was also attached advicing ICI should should cooperate however ask written confirmation from SPCC that SPCC will not institute legal proceedings (nor SPCC nor Water Board were likely to mount prosecutions). Also some 'housekeeping' (written arrangements were adviced.	Loek
11	22/02/1991	letter		ICI	Waste management Authority	Letter regarding the document "procedure for stabilisation and disposal of Brine Waste (12-2-1991)" being sent to the waste management authority. The letter also states that some minor alterations were made to previous discussions and some other modifications might be necessary once practical operating experience is gained. *(CDM Smith: this indicates that prearation of blocks was not undertaken prior to 2/1991)*	Loek
11	1/03/1991	other		ICI		Handwritten notes from various visits of landfills, eastern creek, camden, lucas heights, madison park	Loek
5 of 20	18/03/1991	report	Mercury Balance Survey Results - A Report to the Membership of the Chlorine Institute, Inc.	lance Task Group (Environment & Health	Membership of Chlorine Institue, Inc	Mercury Balance Task Group formed in April 1990 to due amongst member companies that regulations would be implemented requiring strict accounting of mercury usage. The document discusses various aspects of mercury balances and methods used by different plants based on a survey - 14 respondents. Main areas where unmeasured Hg can collect were reported to be Caustic Tanks (12 responses), hydrogen purification (10 r), DI water system tanks (8 r), Hydrogen piping (7r), Cell Room sump (6r), End box ventilation system tankage (4r), Cell room trenches (4r) and 14 more locations but decreasing levels of response. Hg consumption in grams per ton of Cl2 reported to be <0.10 (5 responses), 0.10-0.19 Hg/t (3 r), 0.2-0.29 (2r), 0.3-0.39 (3r) and 0.4-0.425 (1r)	Andrew
5 of 20	1/05/1991	other	Mercury Strategy and Action Plan (Second Draft)	ICI	al - To Hg Taskforce (19 members +	Outlines ICI's plan for Mercury Acocuntability, Factory Residues and Waste Strategy, Reduction of Mercury to the Environment, CAP technology retrofit, ICIA-Imposed Mercury Burden and Public Perception Strategy.	Andrew
9	4/06/1991	letter		Waste Management Authority NSW		Waste management is prepared to accept the blocks as Special Waste	Loek
12	21/06/1991	internal memo		ICI	ICI	Analysis of concrete blocks for Hg Three blocks (3/6/91, 5/6/91 and 28/5/91) were tested for Hg. Levels were 900; 867 and 933 =/- 10% ppm	Loek

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Volume	Date on document	Type of Document	Title/Subject	From	To	Content	Reviewer
12	1/07/1991	report		ICI		The Mercury Burden, written by J Macmillan Hg content in black coal ranges from 0.015 - 0.40 ppm Hg in Australia to 0.015 - 0.34 in NSW On the Botany site *(CDM Smith: we assume the writer means the ICI site)* 85,000 te/year of coal is burnt. The coal is usually from the western distric in NSW and its Hg content ranges from 0.015 to 0.07 ppm. The conventional wisdom is that 10% of the Hg remains in the ash and the ash is 10% of the total coal then the ash should rougly have te same content as the original coal. This would then be very different from the content of Hg measured in the ash in the Phase 1. The emission of Hg from this source would be 1.28 - 5.95 kg/year. If the coal had 20ppm Hg (as measured in the Phase 1) the total output from the site would be 1700 kg/year of which some 1500 kg/year would be liberated to the atmosphere. The total Hg usage corresponds to ca. 0.37 kg/tonne Cl2 (*CDM Smith: 1987-1991*). A thorougly Hg balance has been instituted in order to identify the ca. 40% unaccounted losses. Fugitive emmissions from the ceel building: there is no reliable information. Geometry of the building, position of the fans, and positioning of natural ventilation has seeminly proved to difficult to allow any data. Recent UK data suggest the weighted average over 3 years fro ICI palnts is 7.5 g Hg/t Cl2. Losses to atmosphere for all ICI plants are 15% (*CDM Smith: unsure if stack emissions are included in this number).* It is assumed/calculated that Botany atmospheric losses are 1.5 kg/day to 12.15 kg/day. About 1000 tpa is removed from Boatny Site in 1 tonne blocks, each block containing 1000 ppm. This amounts to 1000 kg/a or 2.74 kg/d or 13.7 g/t Cl2. For Botany the range of mercury in solid disposal is between 6.6 - 42.1 kg/day. The balance will show some substantial losses over and above the brine sludge loss. *"wherever there is any data available from Botany then this data is much less than comparable data from the calculations. Given the much lower losses in the UK and the probable amount of technical work (and spending) which has been expended into reducing the losses and into characterising them if reasonable to say (unless the plants are very different in physical design and operation):* *- additional loss sources have been identified and/or* *- the amount of Hg lost via each of the possible routes is much greater than is currently thought at Botany* *- given that the credibility of current analytical methodology is high then errors in estimation of Botany losses would probably arise from the sampling procedures employed and/or estimates of matrix flow i.e. water, air, etc."*	Loek
5 of 20	4/09/1991	internal memo	Stored Mercury Waste at Botany (Minutes of Hazop/Design Meeting)	ICI	ICI	See Tab 'Stored Hg' on this spreadsheet.	Andrew
12	1/11/1991	report		ICI	ICI	Supplement to the Mercury Burden. This reports summarizes incidental Hg emissions in Australia and NSW. Black coal combustion (4.2 tonne/year), petroleam products (3.2 te/year) to crematoria (0.09 te/yr)	Loek
5 of 20	1/12/1991	report	Report prepared on behalf of Unisearch Limited on 'Aspects of the Occurence of Mercury in Geological Materials, Including Coal, Oil, Metalliferous Ores and Construction Materials'	Groundwater Management and Hydrogeol	ICI Botany Operations Pty Ltd	Contains various data on background Hg concentrations os soils, ores and other materials, plus other sources. Very useful - Ask Steve to copy.	Andrew
12	1/12/1991	scientifical publication		University of NSW	ICI	Aspects of the occurrence of Hg in Geological Materials, Inluding Coal, Oil, Metalliferous ores and Construction Materials (revision of report submitted Sept 1991). Report presents background levels in rock types, coals (100 ppb average), limestone, background soils (30-60 ppb), sewerage sludge. Hg released per year by Malabar in digester effluent is 110 kg (1448 kL/day, 216 ug/l). The solid component of the sludge holds 1900 ug/l	Loek
12	4/12/1991	letter		ICI	Waste management Authority	ICI decided that the most appropriate disposal would be to Pacific Waste Management, Elizabeth Drive Landfill. This landfill will be available early 1992 so ICI is storing stabilised waste onsite. TCLP tests can be provided	Loek
6	1991-1992	report	Mass balance report	ICI	ICI	Already provided in different volume	Loek
9	2/04/1992	internal memo		ICI	ICI	five soil samples from salt hoper project excavations have been analysed for total Hg:higest reading 79ppm (CTC decontamination pad) and composite sample of 4 discrete samples: 39 ppm	Loek
12	13/04/1992	letter		Pacific Waste Management	ICI	summary of points raised at meeting with Elizabeth Drive Landfill: Feb-Dec: 76 batches, 6.9 per month Jan-March: 19 batches, 6.3 month	Loek
12	13/04/1992	internal memo		ICI	ICI	Stabilised Brine Waste Blocks Hg content in brine blocks is about 1,000 ppm	Loek
9	6/05/1992	letter		ICI	pacific waste management	normal disposal practise for brine sludge cement in other countries is farr less rigorous than in NSW. For example in the US this material can go to municipal landfills. It use to go to Castlereagh Depot but this became unavailable so now it goes to Pacific Waste Management at Elizabth Drive	Loek
12	25/06/1992	internal memo		ICI	ICI	700 kg Blocks, 34 blocks/24 tonnes	Loek
9	21/07/1992	other		EPA		licence Pollution Control Act TCLP testing once every 3 months or 200 tonnes of blocks which ever occurs first the following mercury waste shall be stored in sealed area: spent carbon packing, dunuder balls	Loek
9	22/09/1992	internal memo		ICI	ICI	Hydromet mercury recovery proposal. Botany has not purchased mercury from China, in recent years times at least. Purchases in recent times were as follows: May 1992: Algeria; Dec 1991 Spain; May 1991 Spain and April 1991 USA	Loek
1 of 20	1/10/1992	report	Mercury Mass Balance Report	ICI	ICI	38% of Hg used in 1991 (9,000kg) cannot be accounted for. Sensitivity analysis showed losses to brine waste, cell room atmosphere, cells waste, thick mercury, stellar filter wate and grey mercury had greatest effect on the balance. Botany ranked 17th out of 55 Europen CAPs based on mass balance closure. Average for the 55 CAPs was 45%. 1991 balance - 70,000 te chlorine produced, 23,000 kg of Hg added to production. 2,446.35 kg in Hg losses, 7,7743.92 kg in accumulation, 4,000kg recovered, 8,809.73 unaccounted for. NOTE: The mass balance reduces to 5% if it is assumed that the difference between the consumption figures is the amount of Hg accumulating ni previously retorted wastes. Mercury consumption while retorting (Pre approx 1988) was 0.13 kg Hg/te Cl2, or 9,100kg mg/yr based on 70,000 te Cl2. Without retorting consumption was 0.40kg Hg/te Cl2, or 28,000kg Hg/yr. [This suggests the variability is Hg content in wastes was around 33% of the 38% unaccounted Hg. This would suggest losses to ground and also from theft may be in the order of 5% - confirm this with data of mercury waste floor sweepings post concreting of CAP floor in approx 1971 (AK)]	Andrew

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1	1/10/1992	report		ICI	ICI	Period of balance is 1991 Cl2 production 1991 : 70,000 te/year with a Hg consumption in 1991 of 23,000kg = 0.33 kg Hg/te Cl2 In 1991: 38% of the Hg cannot be accounted for. Compared to 61 European plants ICI Botany came 17th (if it comes to Hg mass balance closure) The average closure percentage was 45% (between 4 - 98 % Hg accounted for) for 1989 The average closure percentage was XX% (between 3 - 97 % Hg accounted for) for 1988, Botany was 60% The average closure percentage was 46% (between 3 - 91 % Hg accounted for) for 1987, Botany was 62% The avergae closure precentage was 50% (between 8 - 99 % Hg accounted for) for 1986 Sensitivity analysis: greatest effect: brine waste, cell room atmosphere, cell waste, thick Hg, Stellar filter and grey Hg In sept 1988 ICI stopped retorting the Hg Hg consumed March 1981 to April 1992 (11 years) was 182,928 kg Hg on a production of 845,907 tonnes Cl2 this results in 16,630 kg Hg/year or 45 kg/day or 216 gr Hg/tonne Cl2 March 1981 to Sept 1988 (retort in process): 86,665 kg Hg; 600,450 tonnes Cl2 > 144 gr Hg/tonne Cl2 Sept 1988 to April 1992 (retort not in process): 96,263 kg Hg; 245,457 tonnes Cl2 > 392 gr Hg/tonne Cl2 Conclusion at end: "The only idea that has not been fully explored is the possibility of Hg escaping through the cell room effluent drains and pits into the soil. However, the possibility of 9,000 kg/yr escaping into the soil is somewhat unrealistic" Opinion CDM Smith: Hg losses from cell room seems a bit low Product : 1.49 gHg/te Cl2 Wastewater: 0.66 gHg/te Cl2 Process Exhaust 1,83 gHg/te Cl2 cell room : 14,69 gHg/te Cl2 Disposal : 184.07 gHg/te Cl2 balance : 125.84 gHg/te Cl2 sum : 328.57 gHg/te Cl2	Loek
1 of 20	11/11/1992	internal memo	Mercury Balance - Additional Note	ICI	ICI	Note shows that site mass balance closes at 62% (in 1991), based on recovery of 17.4% during a redrumming exercise, 10.6% losses in products and wastes (waste hydrogen, caustic soda, product hypo, waste gas, effluent, brine waste, cell room atmosphere), 33.7% accumulation (product hydrogen carbonm wate hydrogen carbon, end box venting carbon, stellar filter waste, cells waste, caustic tank waste, process equipment, thick mercury, grey mercury). Site mercury consumption shown to be significantly lower when mercury retort was operational.	Andrew
9	9/12/1992	letter		ICI	EPA	handwritten letter regarding handling/disposal of Hg waste brine blocks: 170 batches totally approximately 2500 te of finished cement blocks (prediction was 20te/week = 1000 te/yr)	Loek
8	1/02/1993	other	Water balance over the Chlorine Plant	SD		January 11,000 +/- 1,000m3/Month February 9,300 +/- 1,000m3/Month CDM Smith – this is ~ 50% of the entire plant total 1990 – 355Hg (g/day) 1991 – 100Hg (g/day) 1992 – 63Hg (g/day)	Loek
12	1/03/1993	internal memo		ICI	ICI	Breaches of mass discharge limit. On 3 occasions the mass discharged exceeded the daily mass limit. Severale internal investigation reporst were found in this volume.	Loek
9	2/04/1993	report		ETRS	ICI	TCLP test results and total Hg on the original concrete: 6500 - 5750 - 5500 mg/kg Hg (3 samples/batches tested 182, 195 and 196) CDM Smith Calculation: 2070 tonnes/year with a average concentration of 5917 mg/kg results in a mass of 12.25 tonnes/year Hg	Loek
2	1/06/1993	internal memo		not noted	not noted	Monthly Hg in H2 Waste H2 in 1993 : <0.1 - 3.0 mg/m3 End Box venting in 1993 : <0.1 - 0.3 mg/m3 Ex-stack : 0.1 to 1.0 mg/m3 Hg in H2 in 1992: Ex 2nd on-line <0.1 - 0.2 (to atmosphere mg/m3) feedline to absorber : 23 mg/m3 Hg SPCC specification : 3 mg Hg/M3 H2 vented Period 1/3/92 to 28/5/93: Ex Stack 0.1 - 11.0 mg/m3, Average is 4,2 (CDM Smith: Note that the requirement is 3 mg/m3)	Loek
8	1/06/1993	report	Improvement in Analytical test method for determination of Hg in Botany Site Effluent	Z.P		Analytical test method is free of interferences and accuracy is 60 to 100% of the true value	Loek
9	3/06/1993	letter		ICI	EPA	Batch Leachate results from batch 1 to batch 200 (Feb 1991 to mid April 1993. TCLP results up to 220 (1 occasion above 200) ug Hg/l 9 batches originally failed and were redone. (TCLP as high as 4,600 ug/l) waste approval number 10290/24/0/S CDM Smith: 200 batches in 25 months >> 1440 tonne/yr, with 5,917 mg Hg/kg >> 8,5 tonne Hg/year)	Loek
12	3/06/1993	letter		ICI	EPA	TCLP test results batch 1-150 were provided to the EPA.As of end May 1993 ICI was up to batch 223 (approximately 15 te per batch). Batch 1 is feb 1991: *Calculation CDM Smith: 95.6 batches/year >> 1,433 tonnes/year of waste blocks.*	Loek
9	15/06/1993	scientifical publication				Stabilization of Hg containing sludge by a combined process of two-stage pretrreatment and solidification, C.Y Chang, C.P. Hsu, Journal of Hazardous Materials, 35 (1993) 73-88	Loek
9	26/07/1993	letter		EPA	ICI	after site visit it was noted that some brine blocks were of inferiour quality and could break up upon handling. Concrete strength should be at least 25MPa	Loek
9	8/09/1993	letter		ICI	EPA	TCLP test results for stabilised brine waste for April to July 1993. ICI do leach tests for each batch (app 15 tonnes) Batch 201 - 249: all TCLP <<200 ug Hg/litre. CDM Smith calculation: 46 batches in 4 months >> 2070 tonnes/year in blocks	Loek
12	1/10/1993	report		ICI	ICI	Treatment of Hg contamninated effluent by CS (Chemical Engineering Vacation Student).	Loek
9	7/10/1993	letter		ICI	EPA	there were concerns from EPA regarding strengt cement blocks. Brine waste (with Hg) is being stabilased and solidified NOT encapsulation. Reaction with sodium sulphide. 3 Parts waste, 1 part cement, 1 block weighs 1 tonne, comprehensieve strength is 4MPa	Loek
9	7/12/1993	letter		EPA	ICI	EPA agrees with continue ICIs current micro encalsulation method, 4 Mpa strength	Loek
9	22/12/1993	other	Letter	PA	TC	EPA TCLP QUERY' - This site has contracted about 400 TCLPs/annum through us	Loek

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9	4/01/1994	memo	Lending waste documents for disposal of brine wast blocks	RE	Site enviro	Following observations: records od EPA documents are irregular and infrequent Recommends to Site enviro: - Every was of blocks is documented by a set of EPA documents - Copy of document (to pacific waste) and EPA docket is sent to environment section Figure: Stabilised Brine Waste (leachate results) – Limit 200 Hg in leachate (ug/l) 249 batches with only 1 exceedance (225ug/l) most are ~0.0 ug/L	Loek
1 of 20	24/06/1994	internal memo	Mercury Burden	ICI	ICI	Data regarding mercury burden, natural sources and those from ICIA. Includes ABS data on total Hg imported to Australia plus Hg imported to Botany. See table on next tab for import data in kg Hg.	Andrew
1 of 20	1/03/1997	report	Stage 3 Groundwater Survey, ICI Botany, Springvale Drain investigation - HCB and Mercury Study in Sediments, Surface Water and Groundwater (Proj No. A8600436/0012)	Woodward-Clyde	ICI Australia Engineering P/L	Provides mass of Hg in southlands/springvale drain. Drain length 350m x 4.17m2 cross-sectional area = 1,458m3 vol of sediment x a.5 t/m3 density x 141.4mg/kg average Hg concn = 309 kg Hg. Note Hg concentrations are high within the drain (pre remediation), but reduce a few metres away laterally. however samples in the top 0.5-1m from surface adjacent to the drain show elevated Hg, around 10-40mg/kg, which drops off to <1mg/kg (background) beyond 1m approx.	Andrew
1 of 20	1/03/1997	report	Stage 3 Groundwater Survey, ICI Botany, Preliminary Ecological Study (Proj No. ?) - DRAFT REPORT	AGC WWC	ICI Australia Engineering P/L	Figure 3.2 has good conceptual pathways model for chemical migration. See flowchart in yellow notebook (AK)	Andrew
12	1/03/1997	report		Woodward-Clyde	ICI	Stage 3 Groundwater Survey, ICI Botany Preliminary Ecological Study. This report is draft and CDM Smith reviewed the final report which was provided by the EPA.	
7	1/03/1997	report	Groundwater survey	WC	ICI	Report provided by EPA	Loek
1 of 20	6/03/1997	letter	Summary Note of Mercury Contaminated Sediments in Springvale Drain and Penrhyn Estuary	ICI	AGC WWC	Note re discussions with long-term ICI employees re incidence of mercury contamianted sediments in Springvale Drain and Penrhyn Estuary. Onsite sources included the Chlorine Plant, Vinyls Plants (mercury lutes once used), the original (and long demolished) dedicated ethylene plant at Alkathene (which used a mercury-based catalyst), the (coal fired) steam and power plant, and areas where contaminated fill (particularly boiler ash) was used. Sources in the Chlorine Plant encompassed atmospheric emissions from the cells room, flake caustic plant and retort (the latter two were decomissioned in the 1980's), and historic losses to the ground of both small quantities of metallic mercury and recirculated brine solution. Prior to the connection to sewer being installed in 1958, the whole site's effluent was discharged directly to Springvale Drain. Non ICI sources include - Boiler ash and paper pulp filling in southlands prior to that land being acquired by ICI in 1980, both of which are contaminated with mercury. In the ash Hg is expected to be bound in the matrix of ash particles and any unburnt carbon will absorb more hg from say groundwater in contact. Paper pulp was treated with an organic mercury-based fungicide. The letter recommended further work be undertaken in to the nature of hg contamination at springvale drain.	Andrew
12	13/03/1998	letter		ICI	EPA	Review of waste Management Activities on Boatny Site. We found a copy of this document in the EPA files but this was not complete.: 1500 te per annum of N170, purification process for brine 30 m3 / annum of D120, activated carbon containing mercury sulphide, stockpiled on site 60 te/annum of N160, replacement of old A/C sheeting contaminated with Hg. (stabilised by microencapsulation with portland cement and cast into blocks.	Loek
13 of 20	25/06/1998	report	Environmental Impact Statement, Replacement Chlor-Alkali Plant for Orica Australia P/L	Dames & Moore	Orica Australia P/L	Section 3.4.1 and Table 3.1 (page 3-7) of EIS states existing plant is 35,000 t/yr Cl2 production. Raw Materials and Chemical Consumption are listed as Salt (67.2t) and Hg (11.2t), amongst other chemicals. Section 3.4.2 Water Usage is 205ML/year to the Botany Plant total, of which 17ML/yr was electrolysed in cells, 40ML for dilution to caustic by 50%, 53ML as brine purge make-up and 60ML as cooling tower make-up. 35ML/yr was converted to demineralised water used to produce HCL (15.5ML/yr water) and Sodium Hydopchlorite (19.5ML/yr water usage). Section 4.1 indicates new CAP will have only 25,000t/yr capacity, compared to 35,000t/yr for the old plant, and reduced from 80 Hg cells to 4 membrane cells.	Andrew
9	22/02/1999	other		ICI		General description Brine Waste blocks. 20 blocks/week each with a mass of one tonne and a volume of 0.6 m3 and transported to landfill on a weekly basis ICI will perform monthly testing to ensure continuing compliance	Loek
20 of 20	24/06/1999	letter	Waste Licence 006901 - Resubmission of Waste Immobilisation for Ongoing Approval	Orica Australia P/L	EPA	Six samples of untreated filter cake/brine sludge were tested for total Hg with concentrations ranging between 900-4,290mk/kg. Average concentration 2,807mg/kg for the six samples. Samples were collected on 15/03/99. Fixated waste results collected in 27.11.98 for two watches were 2,035 mg/kg average Hg content. See table on Tab E for results.	Loek
20 of 20	15/09/1999	letter	Specific Approval for Immobilisation of Contaminants in Waste - Clause 28 of the Protection of the Environment (Waste) Regulation 1996	NSW EPA	Orica Australia P/L	Approval for 1000t/yr immobilisation of sludge waste from FCAP.	Andrew

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Volume	Date on document	Type of Document	Title/Subject	From	To	Content	Reviewer
8	9/12/1999	other	Review Meeting - Hg in effluent water	ICI	ICI	Report area: Accumulated Hg waste were re-drummed in sept 1989 in 200 polythene lined 200L rheem drums – exported to Japan, shipment in April 1989. Also Orica is persueing longer term Hg waste disposal within Australia (1/2 day/week) including negotiations with Hardman Chemicals Sydney	Loek
N/A	29/06/2000	report	Realignment of Springvale Drain to Bypass Contaminated Sediments at Orica Southlands. Documnet No. C457/000630123	SHE Pacific	n Project & NSW EPA as Part of VRA	Diversion drain created for 350m long section of Springvale Drain at Southlands. Diversion approved by City of Botany Bay for 5 year period from December 1999. Also containment cell created for future placement of contaminated sedments in the drain once dried sufficiently to excavate and move. Not discussed in this report though.	Loek
3 of 20	26/02/2003	other	Analysis of Disposal Costs for Springvale Drain Sediments. Fax from James Stening to James Fairweather, Orica	(Env Engineer), Orica Engineering	Orica Engineering	Shows cost of $279k plus $39.5k for storage of 23m3 of drummed hot spot Hg contamination from springvale drain remediation. Folder also contains WWC Springvale Drain HCB and Mercury Investigation	Loek
15	1/05/2003	other		ICI	ICI	folder full with batch tracking forms: 11 to 15 blocks contain 8 tonne brine waste and 3 tonne cement. Also TCLP tests results from SGS are included in this volume. Also daily job summary forms from Collex Industrial Services for Brine block manufacture (rate is $214.50 per block). Last batch in folder if from 28/5/03 (batch 1060), 8 te brine, 3 te cement, 12 blocks First batch in folder is from 25/6/01 (batch 901), 8 te brine, 3 te cement, 14 blocks Batches 1000 - 1013 are from sludges in the cooling tower and drums content (12+22+4). CTW sludge was mixed with dolocrete cement. TCLP testresults (<0.0005 mg/L) passed criteria (0.2 mg/L). Note CDM Smith: there is documentation from early 2003 when the CAP was not in production anymore. *CDM Smith: brine was still produced for th enew CAP.*	Loek
17 of 20	Various, mostly 2002 and 2004	other	Various	Various	Various	Folder contains details about micro-encapsulating process, TCLP results, register of Hg concentrations in FCAP building materials, photos of demolition wastes and waste dockets for tranport of brine blocks to Penrith Waste Services, Mulgoa (is Castlereagh). Also, summary of demolition materials contamianted w Hg - approx 827m3 at approx 3000mg/kg average Hg concentration. Works out to approx 3 tonnes Hg.	Andrew
7	28/09/2004	report	Final report - HCB & Hg in sediment and biota	URS	ICI	Report provided by EPA	Loek
19	15/04/2005	other		ICI	ICI	table with Hg transferred from Yarraville. 14-10-1999 to 26 june 2002: 87 tonne 7 may 1999 to 6 may 2000: D120, 60,000litres (NSW Consignment number 32990042) 1 nov 2001 to 31 oct 2002: D120, 80 tonnes, 4 loads (NSW Consignment number 32010093)	Loek
7	1/02/2006	other	Excel sheet - Botany Hg waste to site	ICI	ICI	Excel Sheet – waste to site 1 feb 06. 21 tonnes carbon from Hg absorbers 15 tonnes sludge 750 tonnes Soil 145 tonnes Sludge (drus in slipping containers) 150 tonnes untreated brine sludge 250 m3 graphite carbon balls from BI/MK1/H A total of 2,637 tonnes of stored waste + 2695 tonnes buildings still standing = 5332 tonnes. Solid waste to land fill 3,450 tonnes CDM smith: 8.09-21.6 tonnes of Hg in building	Loek
7	12/09/2006	report	Assessment Hg emissions from demolition of the old CAP, 12-09-2006, Job No 2235 PAE	PAE	ICI	- assess potential air quality emissions during demolition and removal of wast (demo + production wastes) - Assess potential impacts on residential -particle bound Hg present in dust or volatilised Hg as result of ambient emissions and exposure of hight Hg in the walls CALPUFF dispersion model was used to predict off-site Hg + deposition levels -NSW DEC provides short term data for organic and inorganic Hg and not for Hgo as thi is the expected form -Outcome: predicted annual concentrations of Hg will double in areas surrounding the FCAP (7/12/05 up to 30/11/06) and predicted annual average Hg are below WHO inorganic guideline of 1ug/m3 Hg in bricks, concrete and asbestos sheets ~ 3000-8000mg/kg -112m3 Sludge on the pad -347m3 drummed sludge in storage -31m3 drummed carbon -55m3 micro-encapsulated brine sludge blocks held in storage as it failed criteria for disposal.	
7	1/07/2007	report	Cap demolition project closeout report	KBR		Mercury in urine (MIU) was tested for in all involved personnel 0.3ug Hg/G creatinine to 21 ug HG/G occurred – average 5.4 ug Hg/G 35ug Hg/G creatinine is Orica's internal action level. Hg environmental monitoring: -HG bacharach meter was used -370 analyses were carried out -One sample measured 40-50ug/m3, 20 between 10-30ug/m3, remainder all less than 5 ug/m3. Results suggested that the use of water sprays and prevailing winds ensured surrounding businesses and residents were not impacted by Hg vapour. Total costs were 6,840,000$	Loek
2	no date	other		not noted	not noted	Process release specification for removal of Hg from Vent hydrogen peak H2 production is app 3500 Rm3/hr Hg content in gas varies from 15 to 30 mg/Rm3	Loek
10	no date	other				graph showing monthly averages of Hg in effluent for the period April 1989 - Aug 1990: 17 monthly averages (68 ppb was the highest) were above the 35 ppb licence limit and only 1 was below. Monthly reports are available in volume 10	Loek
12	no date	report		ICI	ICI	Treatment of Hg contaminated waste on ICI Chlorine plant, Sydney Uni Chemical engineering, No date 30 tonnes produced annually, used to be retorted, disposal offsite is $3,000, 200 tonnes of Hg waste is stored in drums. 7 sludge samples were tested. Average percentage Hg was 7.31% (see other tab) Waste from cells: 55 drums of 200L and 234 drums of 60 L >> 46 tonnes, assuming 20% Hg All Hg contaminated waste on site: 213 tonnes, assuming 20% Hg >> 42.6 tonnes of Hg	Loek
19	no date	other				Photos with drums with Hg waste (from Hydrogen waste absorber, Nov 1996) and containers with hg waste	Loek
19	no date	other		ICI		Application it DEC EPA for Approval to Macro Encapsulate Hg Contaminated Wastes from Orica. Disposal at Sita, kemps Creek into a multiple liner waste containment cell to be buildt within the Industrial waste cell at the Sita Landfill. This includes drummed sludge waste residue. 3642 m3 Hg contaminated waste is envisaged for disposal of which 1957 m3 presently stored on site with a further 1685 m3 of contaminated bricks and masonrycoming from further demolition.	Loek
19	no date	other		ICI		several Hg waste Inventory spreadsheets	Loek

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Volume	Date on document	Type of Document	Title/Subject	From	To	Content	Reviewer
19	no date	report		ICI		Solid mercury waste, Options for minimisation and disposal *Until 1987, expect for brine sludge which was deposed of at landfill, and expect for iodised carbon which was stored in drums, all solid mercury wastes were retorted at Botany. Retorting was discontinued because it became impossible to meet modern operating standards with the existing old equipment. from 1987, previously retorted material has been stored in drums. In 1989 some of the stockpile of drummed waste was exported to Japan for reprocessing. This avenue has been virtually closed off by Government Authorities and a recent attemtp to export to China for reprocessing through a company called Hydromet has been abandoned* (installing plant in darwin for Pasminco wastes recovery) table with wastes provided, see other tab in excelsheet Loek	Loek
9	no date	other	Cell/Brine process descritopm			Clarriff Locators – necessary for settling and separation of impurities in brine Brine composition: inlet bring 10ppm W/W. Outlet brine <20ppm W/W Sludge filtration: treats sludge from clarri floculators large Hg report: removes Hg from rich contaminated material obtained from steller filter and drains. Retort - capacity: 0.042 m3/tray (3 trays/day) Retort ash – 1100ppm W/W Hg (dry bars) Retort fuel – 30m3/hr of H2 Temperature – 400/550oC Cells effluent Effluent from cell basement is pumped though a pressure filter (cloth covered steel mesh). Filtrate is discharged to the effluent drains. – opens to retort Brine/effluent treatment for Hg 1 removal of chlorine (addition of metabisulphite) as it prevents Hg from precipitating 2 adjustment of alkalinity – very acid conditions in crease solubility of HgS thus reducing precipitation 3 addition of sodium sulphide	Loek
17 of 20	Unknown	other	Attachment 1 - Solvents Plant, Heavy Ends, 1963-1972	unknown	unknown	Refers to incident where an attempted illegal disposal of waste between 1966 and 1972 by cartage contractor employed by R Press. The contractor arrived at St Pteres Tip too late to leave one truck load of waste, so he then travelled homewards and dumped the load beside the Menai Road. The dumping was discovered by a ranger and material was recovered by ICI. (It did not contain Hg - AK, but shows Orica was committed to ensuring this sort of activity did NOT occur, and recovered waste when it did) Document also shows for the CAP - 1944-1958: Sludge from batch settlers was discharged with some brine by pipeline to Springvale Drain. 1958 - 1975: Sludge was discharge to sewer. 1975 onward: Sludge is stabilised with sulphide and cyanamide, mixed with cement and sent to Castlereagh Waste Disposal Depot. (Filter not mentioned - AK)	Loek
9	unknown					mercury Pollution Abatement. Licence prior to april 1991: limit is 200ppb, average may not exceed 90 ppb, total daily flux below 0.6 kg/day. 90%percentile is derived from 12 daily discrete samples New licence for April 1991 average concentration 35 ppb, 95%percentile 50 ppb, max daily mass is 0.25 kg	Loek
18 of 20	Various	other	Various	Various	Various	Folder contains partial copy of Davies report and mass balance, MSDSs, plans of FCAP and sampling results for future demolition materials. Not a huge amount of relevant info.	Andrew
20 of 20	Various	other	Various	Various	Various	Folder also contains large numbers of waste transport dockets, quote for stabilisation of sludge waste by Collex and PWS (Mulgoa). Approx cost $471,768/yr for 1 Aug 1997 to 31 Jul 1998 (12 months) based on hand noted calculations. Cost is for 94 batches at 18 blocks/batch = 1,692 blocks.	Loek
1 of 4	Various	other	Various	Various	Various	Folder contains Woodward Clyde (WWC) Stage 1 and Stage 2 reports	Loek
2 of 4	Various	other	Various	Various	Various	Folder contains Woodward Clyde (WWC) Stage 2 report appendices A-O, Biota Report and HRA	Loek
3 of 4	Various	other	Various	Various	Various	Folder contains Woodward Clyde (WWC) Stage 2 report HRA appendices A-C and D-J.	Loek
4 of 4	Various	other	Various	Various	Various	Folder contains Woodward Clyde (WWC) Stage 2 overview report	Loek
2		scientifical publication				PJ Temple and SN Linzon: Contamination of Vegetation Soil, snow and garden crops by athmospheric deposition of Hg from a CAP	Loek
2		scientifical publication		ICI	ICI	Deposition of Airborne Hg from 6 Swedish Chlor-Alkali plants surveyed by moss analysis background level was reached at 9-15km distance from the plant estimates of the annual fall-out indicated that only a minor part of the emitted mercury (usually <10%) was deposited locally. The major part spread over very large areas or probably contributes to the global circulation	Loek
12		other				Brine waste MDDS: Hg in waste blocks is <1000ppm	Loek
8		other	1974 - state of the art - Hg losses to the waterways	J.A. C - PPG I			Loek
6		report	Clari flocculator sludge and its disposal			Sludge operation from June 1974 Hg in filter cake is present as Hg hydroxide (Hg OH – sodium chloro mercurate) and small amounts of Hg	Loek

Table I - Comparison of ABS Hg Import Data vs Import to Botany, and Usage at Botany (all Data in kg)

ABS Data				Botany Import/Usage			
Year	Total	VIC	NSW	Import for Same Period as ABS	ICIA Year	Import (kg Hg)	Usuage
FY87/88	60574	12674	46865	11385	Ending 30/09/88	11385 + 11170 (1)	16490
FY88/89	83339	10984	69165	20700	Ending 30/09/89	20700 + 194 (2)	34027
FY89/90	73558	8229	65328	21735	Ending 30/09/90	28566 + 73 (3)	30387
FY90/91	61369	14883	46465	20637	Ending 30/09/91	13800 (4)	11972

(1) 10,700kg from Tas and 470kg from Newcastle
(2) 194kg from Newcastle
(3) 73kg from Newcastle
(4) Another 1725kg arrived 14/05/91

Countries Imported from in Order of Vol
USA (20t), China (18t), Germany (4t), UK (3.8t), Netherlands (0.8t)
Spain(20t), China(17.5t), HK(15.3t), US(14.6t), Netherlands(0.6t)
HK(30t), China(23t), US(9t), Netherlands(0.6t)
HK(19t), China(11t), Netherlands(7t), Spain(3.5t), UK(2.7t), USA(2.6t), Germany(0.6t)

Average prices ranged between $8/kg up to $100-800/kg according to ABS stats (incorrect?)
Most $15/kg in FY87/88

Oct 92 - Appendix 6: Mercury Consumption (from Mass balance Report - Kerrie Bonham)

Year	Chlorine Produced (t)	Mercury Consumed (kg)	Merucry Usage (kg/te Cl2)
3/81-9/81	42666	7219	0.169
9/81-3/82	36563	5444	0.149
3/82-11/82	53787	6675	0.124
11/82-3/83	30604	2832	0.093
3/83-9/83	40300	3901	0.097
9/83-3/84	42158	7204	0.171
3/84-9/84	37670	3353	0.089
9/84-3/85	41392	5634	0.136
3/85-9/85	42297	2696	0.064
9/85-3/86	36891	3612	0.098
3/86-9/86	42130	6423	0.152
9/86-4/87	44093	8988	0.204
4/87-9/87	32842	6141	0.187
9/87-5/88	49165	13866	0.282
5/88-9/88	27892	2677	0.096
9/88-4/89	34294	16482	0.481
4/89-10/89	35064	17467	0.498
10/89-3/90	35900	12193	0.340
3/90-10/90	38931	18220	0.468
10/90-4/91	35954	11978	0.333
4/91-10/91	30327	12707	0.419
10/91-4/92	34987	7216	0.206

Stored Mercury Waste at Botany (Appendix 2)

660 x 60 litre drums redrummed into 213 x 200 litre drums

	Drums	Wt te	% Hg	Wt Hg te	
Stellar	135	30	10	3	
Cells Waste	55	18	20	3.6	
Caustic Tank Waste	23	10	35	3.5	
	213	58	17.4	10.1	te Hg

4 tonnes of Elementral Mercury recovered in addition to above

Other Drums (200 litre)

	Drums	Wt te	% Hg	Wt Hg te	
H2 Carbon	160	20	20	4	te Hg
Various	190	52	17	8.8	te Hg
GRAND TOTAL	563	130	18	23	te Hg

(Not including 4 te recovered)

Out of the above wastes material recoverable by normal retorting

	Drums	Wt te	% Hg	Wt Hg te	
Normal Retorting	403	110	17	19	te Hg

From Orica Immobilsation Application Resubmission Section 3 - Description of Waste (24.06.99 to EPA)

Date Sampled	Material	Batch	Total Hg (mg/kg)
15/03/1999	Untreated Sludge	BD1	4,290
15/03/1999	Untreated Sludge	BD2	1,240
15/03/1999	Untreated Sludge	BD3	3,400
15/03/1999	Untreated Sludge	BD4	900
15/03/1999	Untreated Sludge	BD5	3,410
15/03/1999	Untreated Sludge	BD6	3,600

Section 5 - Results of Stabilisation

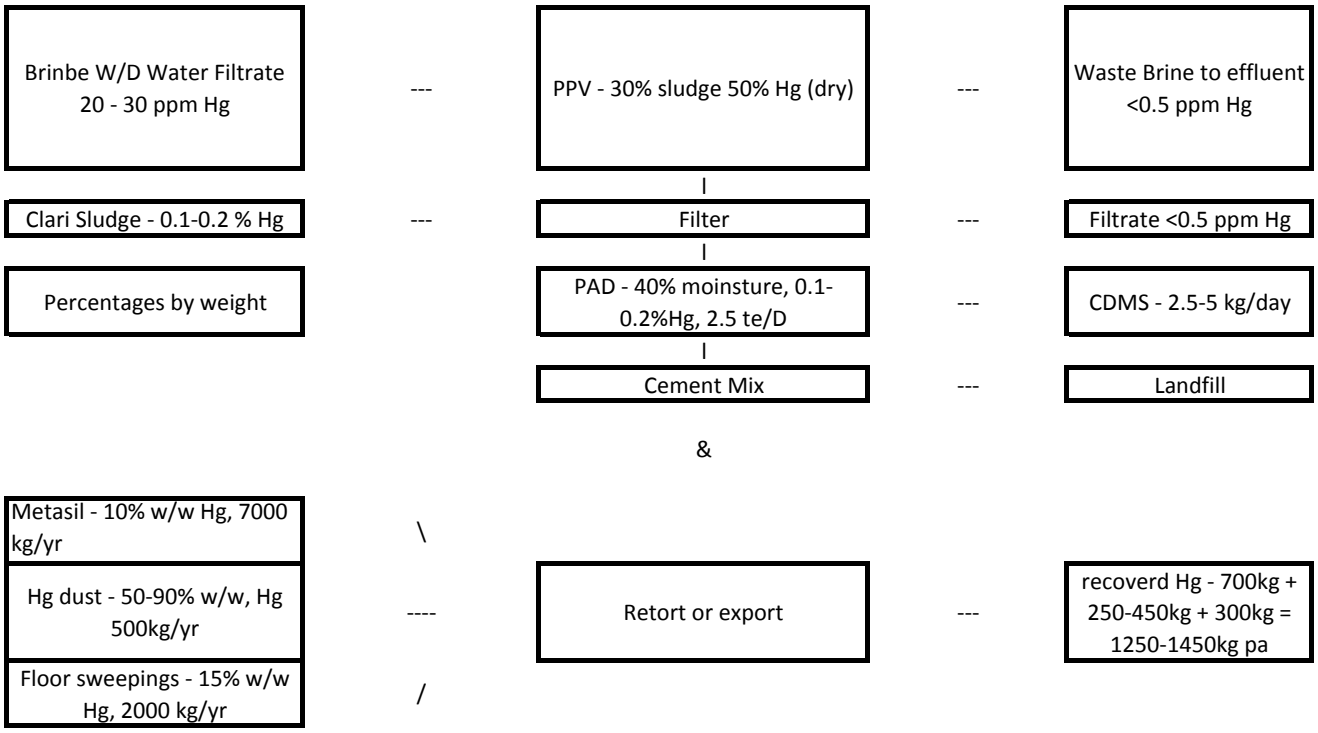
Date Sampled	Material	Batch	Total Hg (mg/kg)
27/11/1998	Fixated Waste	737	2,110
27/11/1998	Fixated Waste	739	1,960

Note: stabilised waste results collected before the untreated sludge, suggesting the batches were not the same. (AK)

mass of sludge	40.05	41.07	41.03	41.4	41.5	30.5	42.5	
Hg in sludge	2.8	3.21	3	3.18	4.1	1.5	2.8	
	6.99%	7.82%	7.31%	7.68%	9.88%	4.92%	6.59%	7.31%

Vol 19, solid Hg Waste options

	Concrete Blocks (not included in total)	Sulphur Carbon	Iodised Carbon	Stellar Carbon	Grey Hg	Thick Hg	Caustic waste	Cell waste	Unclassified	Accumulation	Total stock	
Hg content (%)	0.1	30	30	11	35	50	35	20	17			
stock (te)		22	2	77	6	4.5	11	72	20		214.5	
weight Hg (te)		6.6	0.6	8.5	2.1	2.3	3.9	14.4	3.4		41.8	19.5%
generation (te/yr)	1140 (1500 blocks)	0.4	0.1	8	1	0.5	0.3	14		24.3		
weight Hg (te)	1.1	0.1	0	0.9	0.4	0.3	0.1	2.8		4.6		


Brinbe W/D Water Filtrate 20 - 30 ppm Hg

PPV - 30% sludge 50% Hg (dry)

Waste Brine to effluent <0.5 ppm Hg
Clari Sludge - 0.1-0.2 % Hg

Filter

Filtrate <0.5 ppm Hg
Percentages by weight
PAD - 40% moinsture, 0.1-0.2%Hg, 2.5 te/D

CDMS - 2.5-5 kg/day
Cement Mix

Landfill
&
Metasil - 10% w/w Hg, 7000 kg/yr
Hg dust - 50-90% w/w, Hg 500kg/yr
Floor sweepings - 15% w/w Hg, 2000 kg/yr
\

/
Retort or export
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recoverd Hg - 700kg + 250-450kg + 300kg = 1250-1450kg pa

Volume 8 Date - NA Document Title - Yearly average Hg in Urine (ug/L) - between 1979-1983

	Cell shift process	Cell shift day	Cell shift maintenance	Cell shift Day
79	0.1	-	0.16	0.06
80	0	0.12	0.13	0.06
81	0	0.12	0.16	0.05
82	0.07	0.08	0.13	0.04
83	0.05	0.07	0	0.03

Volume 8 - Date - 1991 - Document Title - Hg Balance
CL2 production - 70,000te
H2 production - 10784000m3/yr Waste H2 - 12517600m3/yr ~ 1428m3/hr Hg lost in production of H2 - 0.0011 kg/yr Hg lost in waste hydrogen - 1.25 kg/yr Hg accumulation Product absorber - 16,38 kg/yr Waste absorber - 284,15 kg/yr - prior to 1978 this used to go into air Hg is H2 before waste absorber is 22.8 mg/m3 - 1978 it was 15-30 Caustic soda Production - 139.000 te/yr - 87.321 te/yr in 1980 Hg in caustic soda - 0.7 g/te - 97.30 kg/yr Hypo Production- 31500.00 m3/yr - 19,000 m3/yr Hg in Hypo (17.5% Caustic) - 0.18 g/te - 6.8 kg/yr Effluent Flowrate effluent - 6300 kl/d Hg in effluent - 0.02 mg/l - 45.99 kg/yr Box Venting Flow rate in end box - 2300 m3/hr (flow rate in stack) before absorbed - 13.4 mg/m3 after basorption - 0.1 mg/m3 (CDMS incorrect - in 1999-2001 acerage concentration was 0.515 mg/m3) Hg Concentration leaving stack - 6.3 mg/m3 Hg loss in waste gas - 126,93 kg/yr Hg loss in absorber - 267.97 kg/yr Brine waste Production brine - 1140.00 te/yr - in 2000 - 2709 tonnes/annum Hg - 1000 g/te - CDMS memo 10/4/87 suggests 2000 g/te ~ 1140kg/yr Cell room atmosphere - average Hg in cell room air - 60 ug/m3 - in 1981 an average of 30 ug/m3 was measured Roof - 100m3 wind speed - 5 m/s Hg - 60 ug/m3 Hg content - 0.03 g/s ~ 946.1 kg/yr Side walls 200 m2 wind speed - 0.65 m/s Hg concentration - 20 ug/m3 ~ 82 kg/yr Negligable losses - produc chlorine = 50ppb w/w Hg Waste from Stellar Filter - 2 * 83 kg/week, 11% w/w ~ 950 kg/yr Cell waste Hg - 20% Weight of solids - 18 te/yr Mistake in massblanace as too many drums (15 not 32) ~ 1920 kg/yr not 3600kg/yr Caustic waste tank - 300kg/ya, 35% Hg ~ 105kg/yr Thick Hg sludge separation tank - 50% Hg, 300Kg/Drum, 12 drums/yr ~ 1800kg/yr Grey Hg accumulates in 4 coffins on the site - 15% Hg ~ 720 kg/yr Hg consumption with retorting - 0.13 Hg/te CL2 Hg consumption without retorting - 0.4 Hg/te CL2
Additions - 23000 kg/yr Losses - 2446.35 kg/yr Accumulation - 7743.92 kg/yr Recovery - 4000 Kg Balance 8809.73 kg/yr ~38%

Volume 8	Date - 20/09/82	Memo title - Site effluent flow 6000m3/d			
Brine sludge	25	50	75	100	500
Contribution of Hg in effluent (ppb)	4	8	12.5	17	83

Hg content in brine sludge typically 150ppm +- 200ppm
Hg content in brine liquid typically 15 ppm +- 24 ppm
Average Hg in brine sludge = 1000ppm

Volume 7	Date - 29/10/73	Memo title - The Economic Impact of future Hg emission standards on chlorine costs at botany and yarraville

Aqueous emission Hg

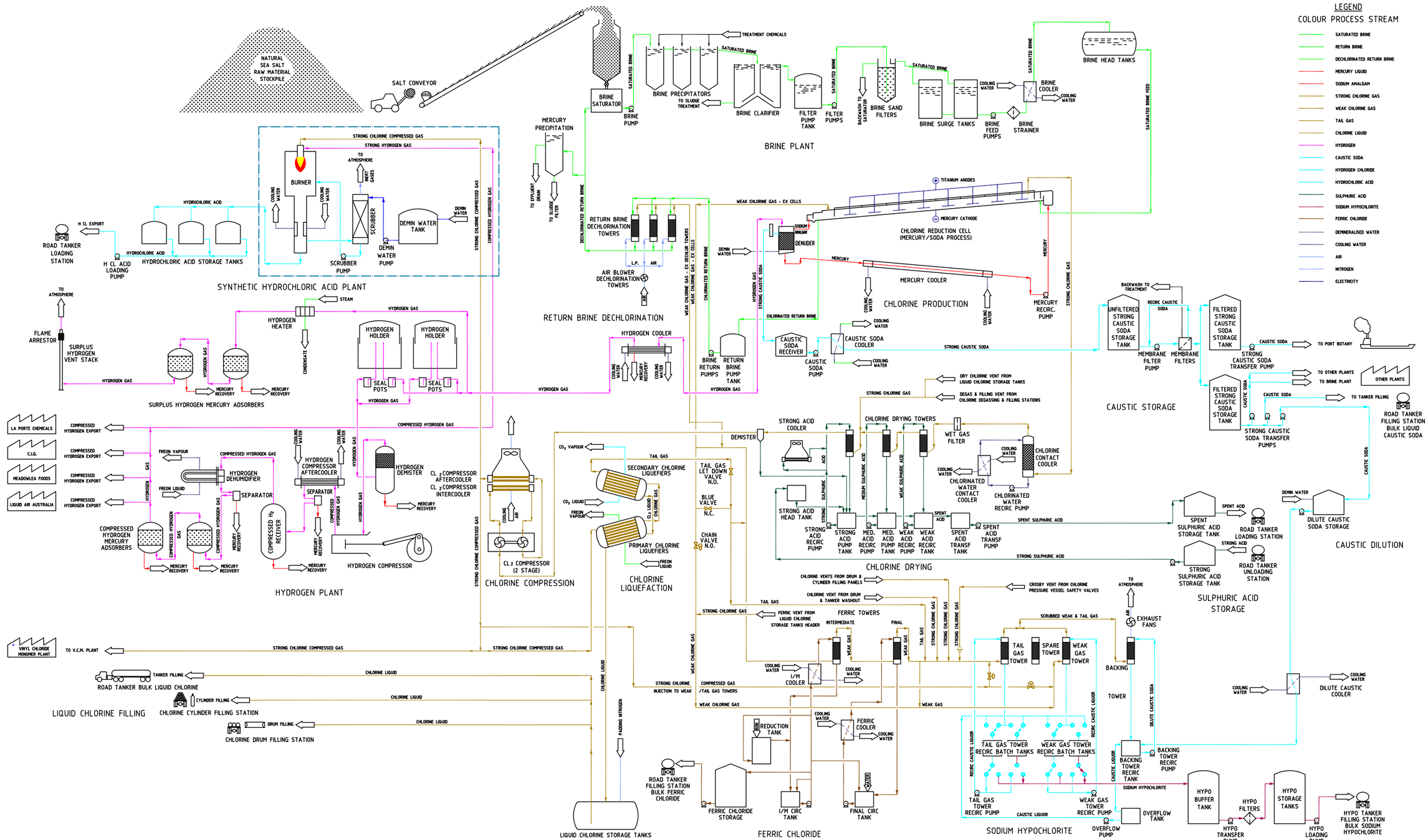
	MWS&DB standard	Expected Compliance with standard (mg/l)
Present	Nil	0.5
74	Nil	0.05
77	Nil	0.01
82	Nil	0.005

Gaseous emissions Hg

	Expected emission standard mg/m3	Basis of standard	Expected cell room MAC mg/m3
Present	20	Standards	0.1
76	20	Standards	0.05
78	3	Standards	0.05
beyond	3	Standards	0.05

Volume 9	Date - NA		Document title - Cells/Brine Process Description		
	H		MK	BI	
Number Cells		24	28		28
Cath area	10.2m2		1.5m2	20.8m2	
Hg flow	20 L/min		23 L/min	9 L/min	
Length plates	15.29 m		14.52m	18.08m	
Width	0.673m		0.864m	1.149m	
	Filtrate w/w		Sludge w/w	filter cake w/w	
Hg	25 pm		150 ppm	900 ppm	

Appendix N - Process Flow Arrangement



CAD DRAWING - DO NOT MANUALLY REVISE THIS DRAWING

REV.	RES/PROJECT No.	REVISION DETAILS	DRAWN	DATE	CHECKED	DATE	PASSED	DATE	APPROVED	DATE
G	-	-	-	-	NOT CHECKED	-	NOT PASSED	-	NOT APPROVED	-
F	-	-	-	-	NOT CHECKED	-	NOT PASSED	-	NOT APPROVED	-
E	-	-	-	-	NOT CHECKED	-	NOT PASSED	-	NOT APPROVED	-
D	D4987	REVISED	SUE NOBLE	10/95	B. DILLEY	10/95	N. BROWN C. WILEY	10/95	D. STANIC	11/95
C	D3559	REVISED	ASN	2/91	-	-	-	-	P. GREEN	2/91
B	D3450	REVISED	ASN	10/90	-	-	-	-	P. GREEN	10/90
A	D3281	DRAWN ON CAD	JMB	9/90	-	-	-	-	DW	9/90

PLEASE READ

NOTE: THE INFORMATION ON THIS DRAWING IS PRELIMINARY ONLY AND SHALL NOT BE USED FOR CONSTRUCTION OR MANUFACTURE UNLESS THE DRAWING HAS BEEN CHECKED, PASSED AND APPROVED.

SPACES ON THE TITLE BLOCK SHALL BE SIGNED AS FOLLOWS -

"DRAWN" DRAFTSPERSON OR TRACERS NAME TO BE PRINTED IN FULL

"CHECKED" TO BE SIGNED IN FULL AND NAME PRINTED IN FULL BY PERSON CHECKING THE DRAWING

"PASSED" TO BE SIGNED IN FULL AND NAME PRINTED IN FULL BY RESPONSIBLE ENGINEER SIGNIFYING THE DRAWING MEETS ALL TECHNICAL REQUIREMENTS

N.B. ENGINEER PASSING THE DRAWING SHALL ENSURE THAT ALL INTER-DISCIPLINARY CHECKS HAVE BEEN MADE

"APPROVED" TO BE SIGNED IN FULL AND NAME PRINTED IN FULL BY RESPONSIBLE FACTORY REPRESENTATIVE

0 1 2 3 4 INCHES
0 1 2 3 4 5 6 7 8 9 10 METRIC

DRAWN	J M BROWN	DATE 8/90
CHECKED	D WORKMAN	DATE 9/90
PASSED	C EWING	DATE 9/90
APPROVED	P DONNELLY	DATE 9/90

WORKS	BOTANY
PLANT	CHLORINE
SECTION	SITE & SERVICES
PROJECT No.	D3281

ORICA Australia Pty Ltd (ACN. 004 989 093)

TITLE

I.C.I. BOTANY
CHLORINE FACTORY
PROCESS FLOW ARRANGEMENT

SCALE	PLANT	SEC	SUB	DRAWING No.	REV.	A	B	C	D	
N.T.S.	B201	05	01	B52968	DATE PLMD					

Appendix O - Provisional Sampling Plan

Figure 10-1 (Provisional Sampling Plan Residential) has been prepared by CDM Smith and will be released to the Consultant for Stage 2 under confidentiality. The Provisional Sampling Plan Parks has been included in the report.

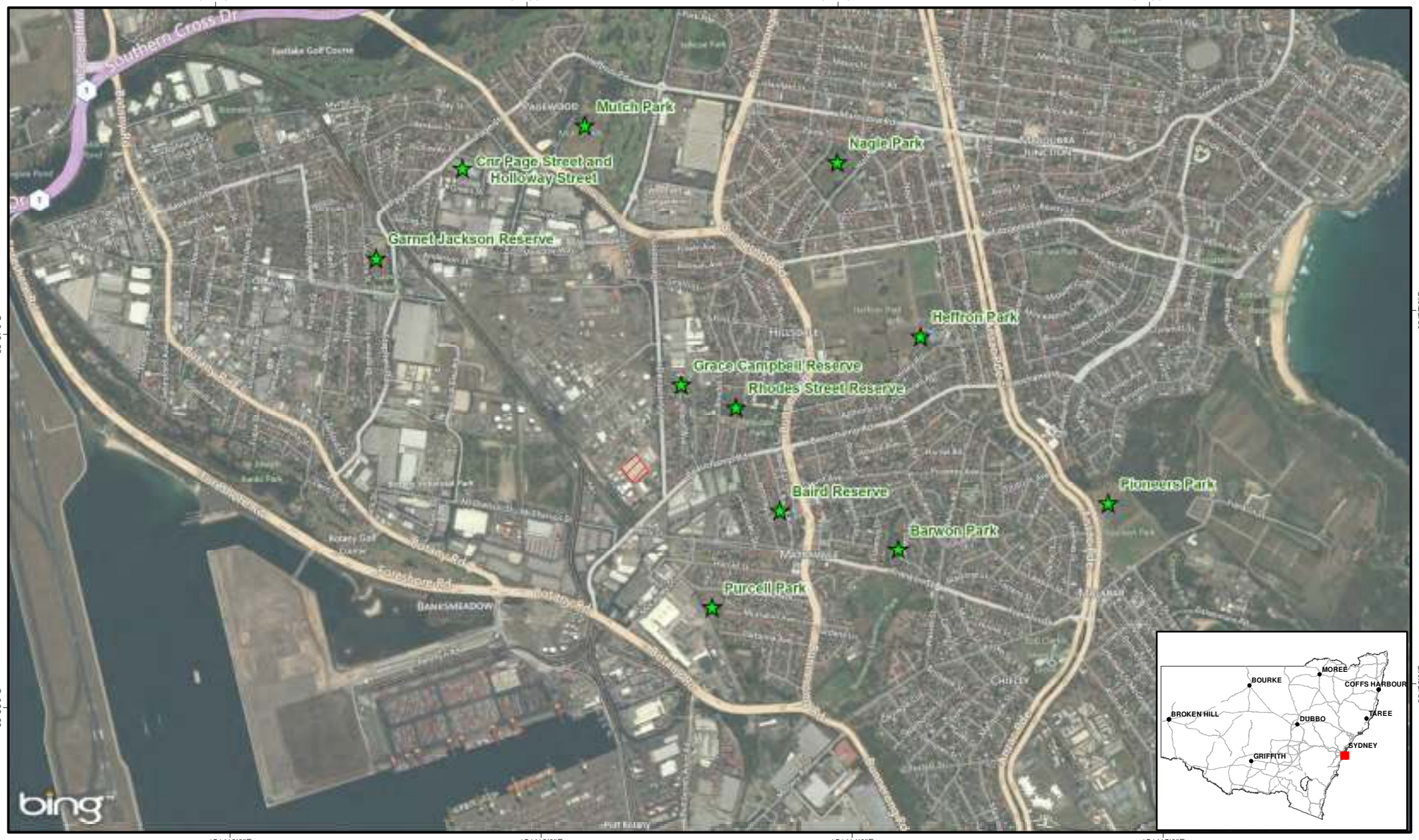


Figure 10-2 Public Parks and Reserves Proposed for Limited Sampling

Key

Former Chlor-Alkali Plant

0 500 1,000

Metres

GCS GDA 1994 MGA Zone 55

N W E S

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CDM Smith has endeavoured to ensure accuracy and completeness of the data. CDM Smith assumes no legal liability or responsibility for any decisions or actions resulting from the information contained within this map.

Data Source:
BingMaps, 2011.

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Date (11/21/2013)

Appendix P - Mass Balance Calculation

Section 5 Detailed Mercury Mass Balance Calculation – FCAP

In this Appendix EPA documents are referred to as follows: (Document X). The number refers to the EPA documents list in **Appendix I** and Review Summaries in **Appendix G**. Orica-ICI document (Volume X, Orica folders) is a reference to the number in the first column in **Appendix M**.

5.1 Mercury demand ('IN')

In the documentation provided by the NSW EPA, CDM Smith did not find any information regarding the mercury demand for the FCAP. However, Orica's documents did contain the following evidence for the mercury demand:

- In "*Mercury Waste Water Management, Technology and Costs for mercury cell users in the Chlor Alkali Industry by I. Frankel, 1 June 1977, CIC/ACS*" the mercury replacement was 0.17 kg mercury/tonne chlorine production (range from 0.09 – 0.41) for the year 1975. This number was the average for 12 plants;
- Volume 8 (Orica folders) contained a handwritten table regarding mercury usages between Sept 1971 to Sept 1983 (range 0.064 to 0.253) with an average use of 0.127 kg mercury/tonne chlorine;
- Letter from ICI to SPCC (30/11/1977, volume 8 Orica folders): mercury inventory was budgeted at 0.12 kg mercury/tonne chlorine;
- In ICI report "the mercury burden" from 1987 to July 1991, the total mercury usage for the Botany plant corresponds to approximately 0.37 kg mercury/tonne chlorine. A thorough mercury balance has been instituted in order to identify the approximate 40% unaccounted losses;
- Mercury mass balance: by Orica employee, October 1992: Mercury consumption in 1991 was 23,000 kg with a chlorine production of 70,000 tonne/year resulting in 0.33 kg mercury/tonne chlorine usage. In the same document the mercury consumed over the period March 1981 to April 1992 (11 years) was 16,640 kg mercury/year resulting in 0.216 kg mercury/tonne chlorine (total capacity over these years was 845,907 tonnes Chlorine and 183 tonnes of mercury). In 1988, ICI removed the retort as it was inoperable and costs to restore it to suitable and workable conditions were unjustifiable (internal memo 28-7-1988, Volume 8 Orica folders). This resulted in an increase in mercury demand from 0.144 kg/tonne to 0.392 kg/tonne; and
- In document 18, (EIS for closure of the FCAP, year 1998) an annual raw mercury usage of 11.2 tonnes/year is mentioned.

The United Nations Environment Program (UNEP) Chlor Alkali Partnership Area has published data in the following documents:

- Global Atmospheric Mercury Assessment: Sources, Emissions and Transport, Geneva, Switzerland December 2008 (UNEP 2008); and

- US-EPA International Conference on mercury as a global pollutant, 25 July 2011, Factsheet (UNEP 2011).

According to the above factsheet (UNEP 2011) the mercury demand from the global Chlor-Alkali sector was about 500 tonnes in 2005 with a production of 8,200,000 tonnes (Chlorine) resulting in 0.06 kg Mercury/tonne Chlorine in 2005. Mercury emissions to the air from the sector were estimated to be 47 tonnes in 2005 representing 9.4% of the total demand. This percentage has been based on data compiled from some 100 facilities in 43 nations worldwide and is therefore a reliable indicative number.

In an interview with a former Orica employee, he asserted that one tonne of mercury per month, resulting in 12 tonnes/year (early 1970s), was required to make up for the plant losses.

During the review CDM Smith has not been able to find any plant related information on historical mercury demand (prior to 1970s). In January 1971 the USEPA published a document (AP-80) named "*Atmospheric Emissions from Chlor-Alkali Manufacture*". In this document daily mercury losses of 0.6 pound (0.27 kg) per ton of installed daily chlorine capacity were presented. For the Orica Botany plant the chlorine capacity (full capacity, three cell rooms) was ~230 tonnes/day (document 105 and several Orica documents). Using these indicative numbers a total mercury demand of 62.1 kg/day (or 22.7 tonnes/year) was calculated.

Table 5-1 contains a summary of the mercury (estimate only) used in the FCAP. It should be noted that these numbers are indicative however it is our opinion that these numbers are defensible.

Table 5-1 Mercury Demand FCAP Orica/ICI - Botany (estimate only)

Period	Total years	Cathode area (m2)	Capacity (tonnes/day)	Mercury demand per tonne capacity (kg/tonne)	Mercury demand (tonnes/yr)	Total (tonnes)
1945-1954	10	10.2	54 [1)]	0.27	5.32	53.2
1955-1965	11	22.7	120 [1)]	0.27	11.83	130.1
1966-1974 [2)]	9	43.5	230 [8)]	0.27	22.67	204.0
1975-1986 [3)]	12	43.5	230	0.14	11.75	141.0
1987-1998 [4)]	12	43.5	230	0.39	32.74	392.9
1999-2002 [7)]	4	12.5	120 [5)]	0.20 [6)]	8.76	35.6
Lifetime of the FCAP	**58**					**957**

1) Plant capacity after 1965 (3 cell rooms) is well documented. There is no documentation on cell capacity for the periods when only 1 or 2 cell rooms were in operation. Therefore daily capacity is calculated relative to the total cell cathode surface.
2) 1974 start of retorting (mercury recovery process) and installation sludge filter.
3) 1986 stop retorting process.
4) 1998 decommissioning H and MK1 cells.
5) Number provided by Orica.
6) Relative to Mercury demand for 1987-1998 (well documented)
7) Closure of EDC plant.
8) This is a conservative number. In the 1998 EIS (document 18) it is mentioned that the production in March 1998 was 70,000 te/year (192 tonnes/day) with a maximum capacity of 80,000 te/year. When using these production rates the total mercury amount during the lifetime of the FCAP would be 804 tonnes.

5.2 Mercury losses ('OUT')

CDM Smith has identified the following main sources of mercury losses:

- Effluent to sewer (Malabar treatment plant);
- Stormwater drain discharges into Springvale Drain that discharges into Penrhyn Estuary;
- Mercury loss via product (Chlorine, Caustic Soda and Hydrogen gas);
- Mercury loss via air (fugitive emissions via cell room atmosphere and via Hydrogen waste venting stack);
- Losses to soil; and
- Solid Wastes (e.g. sludges, filter cakes, floor sweepings).

The identified sources, are described in the documentation outlined below.

5.2.1 Effluent to sewer

The following is a summary of information from various sources on the concentration and mass of Mercury discharged to sewer historically:

- Internal memorandum (Volume 8 Orica files): mercury content in effluent on September 1970 was 0.8 mg/l (5,440 g/day; 1.99 tonne/year) and in October 1978 it was 0.037 mg/l (252 g/day);
- In an internal memorandum (Volume 8, Orica files) from 1 April 1987 it is mentioned that the long term average (period 1980 – 1986, pre abatement) was 72 µg/l (ppb). Assuming 6.8 ML/day (Document 105) of effluent this then results in a daily mass of 0.49 kg/day or 0.178 tonnes/year. The licence requirements allowed Mercury concentrations up to 100 ppb to be discharged to sewer;
- In Volume 10 from the Orica files a graph indicated monthly averages of Mercury in effluent for the period April 1989 - Aug 1990. This document included 17 monthly averages (68 ppb was the highest) were above the 35 ppb licence (new licence) limit and only one was below. Monthly reports were made available in Volume 10;
- Another internal memorandum (Volume 8, Orica files), which was also published in a local newspaper, showed a graph of the monthly average mercury mass that was discharged to sewer. The level decreased from 0.8 kg/day in January 1986 to 0.3 kg/day in January 1990 (0.292 tonnes/year to 0.11 tonnes/year);
- ICI internal memorandum (Volume 10): Mercury in effluent monthly report for August 1990. 12 samples per day were collected. Average was 37.6 ppb;
- In order to reduce the aqueous Mercury emissions from the FCAP to sewer, ICI (now Orica) embarked on an Abatement Program beginning in January 1990. This program has involved numerous changes in operating practices together with upgrading of plant and equipment.

In order to demonstrate the outcomes of the program, ICI ordered an independent review by the Department of Chemical Engineering, University of Sydney, October 1991 (the "Davies" report, Document 105). The Steering Panel provided CDM Smith with a copy of this report. The report was also made available to the members on the Panel. It should be noted that the Davies report has been provided by Orica under a confidentiality agreement. CDM Smith has reviewed this document in detail;

- Document 105 states that a reduction of 62.5% of mercury losses to sewer was achieved as a result of the abatement program: "*A reduction in mercury flux to effluent (sewer) from more than 400 grams/day in 1987/88 to less than 150 grams/day May 1991*". Based on a total water flux of 6.8ML/day (Document 105 and Volume 8 Orica folders (memo from S. Davies Feb. 1993)), this results in a pre-abatement program mercury mass of 0.146 tonnes/year and 0.055 tonnes/year post-program; and

- In the same folder (Volume 8, Orica files, mass water balance done by S. Davies, handwritten) the mercury mass in 1989 was calculated to be 0.355 kg /day (0.129 tonnes/yr), 0.100 kg/day (0.036 tonnes/yr) in 1991 and 0.063 kg/day (0.023 tonnes/yr) in 1992.

Mercury losses to effluent are estimated and summarised in **Table 5-2**.

Table 5-2 Mercury losses to effluent (estimate)

Period	Total years	Capacity (tonnes/day)	Assumed Mercury loss (tonnes/year)	Total (tonnes)
1945-1954	10	54	0 (no sewer)	0
1955-1958[1)]	4	120	0 (no sewer)	0
1959-1965	7	120	1.04 [3)]	7.3
1966-1974[2)]	9	230	1.99 (1970)	17.9
1975-1986	12	230	0.29 (1986)	3.5
1987-1990	4	230	0.2 (average 1986-1990)	0.8
1991-1992	2	230	0.04 (1991)	0.1
1993-1998	6	230	0.023 (1992)	0.14
1999-2002	4	120	0.023 (1992)	0.1
Lifetime of the FCAP	**58**			**29.8**

1) Connection to sewer in 1958
2) Sludge filter installed
3) Same as the period 1966-1974 but adjusted for the lower capacity

5.2.2 Stormwater Drain > Springvale Drain > Botany Bay

In a February 1942 ICI report (Orica Volume14) for Botany works, *Design of Brine Plant* it is mentioned that "*all the tanks in the brine plant will require sludging. There is a main concrete 10m³ sludge sump below the lowest sludging cock on the plant. The sump is agitated and emptied through two pumps who deliver the sludge to the sludge lagoon*".

The 1942 documents also mentions a working floor for the brine plant level with the 10 foot cell room working floor.

In an ICI report (Orica Volume 14) titled *Effluent segregation at Botany Factory* from September 1949 "*it is proposed to run waste liquors to gravity through gravity flow stoneware drains (*195m long drain*) into an unused 300' x 50' area situated on that portion of block V beyond the present factory boundary fence*". This action is necessary as the discharge of the materials within the main factory effluent has been forbidden by the Maritime Services Board. This document also discusses "*settling sumps outside the building, but a considerable portion carries on to the drain, which leads to a sump on the Burma Road corner of the salt store*".

Prior to 1958 the FCAP was not connected to sewer and all the mercury wastes went on to the stormwater drain that was connected to Springvale drain This was an open drain at that time until it was remediated and replaced by a closed drain in January 2000.

Document 105 states that prior to the abatement program the sludge pad was in an un-bunded area open to the air. Rainwater had an excellent opportunity to leach soluble material from the pile to the stormwater system. A new sludge pad has been constructed and leachate is collected in a sump and put to the treatment plant before discharge.

Hosing the concrete floor of the FCAP which resulted in rinse water entering the stormwater system, has been reported by former employees as well as by Orica. Given that mercury is expensive and fairly easy to recover in case of a spill, CDM Smith has assumed that the total mercury mass entering the stormwater system via this pathway was minimal after the site was connected to sewer in 1958.

The total amount of mercury losses via the Springvale drain is not yet known and it is our opinion that it will always be an unknown factor. A total mass of mercury present in Springvale drain sediments is calculated to be 309 kg (Document 92). CDM Smith considers that this volume is likely to be a small fraction of the total mercury mass that was disposed of via the Springvale drain.

5.2.3 Mercury losses via product

The following is a summary of information from various sources on the concentration of Mercury in the products produced at the FCAP:

- In the Orica files (Volume 2) the following is discussed: Mercury is present in caustic (1 ppm), hypo (0.25 ppm) and hydrogen (0.05 mg/m^3) products;
- The improvements to the plant, described in the Davies report, (Document 105) resulted in a decrease in mercury content in 50% caustic soda from 1.5 ppm to about 0.9 ppm;
- In Volume 2 (Orica folders) a letter from SPCC addressed to Orica dated 25 August 1977 contained written notes stating the caustic soda streams contained 0.3 g mercury per tonne (0.3 ppm) and 518 tonne caustic soda (50 w/w%) was produced;
- Mercury losses to hydrogen product are considered minimal and therefore are not included in the calculations; and

- Assuming 518 tonne/day production of caustic soda with 1.5 ppm prior to 1991 and 0.9 ppm after 1991 a total mercury loss of 0.28 tonnes/year and 0.17 tonnes/year, respectively were calculated at full capacity.

Mercury losses via caustic soda are summarised in **Table 5-3**.

Table 5-3 Mercury losses in Product

Period	Total years	Capacity (tonnes/day)	Assumed Mercury loss via product (tonnes/year)	Total (tonnes)
1945-1954	10	54	0.07 [1)]	0.7
1955-1965	11	120	0.15 [1)]	1.7
1966-1991	25	230	0.28	7
1992-1998	8	230	0.17	1.4
1999-2002	4	120	0.09 [2)]	0.4
Lifetime of the FCAP	**58**			**11.2**

1) Equally adjusted for the lower capacity assuming 0.28 tonnes / year is full capacity
2) Equally adjusted for the lower capacity assuming 0.17 tonnes / year is full capacity

5.2.4 Air emissions

Two types of air emissions were identified at the FCAP:

1. Fugitive mercury emissions in the cell rooms; and
2. Mercury emissions via the stack.

5.2.4.1 Fugitive air emissions

- In the Chlor-Alkali Industry, it is widely recognised that fugitive air emissions are difficult to quantify in open designed cell rooms. This has also been recognised by the author of an internal ICI memorandum (Volume 2, Orica folders). In the same memorandum, it was mentioned that the mercury concentration within the cell rooms ambient air was less than 50 µg/m^3.
- ICI monitored mercury levels in the cell rooms and offices since 1947.
- A letter from Orica (Volume 2 Orica folders) dated 8 February 1977 stated that air samples were collected at the Site boundary. Levels of mercury in these samples were below 1 µg/m3 which is considered to be the acceptable limit. Levels in ambient air within the chlorine plant, in particular near the hydrogen gas holder were between 1.5 – 22 µg/m^3.
- An internal memorandum (Volume, 8 Orica folders) dated 9/10/1973 discusses that the total cell room ventilation is difficult to assess. A measurement in 1969 indicated a total flow of 750,000 cfm for both cell rooms (1.3*10^6 m^3/hr). If the flow contained 0.05 mg/m^3 of mercury vapour this would represent an (*fugitive*) emission of about 1.5 kg/day (548 kg/year).

- In Volume 2, (Orica folders) several field logs were found with cell room ambient air measurements. Orica calculated the weighted exposure on a weekly basis. The average weighted exposure between 8/7/81 to 30/9/81 was calculated at approximately 30 µg/m^3. In an Occupational Hygiene report, exposure to mercury at Botany Chlorine Plant dated early 1987 (Volume 2, Orica folders) it is explained that these weekly ambient air monitoring rounds were conducted (using a Bacharach detector with silica gel pre-filters) during the hottest times of the day (1 – 3 pm) and that the concentrations were summed using weighting factors. These factors were presumably based on average occupancy times in an area to give a total weighted exposure. In the same document, it is stated that general area ventilation relies on air movement from heat convection, natural wind and electric blowers.

- In a mercury balance undertaken by Orica documented in an internal memorandum, (Volume 1 Orica folders) an average emission of 60 µg/m^3 was used and total fugitive emissions were calculated as being 1,028 kg/year.

- Assuming that the dimensions of the 3 story high footprint of the cell plant were 3,984 m^2 (totalling 39,840 m^3) and a natural/mechanical ventilation rate of 5o/h (http://www.engineeringtoolbox.com/air-change-rate-room-d_867.html), this then results in a worst-case fugitive emission of 1,047 kg/year (based on 60 µg/m^3).

- In January 1976, the USEPA published a document (EPA-600/2-76-014) named "Molecular sieve mercury control process in Chlor-alkali plants". In this document typical mercury loss ranges for cell emissions were presented (0.5 – 5 pounds per 100 tonnes produced Chlorine). For the Botany plant (230 tonnes/day) the range would be 190.5 – 1,905 kg mercury/year. The above calculated 1,047 kg/year is in the middle of this range and therefore seems reasonable.

- In June 1983 a meeting was held between ICI and the EPA in relation to emissions.

- Ongoing fugitive mercury emissions from the building for the period 2002 – 2006 were estimated at 340 kg/year as reported by Orica to the National Pollution Inventory. After plant demolition, annual mercury emissions were 8 kg/year (Groundwater Steam Stripping Plant) for the period 2006 – 2010. For 2010 and ongoing Orica reported no mercury emissions.

5.2.4.2 Stack emissions

The following is a summary of emissions from the stack:

- Produced hydrogen gas was either purified into the existing purification plant, sold to (internal) clients, vented to the air via hydrogen stack or box venting or burnt into the power station for the retort;

- In Volume 2, Orica folders several memorandums from 1978 to 1979 were included on the SPCC (now EPA) proposed reduction in the emission standard from 20 mg/m^3 to 3 mg/m^3 (NHMRC level) to reduce the mercury levels in the strong hydrogen vented from the FCAP;

- Prior to 1979, the hydrogen waste that was vented to the atmosphere was not treated for mercury (internal Orica memorandum 21/8/1979). Around 1978-79 two absorbers (sulphur impregnated carbon) were installed to treat the hydrogen waste. Most of this mercury (~725 kg/year) ended up in the waste stream (carbon filter sludge). In the 1991 mass balance, it was calculated that only 1.25 kg Mercury was emitted via the hydrogen waste stream that year;

- In a draft memorandum (no date, Volume 2, Orica folders) it was mentioned that the mercury content in the gas varies from 15 to 30 mg/m^3 with a venting rate of approximately 3,500 m^3/hr (at peak production). In another internal memorandum dated 21/8/1979 the hydrogen output was calculated to be 4.5 tonnes/day (H_2) or approximately 2,200 m^3/hour;
- In Volume 2, Orica folders a letter from SPCC addressed to Orica dated 25 August 1977 was found with written notes stating volume of hydrogen lost to atmosphere was 3,000 m^3/hour with a concentration of 40 mg/m^3 and an annual mercury loss via hydrogen gas of 900 kg/year;
- In January 1971 the USEPA published a document (AP-80) named "Atmospheric Emissions from Chlor-Alkali Manufacture". In this document it is stated that for European plants 3% of the mercury lost is emitted to the surrounding atmosphere;
- In January 1976 the USEPA published a document (EPA-600/2-76-014) named "Molecular sieve mercury control process in Chlor-alkali plants". In the document it is stated that the mercury loss will be higher than 2.25 kg/day for a 100 tonne Chlorine capacity plant. Using these figures on the Botany plant (230 tonne capacity plant) gives a mercury emission in the hydrogen waste of 1,889 kg Mercury/year; and
- Assuming an average yearly flow rate of 2,750 m^3/hour and a mercury concentration of 30 mg/m^3 (real-time data) the mercury loss via the stack prior to 1979 can be calculated to be ~725 kg/year (calculation CDM Smith).

In Volume 2, Orica folders evidence was found on mercury levels in hydrogen gas for the years 1992 and 1993:

- In 1992 mercury in Ex 2nd on-line absorber was <0.1 – 0.2 mg/m^3;
- In 1993 mercury levels in the waste H_2 gas were <0.1 – 3.0 mg/m^3 (with a maximum out of specification level of 10 mg/m^3); and
- For the period 1/3/91 to 28/5/93 the Ex stack levels of mercury were between 0.1 – 11.0 mg/m^3 with an average of 4.2 mg/m^3.

Orica has reported on their annual returns air emissions in several documents. In 1998/1999 a total mass of 230kg was being reportedly being emitted to air (see also the National Pollution Inventory).

In various Annual Returns (licence requirement) CDM Smith has found monthly monitoring results for mercury in air at control points 1 and 2. Note that mass monitoring was not required as per the licence (R1.1 and M6 in EPA Licence 2148). Results have been summarised in **Table 5-4,** below:

Table 5-4 Mercury in air emissions, annual returns Orica to EPA

Document ID	Year	Sampling point (EPA Licence) 1) 2)	Number of samples	Minimum	Mean	Maximum mg/m3
33	21/7/1999 to 20/7/2000	1	9	0.01	0.41	1.7
33	21/7/1999 to 20/7/2000	2	11	0.01	0.14	0.93
33	21/7/2000 to 21/7/2001	1	10	0.1	0.62	1.2

Document ID	Year	Sampling point (EPA Licence) 1) 2)	Number of samples	Minimum	Mean	Maximum mg/m3
33	21/7/2000 to 21/7/2001	2	11	0.1	0.13	0.4

1) Sampling point 1: Outlet final mercury absorber in waste hydrogen
2) Sampling point 2: End Box Vent

In an internal mass balance calculation, for the year 1991, Orica calculated a total loss of mercury to waste gas (box venting) of 126.9 kg/year. Orica-ICI used a mercury concentration of 6.3 mg/m^3 (*note CDMS: this is a very conservative number as for 1999/2001 an average of 0.135 mg/m^3 was measured*) and 1.25 kg/year (using mercury concentration <0.1 mg/m^3, *note CDMS: this is incorrect and should be the average of 1.7 and 1.2 resulting in 18 kg/year at a waste H_2 stream of 12,517,600 m^3/year*) via the hydrogen waste with a total mass of 284.15 kg/year of mercury trapped in the waste absorber. Note that this mercury was emitted to the atmosphere prior to installation of the absorbers.

Based on the data provided in the Orica mass balance (see also **Section 5.3**), CDM Smith calculated the total mercury air emissions to be 5% of the total mercury demand for that year (0.0165 kg Mercury / tonne Chlorine air emissions on a mercury consumption rate of 0.329 kg Mercury/tonne Chlorine). This number could be compared to the 3% detailed in the USEPA document (AP-80). However, there is a 2 decade difference in time and in those decades plants improved their mercury emissions.

5.2.4.3 Summary fugitive and stack emissions

Based on the above and for the purpose of the input of fugitive and stack emissions in an air dispersion and deposition model (**Appendix L**), CDM Smith used the following data (**Table 5-5**):

Table 5-5 Air emissions over the lifetime of the FCAP

Period	Total years	Fugitive emissions (kg/year) 1)	Total (tonnes)
1945 - 2002	58	548 – 1,047 [2)]	31.8 – 60.73
2002 - 2006	5	340	1.7
Period	**Total years**	**Stack emissions (kg/year)**	**Total (tonnes)**
1945 - 1979	35	725 – 900 [2)]	25.4 – 31.5
1979 - 2002	23	145	3.3
Total [3)]			62.2 – 97.3

1) Via roof and walls of the building
2) This is a conservative number as the lower production rates during the first 2 decades of the plant's operation were not accounted for
3) Not adjusted for capacity

Note that mercury emissions from the mercury retort are not included in the numbers above. In May 1983, samples were collected and flow was measured by ICI (memo 6-5-1983, Volume 8, Orica folders). Based on these numbers CDM Smith calculated mercury emissions from the retort to be between 19 – 43 kg/year. With the retort operational for 15 years this equates to 0.3-0.64 tonnes mercury emitted to the air.

5.2.5 Soil Contamination

The total mass of mercury present in the onsite contaminated soils has been calculated by the EPA (refer to EPA "answers to community questions raised at the meeting of 22 November 2012"). A total mass of 12 tonnes is estimated to be present in the soils at the FCAP.

During a 31 October 2013 site visit, Orica personnel informed CDM Smith that 9 tonnes of mercury had been recovered as of the date of the site visit. This includes 1 tonne recovered during soil washing treatments from the soils underneath the FCAP. The excavation works were on schedule and planned to be finished end November 2013.

5.2.6 Groundwater Contamination

The total mass of mercury in the groundwater was estimated by CDM Smith. Based on 2012 groundwater concentrations, it is estimated that approximately 144 kg of dissolved mercury is present in the groundwater onsite, and approximately 6 kg of dissolved mercury is present in the groundwater offsite.

5.2.7 Waste

Mercury losses via brine sludges (waste blocks) were treated differently than mercury losses via other sludges and spent carbon as other sludges were either sewered, retorted or stored. Mercury in sludges and spent carbon from the plant are considered to be the largest contributors to mercury losses (or accumulations).

During our review, CDM Smith has identified the following relevant information:

- Prior to 1958, sludges went to settling/evaporation ponds before potentially being released to the Springvale Drain;
- In the period 1958 – 1974 (after installation of mercury effluent filters) all sludges went to Malabar sewer treatment plant;
- A mercury retort, to recover mercury, was constructed in/around 1974 and it operated up to September 1986. Up to 1986, all solid mercury wastes were retorted at Botany. This excludes brine sludge which was disposed of at landfill, and for iodised carbon which was stored in drums. Retorting was discontinued because it became impossible to meet modern operating standards with the existing aging old equipment. This was due mostly to leakages, damaged floors and blockages resulting in unacceptable mercury emissions to air being observed. The retort was not replaced as is was deemed economically not viable;
- Fourteen samples of filtercake were analysed in 1975 (Volume 1, Orica folders) and concentrations ranged between 940-2,630 ppm Mercury, with mean of 1,857ppm w/w on dry basis. The concentration on a wet basis was 1,105 ppm Mercury based on 40.5% moisture;
- In 1977 ICI calculated the mercury content (wet basis) before retorting: The calculated values were 4.4% w/w before retorting and after retorting 9.4ppm w/w;
- In numerous internal and external Orica memorandums and communications it has been mentioned that mercury waste was being stored onsite in drums from 1987 onwards. At least on one occasion, the waste was re-drummed. Waste including filter wastes and 2

tonnes/year of floor sweepings was sent to Japan for mercury recovery. Average processing costs for the waste were $1,500/tonne. It is unknown how much waste was transported to Japan. This avenue has been virtually closed off by Government Authorities and an attempt to export to China has been abandoned;

- Internal memorandums ICI: between 1985 – 1988: Waste has been exported to Japan. Japan now has decided not to accept waste with a mercury content lower than 15% (Botany waste has 10% Mercury);
- Internal ICI report (August 1988) – "*Mercury in effluent*": cell room floor drains were connected to the precipitation vessel No 1 (PPV). Filter cake (2.5 tonne/day) contains 7.5 kg mercury per day or 2.7 tonnes/year;
- In April 1989 200 x 200 litre drums with waste were transported to Japan (internal memo 9 December 1991);
- In an internal 1990 memorandum (Volume 2, Orica folders) it is mentioned that mercury containing carbon from end box venting, H_2 adsorption, HCl purification and Caustic Filtration is stored on site. Mercury sludges removed from cells and pits are also stored on site;
- The 1998 EIS mentions that at present 340 tonnes of Mercury sludges from the cells, spent carbon from caustic purification and carbon from the hydrogen purification process are recovered and stored on site;
- Prior to July 1990 brine sludge was mixed with cement and sent to landfill (Castlereagh depot) in liquid stage (*CDM Smith: it is unclear when Orica started this process*). As of January 1991, the mercury rich sludge had to be immobilised in fixed blocks and the blocks were sent to Pacific Waste Management at Elizabeth Drive (Kemps Creek). Solids (known as sludge) removed from the brine treatment step contained mercury. The sludge is filtered and the filter cake (with a mercury concentration of about 0.1% m/m or 1,000 ppm) is normally disposed by casting into cement known as brine blocks (1 part cement in 3 parts waste);
- ICI Australia Operations P/L, 1990 Waste Quantities (Volume 9, Orica files): Total waste blocks for the year 1990 is 1,461 tonnes (fluctuates between 25 - 325 tonnes/month);
- In "*The Mercury Burden*", ICI report from 1991 (Volume 12, Orica files) it is mentioned that about 1,000 tonnes/year is removed (CDM Smith: solidified brine waste) from Botany Site in 1 tonne blocks, each block containing 1,000 ppm. This amounts to 1,000 kg/year. For Botany the range of mercury in solid disposal is between 6.6 - 42.1 kg/day. The balance will show some substantial losses over and above the brine sludge loss;
- Internal ICI memo June 1991: Analysis of concrete blocks for mercury. Three blocks (3/6/91, 5/6/91 and 28/5/91) were tested for mercury. Levels were 900; 867 and 933 +/- 10% ppm. This averages to 900 ppm Mercury in the waste blocks;
- In Orica's files (Volume 9) test results for the mercury content in the waste blocks were present. In April 1993, (only) three batches of immobilised waste blocks were tested and the average concentration Mercury was 5,917 mg/kg. TCLP leachability test results showed that on 9 occasions from 249 TCLP results (between Feb 1991 to July 1993) the batch failed considerably (these batched were crushed on site and immobilized again). Each batch is

approximately 15 tonnes (volume 9 Orica folders, single observation) resulting in 1,494 tonnes/year (calculation by CDM Smith);

- Internal memorandum ICI (January 1994) from site environmental manager: records of EPA dockets are irregular and infrequent and a set of EPA dockets and disposal dockets should be sent to the site's environmental officer;
- March 1998: ICI letter to EPA: 1,500 tonnes/year brine blocks (made of the filter cake from brine sludge) were sent to landfill;
- In (Volume 9,Orica folders) a general description (22/02/1999) of the waste block process was provided. It was described that 20 blocks/week each with a mass of 0.8 tonne and a volume of 0.5 m^3 will be transported to landfill on a weekly basis. This is 832 tonnes/year;
- In volume 12 a brief summary was provided from a meeting between ICI and Pacific Waste Management. It was mentioned that approximately 6.8 batches per month were generated. CDM Smith: assuming 15 tonnes/batch this then gives 1,224 tonnes/year;
- Letter from Orica to EPA (found in Volume 20, Orica folders) dated 26 June 1999 regarding Orica Waste Licence 006901 - Resubmission of Waste Immobilisation for Ongoing Approval Six samples of untreated filter cake/brine sludge were tested for total Mercury with concentrations ranging between 900-4,290 mg/kg. The average concentration was 2,807 mg/kg for the six samples. Assuming 1 part cement on 3 parts brine sludge gives an average Mercury concentration of 2,105 mg/kg (samples were collected on 15/03/99). Fixated waste results collected on 27.11.98 for two batches were 2,035 mg/kg average Mercury content;
- In document 28 (copy of a table submitted to the EPA in the application for renewal of the Orica Botany Site Waste Facility Licence No. 006901, in March 1999) Orica states that on an annual basis 2,709 tonnes of stabilised brine waste blocks were sent to landfill. However in document 9 (letter Orica to EPA, 12 March 1998) it states that 600 tonnes of brine blocks were generated at the FCAP per annum;
- Reviewing the EPA files a few letters from Botany Industrial Park P/L regarding waste streams are included (Documents 27, 28, 30 and 33). The waste code for the brine blocks was N170 (Chemically fixed waste) and for mercury containing waste was D120. It can be concluded that between 72-188 tonne immobilised waste blocks were transported offsite per quarter resulting in 288 – 752 tonnes / year. Note that only a few quarterly waste reports (Q4/99; Q2/2000; Q3/2000 and Q2/2001) provided by Botany Industrial Park Pty/Ltd were included in the EPA files. Therefore, this number may not be very reliable;
- In a report prepared in February 2005 by Orica (Volume 19, Orica files) on "Mercury waste assessment and disposal" it is mentioned that mercury fixation using sulphide is limited to wastes with a mercury level < 1,000 ppm; and
- In Volume 19 the report Solid Mercury Waste, Options for minimisation and disposal, no date that provided data on stored mercury wastes on site. This details brine sludge waste blocks Brine sludge with a mercury content of 1%, with a generation rate 1,140 t/year (1,500 blocks). CDM Smith calculated that this represents 1.1 tonne / year mercury.

Several documents presented above detail that various amounts of immobilised waste blocks were being disposed onsite in the range of between 288 –2709 tonnes per year. It is CDM Smith's

view that for the period 1991 and ongoing, a total of ~1,500 tonnes waste blocks with an average mercury content of 1,000 mg/kg were produced (note that on one occasion Mercury levels were analysed approximately 6 times this value). This results in 1.5 tonne mercury per year (assuming the plant operates on full capacity, ~230 tonne Chlorine/day).

5.2.7.1 Waste stored at the site

All stored wastes (*CDM Smith: for the period after retorting stopped in 1986*) were disposed offsite to Sita Kemps Creek during the demolition works of the building.

- Mercury contaminated carbon is stored onsite pending recovery of mercury (Document 28). In Document 9 the mercury stored waste (as per March 1998) from the chlorine plant has been presented as follow:
    - Spent activated carbon containing mercury, accumulating at 4,4 m^3 per annum. Current stockpile: 37 m^3 (equivalent to 8.5 years);
    - Mercury-rich sludges from stella filters, maintenance of caustic tank as well as cells and brine sumps, accumulating at 5.7 m^3 per annum. Current stockpile: 68 m^3 (equivalent to approximately12 years);
- In an internal report (*Treatment of Mercury contaminated waste on ICI Chlorine plant, no date*) prepared by a University Student it was calculated that the average (based on only 7 samples) percentage of mercury in the sludges was 7.31%;
- Orica applied with DEC EPA for Approval to Macro Encapsulate Mercury Contaminated Wastes from Orica. Disposal was proposed at Sita, Kemps Creek into a multiple liner waste containment cell to be built within the Industrial waste cell at the Sita Landfill. This includes drummed sludge waste residue. 3,642 m^3 Mercury contaminated waste is envisaged for disposal of which 1,957 m^3 presently stored on site with a further 1,685 m^3 of contaminated bricks and masonry coming from further demolition *(Note that no mercury flux has been calculated nor provided by Orica as part of this application)*;
- In Orica's files (Volume 10) a 1989 handwritten memorandum detailed the onsite mercury stored wastes. A total amount of mercury in these wastes was calculated to be 8.5 tonnes Mercury/year. In a rough mercury balance done by Orica (Volume 10, 14 November 1989)over the period 1986-1989 accumulation of mercury waste was calculated to be 12.85 tonnes Mercury/year. In the 1991 mass balance done by KB (Volume 1 Orica folders) the waste accumulations were calculated to be 7.7 tonnes Mercury/year. Please note CDM Smith discovered a miscalculation in the 1991 mass balance (the numbers of waste drums were wrongly calculated) and therefore the accumulations should have been 6.1 tonnes Mercury/year;
- In February 2005 Orica prepared an internal report (volume 19 Orica files) on mercury waste assessment and disposal. CDM Smith reviewed this document and summarised our findings in **Table 5-6** onsite stored FCAP wastes;
- In Volume 19, ORICA's files the report Solid Mercury Waste, Options for minimisation and disposal (no date) provided data on stored mercury wastes on site. These were tabulated

and are summarised in **Table 5-7**. CDM Smith has assumed that this report was provided after 2002 when the new Chlor-Alkali plant was commissioned; and

- On 18 November 2013 CDM Smith received an email from Orica with a load tracking spreadsheet for the demolition works (tracking sheet for internal use). A total of 1,234 tonnes of drums/sludge/Depot 60 wastes was disposed offsite to licensed landfill (Kemps Creek). Concentrations of mercury in the wastes were unknown.

Table 5-6 Onsite stored FCAP wastes (1)

Mercury store		Tonnes material	Concentration Mercury (mg/kg)	Tonnes Mercury
Waste held at H/MK1/B1 stores	Asbestos Sheeting	40	3,000	3.6 – 11.4
	Fibre Glass	-	-	
	Brine Soil	750	4,300 – 14,700	
	Bricks	105	270	
	Sludge	165	90	
	Timber purlings	45	4,300	
	H_2 carbon	21	-	
	Concrete blocks	87.6	-	
54 (old Corvic warehouse)	Stellar Filters	180	11,000 [2]	2.0
	Cells	136	20,000 [2]	2.7
	Solids	28	35,000 [2]	1.0
	H_2 absorber	50 (estimate)	30,000 [2]	0.15
	Carbon Balls	7 (estimate)	10,000 [3]	0.07
53	Sludge	400 drums (205 L/each); 75 m^3 sludge; 37,5 te	20,000 [2]	0.75
60	Denuder balls	600	10,000 [3]	6.0
	Concrete floor/walls [5]	135	3,000 – 8,000 [4]	4.0 – 10.8
-	Drums and pallets	69	10,000 [3]	0.7
Grand Total		**1957 m^3 / 2207 te**		**21 – 35.6**

1) This is exclusive the waste that was transported to Japan (unknown quantity)
2) From "Solid Mercury Waste, Options for minimisation and disposal" internal ICI report, Volume 19
3) Estimate
4) From "*Assessment Mercury emissions from demolition of the old CAP, 12 September 2006 by PAE*"
5) CDM Smith assumed that this is material from cell rooms B and MK-1 which were partially demolished in 1998/2000

Table 5-7 Onsite stored FCAP wastes (2)

	Sulphur Carbon	Iodised Carbon	Stellar Carbon	Grey Mercury	Thick Mercury	Caustic waste	Cell waste	Unclassified	Accumulation	Total stock
Mercury content (%)	30	30	11	35	50	35	20	17		
Stock (te)	22	2	77	6	4.5	11	72	20		214.5
Weight Mercury (te)	6.6	0.6	8.5	2.1	2.3	3.9	14.4	3.4		**41.8**
Generation (te/yr)	0.4	0.1	8	1	0.5	0.3	14		24.3	
Weight Mercury (te/yr)	0.1	0	0.9	0.4	0.3	0.1	2.8		**4.6** [1)]	

1) CDM Smith assumes that the waste generation rate (24.3 tonne/year; 4.6 tonne/year mercury) is representable for a 120 tonnes Chlorine/day production capacity.

5.2.7.2 Mass calculation Wastes

Based on the data in **Table 5-7** CDM Smith has calculated the total losses (accumulations) within the solid waste stream in the plant. This is presented in **Table 5-8** within between brackets the place where the mercury waste was disposed of. For the period 1958 (ICI connected to sewer) – 1974 (installation of the treatment plant, sludge filters and the retort) most of the wastes went together with the effluent to sewer to Malabar Headland Sewer Treatment Plant.

Table 5-8 Solid Wastes Botany FCAP

Period	Total years	Capacity (tonnes/day)	Mercury to solid wastes (tonnes/yr)	Brine sludge (tonnes/yr)	Total mercury (tonnes)
1945-1954	10	54	2.1 (ponds/Bay)	0.35 (ponds/Bay)	21 + 3.5 = 24.5
1955-1958	4	120	4.6 (ponds/Bay)	0.8 (ponds/Bay)	18.4 + 3.2 = 21.6
1959-1965	7	120	4.6 (Malabar)	0.8 (Malabar)	32.2 + 5.6 = 37.8
1966-1974	9	230	8.9 (Malabar)	1.5 (Malabar)	80.1 + 13.5 = 93.6
1975-1986	12	230	0 (most Mercury was recovered)	1.5 (unknown)	0 +18 = 18
1987-1998	12	230	8.9 (landfill / Japan)	1.5 (landfill)	106.8 + 18 = 124.8
1999-2002	4	120	4.6 (landfill)	0.8 (landfill)	18.4 + 3.2 = 21.6
Lifetime of the FCAP	**58**				**277 + 65 = 342**

5.2.8 Demolition of the old plant

The mass of mercury in the building materials that needs to be accounted for is included below.

Volume 7, Orica folders contained an excel spread sheet printout that stated that there was 2,695 tonnes of building materials still standing. In the same folder the report "*Assessment Mercury emissions from demolition of the old CAP, 12 September 2006 by PAE*" detailed that the mercury concentration in the bricks, concrete and asbestos sheets was 3,000 – 8,000 mg/kg.

On 18 November 2013 CDM Smith received an email from Orica with a load tracking spreadsheet for the demo works (tracking sheet for internal use). A total of 3,422 tonnes of demolition rubble was sent to landfill (Kemps Creek).

This results in a total mercury mass of 10.3 – 27.3 tonnes.

5.3 Mercury balance calculated by Orica in 1991

For the year 1991 (volume 1, Orica folders) a mass balance was undertaken for the FCAP (internal report October 1992). It was concluded that 38% of the mercury could not be accounted for. The losses were calculated to be as follow (**Table 5-9**):

Table 5-9 Summary Results Mass Balance 1991

Media	Loss (g Mercury / te Chlorine) 1)	Percentage (%)	
Product	1.49	0.45	Caustic soda, Hypo,
Wastewater	0.66	0.20	Effluent
Process Exhaust	1.83	0.56	H_2 waste, box venting
Cell Room	14.69	4.47	Cell room atmosphere
Disposal	184.07	56.02	Brine waste, stellar filter, cell waste, caustic waste tank, thick mercury and grey mercury
Balance	**125.84**	**38.30**	
Sum	**328.57**	**100**	

1) Production was 70,000 tonne Chlorine (for 1992)
2) Mercury additions were 23 tonne (for 1992)

Appendix Q - Glossary of Technical Words

Word	Explanation
Abatement	Refers generally to a lessening, diminution, reduction, or moderation.
Absorption	The process of taking in. For a person or an animal, absorption is the process of a substance getting into the body through the eyes, skin, stomach, intestines, or lungs.
Adverse health effect	A change in body function or cell structure that might lead to disease or health problems.
Aeolian sand	Refers to sands which are deposited though the mechanics of wind.
Air Dispersion model	Is a mathematical simulation of how air pollutants disperse (spread out) in the ambient atmosphere.
Air Deposition model	Is a mathematical simulation of how air pollutants are deposited (the laying down of matter by a natural process) in the area surrounding the source.
Alluvial clay	Refers to slays that have been deposited through the mechanics of water movement (e.g. streams and rivers).
Ambient air	Relating to the immediate surroundings of something. In this instance air
Anaerobic	A system operating without oxygen.
Anode	An anode is an electrode through which electric current flows (e.g. the + side of a battery).
Anomalous	Deviating from what is standard, normal, or expected.
Anthropogenic	Caused by humans.
Aqueous	A solution in which the solvent is water.
Background level	An average or expected amount of a substance or material in a specific environment, or typical amounts of substances that occur naturally in an environment.
Basalt	A common volcanic rock which is formed by rapid cooling lava.
Bioaccumulation	Bioaccumulation refers to the accumulation of substances up the food chain, such as pesticides, or other organic chemicals in an organism.
Biodegradation	Decomposition or breakdown of a substance through the action of micro-organisms (such as bacteria or fungi) or other natural physical processes (such as sunlight).
Biota	Plants and animals in an environment. Some of these plants and animals might be sources of food, clothing, or medicines for people.
Carcinogen	A substance that causes cancer.
Cathode	An cathode (opposite of an Anode) is an electrode through which electric current flows (for example the – side of a battery).
Chronic exposure	This refers to a continuous exposure (or multiple exposures) that extends over a significant portion of a lifetime. With respect to the quantification of risk from environmental contaminants, most receptors, such as workers and residents, are associated with long-term or chronic exposures while working in the area affected by the impacts identified.
Clari-flocculator	The combined unit of flocculator and clarifierwhich is used in water treatments plants to combine and then filter out sediments.
Delineated	Indicate the exact position and boundaries (extent) of something.
Dermal contact	Contact with (touching) the skin [see route of exposure].
Detection limit	The lowest concentration of a chemical that can reliably be distinguished from a zero concentration.
Dose	The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect.
Dredging	An excavation activity or operation usually carried out at least partly underwater, in shallow seas or fresh water areas with the purpose of gathering up bottom sediments and disposing of them at a different location.
Effluent	An outflowing of water or gas from a natural body of water, or from a human-made structure.
Emissions	The production and discharge of something.
Estuary	An estuary is a partly enclosed coastal body of brackish water with one or more rivers or streams flowing into it, and with a free connection to the open sea.
Exposure	Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term [acute exposure], of intermediate duration [subchronic], or long-term [chronic exposure].
Exposure assessment	The process of finding out how people come into contact with a hazardous substance, how often and for how long they are in contact with the substance, and how much of the substance they are in contact with.

Word	Explanation
Exposure pathway	The route a substance takes from its source (where it began) to its end point (where it ends), and how people can come into contact with (or get exposed to) it. An exposure pathway has five parts: a source of contamination (such as chemical leakage into the subsurface); an environmental media and transport mechanism (such as movement through groundwater); a point of exposure (such as a private well); a route of exposure (eating, drinking, breathing, or touching), and a receptor population (people potentially or actually exposed). When all five parts are present, the exposure pathway is termed a completed exposure pathway.
Fate and Transport	The chemical and physical processes relevant to the transport of a material through the natural environment and the material's eventual fate.
Flux	The action or process of flowing or flowing out.
Groundwater	Water beneath the earth's surface in the spaces between soil particles and between rock surfaces [compare with surface water].
Guideline Value	Guideline value is a concentration in soil, sediment, water, biota or air (established by relevant regulatory authorities such as the Environmental Protection Authority (EPA) or institutions such as the National Health and Medical Research Council (NHMRC), Australia and New Zealand Environment and Conservation Council (ANZECC), the Agency for Toxic Substances and Disease Registry (ATSDR) and World Health Organisation (WHO)), that is used to identify conditions below which no adverse effects of or nuisance or indirect health effects are expected. The derivation of a guideline value utilises relevant studies on animals or humans and relevant factors to account for inter and intra species variations and uncertainty factors. Separate guidelines may be identified for protection of human health and the environment. Dependent on the source guidelines will have different names such as investigation level, trigger value, ambient guideline etc.
Ingestion	The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way [see route of exposure].
Inhalation	The act of breathing. A hazardous substance can enter the body this way [see route of exposure].
Invertebrates	Relating to animal species that do not possess or develop a vertebral column.
Iodised	When various salts of the element iodine are added to a substance.
Iterative	Relating to or involving the repetition of a process, especially of a mathematical or computational process.
Leachate	Leachate is any liquid that in passing through matter, extracts solutes, suspended solids or any other component of the material through which it has passed.
Littoral dune	A littoral-dune is a dune which is close to the shore (specifically between the high-water mark and the shoreline.
Mass balance	Calculation of the percentage difference between the mercury that was purchased ('in') and the mercury that was accounted for ('out') in various waste streams, product and other losses in the plant.
Metabolism	The conversion or breakdown of a substance from one form to another by a living organism.
MRL	The Maximum Residue Limit (MRL) is the maximum residue concentration from the legal use of an agricultural or veterinary chemical that is recommended as the acceptable maximum concentration in a food.
Neonatal	Of or relating to newborn infants or an infant.
NHMRC	National Health and Medical Research Council.
Noxious	Harmful, poisonous, or very unpleasant.
Paleochannels	Remnant of an inactive river or stream channel that has been either filled or buried by younger sediment.
Peat	An accumulation of partially decayed vegetation.
Plume	A volume of a substance that moves from its source to places farther away from the source. Plumes can be described by the volume of air or water they occupy and the direction they move. For example, a plume can describe a column of smoke from a chimney or a substance moving with groundwater.
Point of exposure	The place where someone can come into contact with a substance present in the environment [see exposure pathway].
Porosity	A measure of the void spaces in a material.
Receptor population	People who could come into contact with hazardous substances [see exposure pathway].
Reference concentration (RfC)	The concentration of a specific chemical in air to which a human population may be exposed to without appreciable risk to their health. RfC's are identified by the US EPA.

Word	Explanation
Reference dose (RfD)	Specifically refers to a toxicity value identified by the USEPA. The RfD is similar to an ADI (Acceptable Daily Intake) or TDI (Total Daily Intake) and incorporates uncertainty or safety factors to identify a safe dose assuming daily lifetime exposure to a substance that is unlikely to cause harm in humans.
Retort	Vessel used for distillation (separation based on boiling point) of substances that are placed inside and subjected to heat. Large retorts are widely used in industry in separating gold from mercury in amalgams, in separating zinc-metal vapour from the smelted ore mixture, and in obtaining coke or gas from coal.
Rinsate	A quality control method in which a piece of equipment is rinsed after cleaning. The rinse water is captured and sent for laboratory analysis to determine if concentrations of contaminants are present. This is then used to determine if the cleaning process is adequate.
Risk	The probability that something will cause injury or harm.
Risk reduction	Actions that can decrease the likelihood that individuals, groups, or communities will experience disease or other health conditions.
Route of exposure	The way people come into contact with a hazardous substance. Three routes of exposure are breathing [inhalation], eating or drinking [ingestion], or contact with the skin [dermal contact].
Segregation	Particulate solids tend to be segregated (separated/organised) by virtue of differences properties of the particles of which they are composed.
Silt sediments	A naturally occurring material that is broken down by processes of weathering and erosion, and is subsequently transported by the action of wind, water, or ice, and/or by the force of gravity acting on the particle itself.
Stratigraphic	The study of rock strata, especially the distribution, deposition, and age of sedimentary rocks.
Surface water	Water on the surface of the earth, such as in lakes, rivers, streams, ponds, and springs [compare with groundwater].
Surrogate	A substitute for another person/object in a specific role.
Tolerable Concentration	A tolerable concentration (established by WHO) is an airborne concentration to which it is believed that a person can be exposed continuously over a lifetime without deleterious effects. The tolerable concentration (TC) is based on non-carcinogenic effects and are usually calculated by applying uncertainty factors to a NOAEL or LOAEL. As such the tolerable concentration is similar to the USEPA reference concentration for inhalation exposures and ADI, TDI or RfD for oral exposures.
Tolerable Daily Intake (TDI)	The term tolerable daily intake (TDI) is used by the International Program on Chemical Safety (IPCS) to describe exposure limits of toxic chemicals and the term acceptable daily intake (ADI) is used by the World Health Organization (WHO) and other national and international health authorities and institutes.
Toxicological profile	An assessment that examines, summarizes, and interprets information about a hazardous substance to determine harmful levels of exposure and associated health effects. A toxicological profile also identifies significant gaps in knowledge on the substance and describes areas where further research is needed.
Toxicology	The study of the harmful effects of substances on humans or animals.
Ubiquitous	Present, appearing, or found everywhere.
Uncertainty factor	Mathematical adjustments for reasons of safety when knowledge is incomplete. For example, factors used in the calculation of doses that are not harmful (adverse) to people. These factors are applied to the lowest-observed-adverse-effect-level (LOAEL) or the no-observed-adverse-effect-level (NOAEL) to derive a minimal risk level (MRL). Uncertainty factors are used to account for variations in people's sensitivity, for differences between animals and humans, and for differences between a LOAEL and a NOAEL. Scientists use uncertainty factors when they have some, but not all, the information from animal or human studies to decide whether an exposure will cause harm to people [also sometimes called a safety factor].
WHO	World Health Organisation.