CAMELLIA PRECINCT

Contamination and Remediation Study - Stage 2

Submitted to:
New South Wales Department of Planning & Environment
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Sydney NSW 2000

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Golder Associates (1 electronic copy)
EXECUTIVE SUMMARY

The New South Wales Department of Planning & Environment (the Department) has partnered with Parramatta City Council (Council) to develop a Land Use and Infrastructure Strategy for the Camellia Precinct (the Precinct). The Precinct is bound by Parramatta River to the north and east, Duck River and the Western Motorway to the south and east, and James Ruse Drive to the west (refer Figure 1).

The Land Use and Infrastructure Strategy will identify appropriate land uses and built form for the Precinct as well as identify transport and infrastructure requirements to support future growth.

As a result of its long industrial history, contamination is a key issue for redevelopment of the Precinct. Significant areas of the Precinct are impacted by contaminants such as asbestos, hexavalent chromium and other hazardous substances. A number of properties in the Precinct are under some form of statutory contamination remediation management.

The Department engaged Golder Associates Pty Ltd (Golder) to undertake a study (the Study) comprising a high level assessment of contamination risks across the Precinct, having regard to the area’s previous and current industrial land use, identify the risks which may have a material impact on future land uses, and provide advice on remediation options and indicative costs which would support the Land Use and Infrastructure Strategy and more detailed Precinct planning. The Study builds on the information presented within the Preliminary Remediation Options Discussion Paper, Camellia Precinct, NSW, prepared by Golder for Parramatta City Council (Council) in 2012.

The Study is being undertaken in a staged manner. Stage 1 comprised a review of contamination risks across the Precinct, with the findings documented in report titled Camellia Precinct – Part 1 – High Level Contamination Review, Golder Associates Pty Ltd, 2015.

This report comprises Stage 2 and includes a more detailed analysis of contamination in selected areas of the Precinct and identification of potential remediation options and indicative cost estimates.

The scope of work for this Study comprised the following tasks:

- **Task 1:** Provision of general commentary on remediation options and the management of the medium and high risk sites (identified in Stage 1) within the Precinct, with reference to the Preliminary Remediation Options Discussion Paper, Camellia Precinct, NSW dated 25 June 2012 prepared by Golder for Council.

- **Task 2:** Provision of details of remediation options suitable for areas proposed to change to a more sensitive land use (refer Table E1), with a particular focus on five particular locations or land uses within the Precinct, which were selected in consultation with the Department and are listed in Table E2.

- **Task 3:** Provide broad costing estimates for the proposed remediation options for the contaminants present at the five locations/land uses identified in Table E2. These cost estimates will be used by the Department to inform the feasibility of the development on potentially contaminated sites.

- **Task 4:** Provide recommendations for a Precinct-specific Development Control Plan (DCP) or guideline to be applied by Council regarding the staging/timing of remediation and the ongoing management of potential conflicts.

A range of remediation options may be considered for the management of soil and groundwater contamination within the Precinct. The preferred option for each location would be selected taking into account site-specific environmental circumstances and proposed future land uses.

There are four areas within the Precinct where future land uses may change to a more sensitive category (refer Table E1).
CAMELLIA PRECINCT CONTAMINATION AND REMEDIATION
STUDY - STAGE 2

Table E1: Areas Where Permitted Land Use May Change to a More Sensitive Category

<table>
<thead>
<tr>
<th>Area No.</th>
<th>Current Permitted Land Use</th>
<th>Future Permitted Land Use</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Heavy Industrial Employment</td>
<td>Land between the Parramatta River and Duck River, east of Colquhoun Street and west of Durham Street. Land south of Unwin Street and north of Duck Creek/A’Becketts Creek.</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Business Development and Heavy Industrial Mixed Use / Residential</td>
<td>North-west part of Precinct</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Heavy Industrial Public Recreation</td>
<td>Southern foreshores of Parramatta River in north-west part of the Precinct and some adjoining industrial land</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Business Development and Private Recreation Mixed Use / Entertainment</td>
<td>Vicinity of Rose Hill Station, east of James Ruse Drive</td>
<td></td>
</tr>
</tbody>
</table>

The change in land use may trigger the requirement to assess and manage contamination risks at particular locations. The remediation options and broad costing estimates for five selected locations where the permitted land use may change to a more sensitive category are presented in Table E2. The locations include two sites subject to existing remediation action plans (181 James Ruse Drive and 1 Grand Avenue) where the extent of contamination and proposed remediation methods are defined in public documents. Due to lack of site-specific public information for other locations within the Precinct, three hypothetical scenario sites have been considered. Remediation cost estimates were developed for each of the five sites. The cost estimates are highly sensitive to the scenario-specific assumptions adopted regarding site environmental conditions, extent and characteristics of contamination and approach to remediation. These cost estimates provide a high-level indication of the potential costs which could, but need not necessarily, be incurred in remediating the site for redevelopment, subject to the scenario-specific assumptions.

Table E2: Sites Evaluated for Remediation Costs

<table>
<thead>
<tr>
<th>Number</th>
<th>Site</th>
<th>Remediation Cost Estimate ($AUD, excluding GST)¹</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lower Range</td>
</tr>
<tr>
<td>1</td>
<td>181 James Ruse Drive</td>
<td>$24,500,000 (Site and Foreshore Area)</td>
</tr>
<tr>
<td></td>
<td>A 6.1 hectare former asbestos-cement products manufacturing plant – high disturbance remediation proposed in Remediation Action Plan. Proposed remediation includes additional 0.2 hectare foreshore area.</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1 Grand Avenue</td>
<td>$2,900,000</td>
</tr>
<tr>
<td></td>
<td>A 7.8 hectare former asbestos-cement products manufacturing plant site – low disturbance remediation proposed in Remediation Action Plan</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Hypothetical Low Risk Site</td>
<td>$240,000</td>
</tr>
<tr>
<td></td>
<td>A hypothetical 3 hectare site comprising low risk land along the western boundary of the Precinct on higher ground with no known historical industrial activity.</td>
<td></td>
</tr>
</tbody>
</table>
### Hypothetical Low to Medium Risk Site
A hypothetical 3 hectare site in the southern part of the Precinct representing a low to medium risk site historically used for light to medium industrial activities.

<table>
<thead>
<tr>
<th>Number</th>
<th>Site</th>
<th>Remediation Cost Estimate ($AUD, excluding GST)¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td></td>
<td>Lower Range: $390,000 — Upper Range: $1,700,000</td>
</tr>
</tbody>
</table>

### Hypothetical Chromium-Contaminated Site
A hypothetical 5 hectare industrial site located in the north-eastern part of the Precinct which has been subject to landfilling and hexavalent chromium contamination in soil and groundwater which is migrating off-site. It is assumed that a 500 metre long length of the adjoining foreshore areas may be used for public open space.

| Site | Lower Range: $4,600,000 — Upper Range: $5,500,000 |
| Foreshore Areas | Lower Range: $2,000,000 — Upper Range: $2,400,000 |

¹ Note: Cost estimates have been rounded off to two significant figures or the nearest $0.5 million.

It is recommended that a Precinct-specific Development Control Plan (DCP) or guideline to be developed and used by Council include a statement requiring development proposals to have particular regard to the potential impact of the following Precinct-specific contamination risk factors during the construction and post-construction stages of development:

- Shallow groundwater environment.
- Low lying land within the 1:100 year average recurrence interval flood level.
- Acid sulphate soils.
- Fill materials of variable and unknown composition.
- Hexavalent chromium contamination in fill materials, soil, groundwater and stormwater, including the potential for hexavalent chromium to wick upwards through soil and fill materials into surface pavements and building structures.
- Asbestos wastes in soil and fill materials, including asbestos pulp.
- Hydrocarbon contamination in fill materials, soil and bedrock, soil vapour and groundwater.

In particular, these risks should be considered with respect to the design of in-ground structures and building services, structures at ground level and landscaping plans.
# Table of Contents

1.0 INTRODUCTION ........................................................................................................................................................ 1

2.0 OBJECTIVE ............................................................................................................................................................... 1

3.0 SCOPE OF WORKS .................................................................................................................................................. 1

4.0 METHODOLOGY ....................................................................................................................................................... 3

4.1 Task 1 - Remediation and Management Options for Medium and High Risk Sites ....................................... 3
4.2 Task 2 – Remediation and Management Options for Changes to a More Sensitive Land Use .................... 3
4.3 Task 3 – Costing of Preferred Remediation and/or Management Option ..................................................... 4
4.4 Task 4 – Precinct-Specific DCP or Guideline ................................................................................................  4

5.0 TASK 1 - REMEDIATION AND MANAGEMENT OPTIONS FOR MEDIUM AND HIGH RISK SITES .............. 5

5.1 Environmental Setting ................................................................................................................................... 5
5.2 Implications of Environmental Setting on Contamination Risk ...................................................................... 6
5.3 Land Use Impacts ......................................................................................................................................... 6
5.4 Contamination and Remediation Options ..................................................................................................... 7

5.4.1 Excavation .............................................................................................................................................. 8
5.4.2 Containment ............................................................................................................................................ 9
5.4.3 Immobilisation ......................................................................................................................................... 9
5.4.3.1 Geochemical Fixation / Stabilisation .................................................................................................... 9
5.4.3.2 Solidification ...................................................................................................................................... 10
5.4.3.3 Vitrification ......................................................................................................................................... 10
5.4.4 Pump and Treat .................................................................................................................................... 10
5.4.5 Chemical Treatment .................................................................................................................................... 11
5.4.6 Bioremediation .......................................................................................................................................... 11
5.4.7 Phytoremediation .................................................................................................................................. 12
5.4.8 Permeable Reactive Barrier .................................................................................................................. 13
5.4.9 Soil Vapour Extraction ........................................................................................................................... 13
5.4.10 Air Sparging / In-well Air Stripping ......................................................................................................... 13
5.4.11 Thermal Treatment ................................................................................................................................ 14
5.4.12 Soil Washing / Flushing / Solvent Extraction ......................................................................................... 14
5.4.13 Physical Separation ................................................................................................................................ 15
5.4.14 Monitored Natural Attenuation ............................................................................................................. 15
5.4.15 Emerging Technologies ........................................................................................................................ 15
5.4.15.1 Nanoremediation ............................................................................................................................... 15
5.4.15.2 Bioremediation ............................................................................................................................... 15
5.4.15.3 Electrokinetics ............................................................................................................................... 15
5.4.16 Remediation Options Summary ............................................................................................................ 16

6.0 TASKS 2 AND 3 - REMEDIATION AND MANAGEMENT OPTIONS AND COSTS FOR CHANGES TO A MORE SENSITIVE LAND USE ............................................................................................................................... 16
6.1 Proposed Changes in Land Use ................................................................................................................ 16
6.2 Preliminary Conceptual Site Models and Remediation and/or Management Options and Remediation Cost Estimates ...................................................................................................................... 18
6.3 181 James Ruse Drive, Camellia ............................................................................................................... 19
6.3.1 Previous Investigations ......................................................................................................................... 19
6.3.2 Site Description ..................................................................................................................................... 21
6.3.3 Site History ........................................................................................................................................... 23
6.3.4 Contamination, Exposure Pathways and Receptors .......................................................................... 24
6.3.5 Proposed Remediation and/or Management Options ....................................................................... 28
6.3.6 Site Condition Post Remediation ......................................................................................................... 31
6.3.6.1 Long Term Site Management ............................................................................................................ 31
6.3.6.2 Governance ...................................................................................................................................... 32
6.3.7 Remediation Cost Estimate ................................................................................................................... 32
6.4 1 Grand Avenue, Camellia .......................................................................................................................... 34
6.4.1 Previous Investigations .......................................................................................................................... 34
6.4.2 Site Description ..................................................................................................................................... 35
6.4.3 Site History .......................................................................................................................................... 35
6.4.4 Contamination, Exposure Pathways and Receptors ........................................................................ 36
6.4.5 Proposed Remediation and/or Management Options ....................................................................... 37
6.4.6 Site Condition Post Remediation ......................................................................................................... 39
6.4.7 Remediation Cost Estimate ................................................................................................................... 40
6.5 Low Risk Site in Western Part of Camellia Precinct .................................................................................. 40
6.5.1 Previous Investigations .......................................................................................................................... 41
6.5.2 Site Description ..................................................................................................................................... 41
6.5.3 Site History .......................................................................................................................................... 42
6.5.4 Contamination, Exposure Pathways and Receptors ........................................................................ 42
6.5.5 Potential Remediation and/or Management Options ......................................................................... 43
# CAMELLIA PRECINCT CONTAMINATION AND REMEDIATION STUDY - STAGE 2

## 6.5.6 Remediation Cost Estimate

## 6.6 Low to Medium Risk Site in South-Western Part of Camellia Precinct

### 6.6.1 Previous Investigations

### 6.6.2 Site Description

### 6.6.3 Site History

### 6.6.4 Contamination, Exposure Pathways and Receptors

### 6.6.5 Potential Remediation and/or Management Options

### 6.6.6 Remediation Cost Estimate

## 6.7 Chromium Impacted Industrial Land in Northern Part of Camellia Precinct

### 6.7.1 Previous Investigations

### 6.7.2 Site Description

### 6.7.3 Site History

### 6.7.4 Contamination, Exposure Pathways and Receptors

### 6.7.5 Potential Remediation and/or Management Options

### 6.7.6 Site Condition Post Remediation

#### 6.7.6.1 Employment Zone

#### 6.7.6.2 Public Recreation Zone

### 6.7.7 Proposed Remediation Scenario

### 6.7.8 Remediation Cost Estimate

#### 6.7.8.1 Industrial Site

#### 6.7.8.2 River Bank

## 7.0 TASK 4 - PRECINCT-SPECIFIC DCP OR GUIDELINE

## 8.0 REFERENCES

### 8.1 References Sighted by Golder

### 8.2 References Not Available for Review by Golder

## 9.0 IMPORTANT INFORMATION

### TABLES

- Table E1: Areas Where Permitted Land Use May Change to a More Sensitive Category
- Table E2: Sites Evaluated for Remediation Costs
- Table 1: Locations Evaluated for Remediation Costs
- Table 2: Summary of Proposed Changes to Land Use (Refer to Figure 2)
- Table 3: Site Characteristics - 181 James Ruse Drive
- Table 4: Areas of Contamination, Potential Exposure Pathways and Receptors – 181 James Ruse Drive
Table 5: Areas of Contamination and Proposed Remediation and/or Management Method – 181 James Ruse Drive

Table 6: Site Characteristics - 1 Grand Avenue

Table 7: Areas of Contamination, Exposure Pathways and Receptors – 1 Grand Avenue

Table 8: Areas of Contamination and Proposed Remediation and/or Management Method – 1 Grand Avenue

Table 9: Site Characteristics – Western Part of Camellia Precinct

Table 10: Areas of Contamination, Exposure Pathways and Receptors - Western Part of Camellia Precinct

Table 11: Remediation and/or Management Options - Western Part of Camellia Precinct

Table 12: Site Characteristics – South-Western Part of Camellia Precinct

Table 13: Areas of Contamination, Exposure Pathways and Receptors – South-Western Part of Camellia Precinct

Table 14: Remediation and/or Management Options - South-Western Part of Camellia Precinct

Table 15: Site Characteristics – North-Eastern Part of Camellia Precinct

Table 16: Areas of Contamination, Exposure Pathways and Receptors – North-Eastern part of Camellia Precinct

Table 17: Remediation and/or Management Options - North-Eastern part of Camellia Precinct

FIGURES

Figure 1 Study Area Locality Plan

Figure 2 Areas Where Land Uses May Change to a More Sensitive Category

Figure 3 Conceptual Site Model – East of Central Access Road, 181 James Ruse Drive

Figure 4 Conceptual Site Model – 1 Grand Avenue

Figure 5 Conceptual Site Model – Low Risk Site in Western Part of Camellia Precinct

Figure 6 Conceptual Site Model – Low to Medium Risk Site in South-Western Part of Camellia Precinct

Figure 7 Conceptual Site Model – Chromium-Impacted Land in Northern Part of Camellia Precinct

APPENDICES

Appendix A Important Information
1.0 INTRODUCTION

The New South Wales Department of Planning & Environment (the Department) has partnered with Parramatta City Council (Council) to develop a Land Use and Infrastructure Strategy for the Camellia Precinct (the Precinct). The Precinct is bound by the Parramatta River to the north and east, Duck River and the Western Motorway to the south and east, and James Ruse Drive to the west (refer Figure 1).

The Precinct is located within A Plan for Growing Sydney’s Greater Parramatta to Olympic Peninsula Priority Growth Area (NSW Department of Planning & Environment, December 2014).

The Land Use and Infrastructure Strategy will identify appropriate land uses and built form for the Precinct as well as identify transport and infrastructure requirements to support future growth.

As a result of its long industrial history, contamination is a key issue for redevelopment of the Precinct. Significant areas of the Precinct are impacted by contaminants such as asbestos, hexavalent chromium and other hazardous substances. A number of properties in the Precinct are under some form of statutory contamination remediation management.

The Department engaged Golder Associates Pty Ltd (Golder) to undertake a study (the Study) comprising a high level assessment of contamination risks across the Precinct, having regard to the area’s previous and current industrial land use, identify the risks which may have a material impact on future land uses, and provide advice on remediation options and indicative costs which would support the Land Use and Infrastructure Strategy and more detailed Precinct planning. The Study builds on the information presented within the Preliminary Remediation Options Discussion Paper, Camellia Precinct, NSW, prepared by Golder for Parramatta City Council (Council) in 2012.

The Study is being undertaken in a staged manner. Stage 1 comprised a review of contamination risks across the Precinct, with the findings documented in report titled Camellia Precinct – Part 1 – High Level Contamination Review, prepared by Golder for the Department in 2015.

This report comprises Stage 2 of the Study and includes a more detailed analysis of contamination in selected areas of the Precinct and identification of potential remediation options and indicative cost estimates.

2.0 OBJECTIVE

The objective of this Study is to provide guidance on the possible remediation options and associated indicative cost estimates for selected areas within the Precinct. The cost estimates are intended to assist in informing the Department about the feasibility of future land uses and development.

3.0 SCOPE OF WORKS

The scope of work for this Study comprised the following tasks:

- **Task 1:** Provision of general commentary on remediation options and the management of the medium and high risk sites (identified in Stage 1) within the Precinct, with reference to the Preliminary Remediation Options Discussion Paper, Camellia Precinct, NSW dated 25 June 2012 prepared by Golder for Council.

- **Task 2:** Provision of details of remediation options suitable for areas proposed to change to a more sensitive land use, with a particular focus on five particular locations or areas of the Precinct, which were selected in consultation with the Department and are listed in Table 1.

- **Task 3:** Provide broad costing estimates for the proposed remediation options for the contaminants present at the five locations identified in Table 1.

- **Task 4:** Provide recommendations for a Precinct-specific Development Control Plan (DCP) or guideline to be applied by Council regarding the staging/timing of remediation and the ongoing management of potential conflicts.
The locations considered in this Study, as listed in Table 1, were selected to represent a range of land uses, contamination scenarios and environmental settings across the Precinct. The land within the former Clyde Refinery site was specifically excluded from consideration in this Study as the strategic planning for this site is being addressed specifically by the current site owner.

Two locations of interest (181 James Ruse Drive and 1 Grand Avenue) are subject to publically available information, including approved Remediation Action Plans and were able to be assessed specifically. Other areas of interest throughout the Precinct are not subject to a similar level of publically available information. In order to be able to provide guidance on contamination risks for a variety of land uses throughout the Precinct, three hypothetical scenario sites were evaluated, based on public information on environmental characteristics and the types of land uses and contamination conditions which may be present.

Table 1 identifies the current and proposed land use for each location, reflecting the potential changes in land use. Golder understands that the 'Mixed Use / Residential' land use category may include high density, multi-storey residential accommodation and that the 'Mixed Use / Entertainment' land use category may include multi-storey tourism/business accommodation.

### Table 1: Locations Evaluated for Remediation Costs

<table>
<thead>
<tr>
<th>Number</th>
<th>Site</th>
<th>Current Land Use</th>
<th>Proposed Land Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>181 James Ruse Drive</td>
<td>Former James Hardie asbestos-cement products manufacturing plant – high disturbance remediation proposed. Site area evaluated also includes the Foreshore Area.</td>
<td>B5 – Business Development</td>
</tr>
<tr>
<td>2</td>
<td>1 Grand Avenue</td>
<td>Former James Hardie asbestos-cement products manufacturing plant – low disturbance remediation proposed</td>
<td>IN3 – Heavy industrial</td>
</tr>
<tr>
<td>3</td>
<td>Hypothetical Low Risk Site (Western Part of the Precinct)</td>
<td>Site in the western part of the Precinct on higher ground with no known historical industrial activity, representing low risk land use.</td>
<td>B5 – Business Development RE2 – Private Recreation</td>
</tr>
<tr>
<td>4</td>
<td>Hypothetical Low to Medium Risk Site (South-Western Part of the Precinct)</td>
<td>Site in the southern part of the Precinct historically used for light to medium industrial activities, representing a low to medium risk land use.</td>
<td>IN3 – Heavy industrial IN1 – General Industrial</td>
</tr>
<tr>
<td>5</td>
<td>Hypothetical Chromium-Contaminated Site (North-East Part of the Precinct)</td>
<td>Site located in the north-east part of the Precinct which has been subject to industrial activities and landfiling, including hexavalent chromium contamination in soil and groundwater which is migrating off-site. It is assumed that part of the adjoining foreshore areas may be used for public open space.</td>
<td>IN3 – Heavy Industrial</td>
</tr>
</tbody>
</table>

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1 Remediation approvals cite the intrinsic link between the site and the foreshore area and the requirement to complete a program of combined remediation such that future development aspirations can proceed.
4.0 METHODOLOGY

The methodology for each Task identified in Section 3.0 is outlined in the following sections.

4.1 Task 1- Remediation and Management Options for Medium and High Risk Sites

The majority of the land area and properties in the Precinct were assessed during Stage 1 of the Study as having a medium or high risk of being contaminated to some extent. Remediation and/or management options may be required to enable some of the properties to be redeveloped.

This task comprised a high level overview of the potential remediation and management options for medium and high risk sites in the Precinct, via the following sub-tasks:

- Preparation of a broad description of the environmental setting and type of contaminants potentially present at the Medium and High Risk Sites within the Precinct.
- Conducting a high level, conceptual review of the contamination remediation and management options which may be suitable for the Medium and High Risk Sites, with reference to the Preliminary Remediation Options Discussion Paper, Camellia Precinct, NSW (dated 25 June 2012 prepared by Golder for Council).

4.2 Task 2 – Remediation and Management Options for Changes to a More Sensitive Land Use

The application of remediation options to particular localities within the Precinct will vary depending upon particular contamination risks, environmental conditions and potential future land uses. A consideration of remediation requirements and options for representative parts of the Precinct was undertaken, with a particular focus on areas where future permissible land use was proposed to change to more sensitive uses.

This task involved the following sub-tasks:

- Identification of the areas of the Precinct where the permitted land use under the Draft Land Use and Infrastructure Strategy would be more sensitive than land uses permitted under the current Parramatta Local Environmental Plan 2011(Parramatta City Council, 2011), such as a change from Heavy Industrial (IN3) to Employment or Mixed Use / Residential, or a change from Business Development to Mixed Use / Residential.
- For each of the five locations listed in Table 1 the available information on contamination was reviewed and the site-specific environmental conditions, and specific type, extent and degree of contamination were identified. This information was compiled into a high-level preliminary Conceptual Site Model for each location. It is noted that the amount of site-specific contaminant information available for the five locations varied from extensive to minimal. For the hypothetical sites an ‘indicative scenario’ of environmental and contamination conditions was created to enable consideration of sites reflecting the likely range of conditions across the Precinct. These hypothetical sites should not be considered to represent any particular specific site within the Precinct.
- For each of the five locations listed in Table 1 the remediation and/or management options for the site-specific contamination condition were identified and a preferred remediation and/or management option was selected. This selection process was based on the Conceptual Site Model prepared for each location and the evaluation of the remediation/management options in Task 1. The scope of the remediation options did not extend to remediation of sediments in the local waterways such as the Parramatta River or Duck River as these waterways are located outside of the Precinct boundary and were considered to be beyond the scope of the Study.
4.3 Task 3 – Costing of Preferred Remediation and/or Management Option

Based on the outcome from Task 2, high level cost estimates of the selected remediation and/or management options were developed for each of the five locations listed in Table 1. The methodology and detail of the costing of the preferred remediation and/or management option was driven by the objective of using the costs to inform the overall feasibility of the development on potentially contaminated sites. Task 3 was designed to provide information as to whether the preferred remediation and/or management option is likely to be cost prohibitive or not. It was not proposed to develop costings to a level of detail which could be used for detailed design or remediation works tendering purposes.

The cost estimates were based on broad assumptions taking into account the Conceptual Site Model, selected remediation / management methodology and general, current market, unit rates for undertaking such works. Indicative timeframes were identified for the preferred remediation options. Two of the sites considered (181 James Ruse Drive and 1 Grand Avenue) are subject to Remediation Action Plans prepared by others in consultation with the land owners and various stakeholders including the NSW Environment Protection Authority. For these two sites Golder prepared cost estimates based on the remediation approach documented in the Remediation Action Plans. For the hypothetical locations Golder prepared cost estimates based on the remediation approach developed by Golder for that particular location. The cost estimates for the hypothetical locations are intended to provide an indication of remediation costs for the defined scenarios and should not be considered to apply to an actual site.

The cost estimates are based on a number of assumptions, including the following:

- The remediation of the site would be undertaken as a single exercise over a defined time period in the near future. Should remediation occur in sub-parcels and/or over a longer period of time, the costs may increase.
- Costs for demolition and/or removal of any above ground structures, hazardous building materials, plant, equipment or other materials are not included.
- Project management costs by third parties other than the environmental consultant and remediation contractor are not included.
- Legal, planning and financing costs are not included.
- The remediation cost estimates provided are based on current market conditions and are exclusive of GST. The actual costs to remediate the identified impacted areas may vary significantly from those presented herein due to the following:
  - Market conditions at the time of remediation works.
  - The final waste classification of excavated material to be disposed of from site if any and the availability of suitability licensed receiving treatment and/or disposal sites.
  - Final extent of excavation works.
  - The availability of backfill materials at the time of the works.
  - Methodologies and procedures implemented by the civil contractor during site works.

4.4 Task 4 – Precinct-Specific DCP or Guideline

Task 4 comprised the preparation of recommendations for matters to be included in a Precinct-specific Development Control Plan (DCP) or guideline to be developed by the Department or Council and applied by Council regarding the staging/timing of remediation and the ongoing management of potential conflicts.
5.0 TASK 1 - REMEDIATION AND MANAGEMENT OPTIONS FOR MEDIUM AND HIGH RISK SITES

5.1 Environmental Setting

The Precinct can be defined as a peninsula of land bounded by Parramatta River to the north, Duck River to the east, Parramatta Road to the south and James Ruse Drive to the west (refer Figure 1). It consists of the suburbs of Camellia and parts of Rosehill, Granville & Clyde.

With the arrival of the first colonial settlers, the land was cleared for rural activities. Subsequently Camellia evolved into a significant industrial precinct.

The Precinct comprises low lying land sloping from a high point of approximately 12 m Australian Height Datum (m AHD) adjacent to Rosehill Railway Station, falling to approximately 7 m AHD at Rosehill Gardens Racecourse and to approximately 3 metres AHD in the east near the confluence of the Parramatta and Duck Rivers.

The Precinct drains naturally to the Parramatta River and the Duck River. The south-west corner of the Precinct is also drained by Duck Creek, a tributary of Duck River, and a small section of A’Becketts Creek which drains into Duck Creek.

Flood risk mapping (1:100 year recurrence interval) provided by Council indicates that large parts of the eastern, southern and north-western areas of the Precinct are at risk of flooding.

The soil in the vicinity of Rosehill Railway Station, the highest natural part of the Precinct, is mapped as the Glenorie soil landscape, comprising Yellow Podzolic Soils subject to high soil erosion hazard, and localised impermeable high plastic subsoil. However, these soils are likely to have been modified by development in the area.

Early land maps of the area indicate in the south eastern portion the presence of “salt marsh”. A review of the Prospect/Parramatta River Acid Sulfate Soil (ASS) Risk Map (Edition 2, Department of Land and Water Conservation, 1997) indicates that the area today is underlain by ‘Disturbed Terrain’ which may include areas filled to reclaim low lying swamps. Soil Conservation maps indicate generally extensively disturbed terrain, including “complete disturbance, removal or burial of soil.”

The Sydney 9130 100:000 Scale Geological Sheet (NSW Department of Mineral Resources, 1983) maps the eastern third of the Precinct as comprising man-made fill – dredged estuarine sand and mud, demolition rubble, industrial and household waste.

No maps of the extent of landfilling have been sighted beyond those of the 1:100,000 scale geology and soil maps referred to above. The fill was placed to increase the level of the land in the lower areas adjoining the Parramatta River, Duck River and Duck Creek. Hence the depth of fill is considered likely to be greatest in the northern, southern and eastern margins of the Precinct.

The fill overlies Tertiary (Miocene) estuarine (tidal) sediments of sand, clay and peat, with extensive ferruginous mottles. The clay is thought to be an estuarine silt or mud which was overlain by a laterite horizon and subsequently altered to a plastic, grey, clay with extensive ferruginous mottles.

The extent of Acid Sulphate Soils in the Precinct has been mapped by Council as part of the Parramatta Local Environmental Plan 2011 (LEP). The provisions of Clause 6.1 of the LEP would trigger the need for development consent and preparation of an Acid Sulphate Soils Management Plan for development across the majority of the Precinct depending upon the depth of works below ground surface and/or the depth of lowering of the groundwater table.

The geology of the western third of the Precinct is mapped as comprising fluvial (river flow), Quaternary, silty to peaty quartz sand, silt, and clay, with ferruginous and humic cementation in places and common shell layers. The Quaternary deposits include basal Pleistocene (early-mid Quaternary) deposits of stiff clay and sandy clay with minor sand, shell, and peat layers in many areas. The eroded surface of the Pleistocene
sediments is commonly deeply weathered; the uppermost clays are leached, iron stained, and mottled white, red, and light grey.

The Tertiary and Quaternary sediments are underlain by Ashfield Shale (black to dark-grey shale and laminite deposited in a prodelta to delta environment) of the Middle Triassic Wianamatta Group.

The Ashfield Shale is underlain by the fluvial (river flow) deposited Hawkesbury Sandstone (medium to coarse-grained lithic sandstone). The top of the Hawkesbury Sandstone is mapped as sloping across the Precinct downwards from a depth of approximately 5 metres below mean seal level in the north to a depth of approximately 40 metres below mean sea level in the south.

In summary, the underlying geology comprises fill material, sediments, and residual clays overlying bedrock.

Groundwater is present within the Quaternary sediments and has been encountered at depths between 0.8 metres and 4.5 metres below ground level (for example along Grand Avenue by Douglas Partners, April 2013 and GW Engineers, December 2010).

The presence of groundwater in the bedrock of the Precinct will be influenced by the geology, which may be summarised as follows (D R Woolley, NSW Water Resources Commission, in the Geology of the Sydney 1:100,000 Sheet 9130, Geological Survey of New South Wales, Department of Mineral Resources, 1980):

- Wianamatta Group Ashfield Shale generally yields saline water which is also hard. The water is generally too saline even for stock watering and there are not many bores in the Wianamatta Group within the Sydney area.

- Hawkesbury Sandstone – water is generally of good quality ranging in salinity from 200 to 840 mg/L total salts. Water bearing zones are encountered mostly at depths of 10 metres to 50 metres below ground surface. Low yields generally limit use to domestic and small scale stock requirements which are not applicable to the Precinct.

It is noted that the Precinct is located in an area serviced by reticulated potable water supply as well as an industrial water recycling plant. There are no known users of groundwater in the Precinct. Given the high salinity and/or low yield of groundwater, it is considered unlikely that attempts to use groundwater for industrial purposes would be successful.

5.2 Implications of Environmental Setting on Contamination Risk

The environment of the Precinct is characterised by low gradients; fill material; sediments varying between sand, clays and laterites; overlying relatively impermeable shale and sandstone bedrock. The fill material and more permeable sediments, with shallow groundwater, create an environment where contaminants may infiltrate the ground and then migrate downwards and laterally through the more permeable zones. The fill material which has been placed across the historically lower areas of the Precinct presents a potential source of contamination. The presence of potential acid sulphate soils would require management during excavation works to prevent generation of acid forming conditions.

The waters of the Parramatta River, Duck River, Duck Creek and A’Becketts Creek represent potential receptors for contamination migrating through soil erosion, stormwater and groundwater. Subsurface infrastructure, such as utilities and stormwater drainage pipes may provide preferential pathways facilitating migration of contaminants in the shallow sub-surface environment towards the waterways.

5.3 Land Use Impacts

The Precinct was home to an oil refinery from 1908 to 2014, with Shell purchasing the site in 1928. The site continues to function as a fuel storage terminal (Clyde Terminal) owned and operated by Viva Energy Australia Pty Ltd.

James Hardie companies also operated in Camellia from the 1920’s, however the Precinct has also been home to a number of other industries manufacturing and using a large number of chemicals, including chromium, paints, solvents, plastics and pesticides.
Filling of the area is believed to have commenced from the earliest industrial occupation. Fill has included industrial wastes such as asbestos (off-cuts of bonded asbestos products and friable pulp), and chrome ore processing residues. Areas and details of waste filling are largely undocumented, with anecdotal information suggesting fill depths are highly variable (including deep fill in areas), but in most instances covered by pavements and/or soil.

Several properties on the north-eastern side of the peninsula are contaminated with hexavalent chromium (Cr(VI)), and contaminated groundwater is migrating to the Parramatta River. Along the foreshore of the river chromium contamination is evident in groundwater seeps and drainage from stormwater pipes. Research by the University of Sydney identified the chromium concentrations in sediment of the upper Parramatta River are enriched compared to other locations in Sydney Harbour.

The Clyde Terminal land is likely to have been impacted by petroleum products, although it is understood not generally at levels exceeding industrial/commercial land use acceptance criteria.

The most significant contaminants identified as impacting the Precinct are considered to be:

- Asbestos.
- Chemicals related to petroleum based products, in particular:
  - Petroleum hydrocarbons (measured as Total Recoverable Hydrocarbons – TRH);
  - Benzene, toluene, ethylbenzene and xylenes (BTEX); and
  - Polycyclic aromatic hydrocarbons (PAHs).
- Metals including but not limited to arsenic, cadmium, chromium (trivalent and hexavalent), copper, lead, mercury, nickel and zinc.
- Volatile chlorinated hydrocarbons (VCHs) (carbon tetrachloride, chloroform, dichlorodifluoromethane and trichlorofluoromethane are known to be present).

In summary, a wide variety of contaminants of potential concern are understood to have been identified to co-exist in fill, shallow soil and groundwater at the Precinct:

- Asbestos is likely to be ubiquitous in fill and shallow soil, especially throughout the central and western area of the Precinct.
- Chromium is likely to be ubiquitous in fill, shallow soil and groundwater, especially in the central and northern area of the Precinct.
- VCHs are associated with chromium contamination in the central portion of the Precinct.
- Petroleum hydrocarbons (i.e. TRH, which may contain PAHs and BTEX) are likely to be present at the Clyde Terminal property and, along with metals, possibly in other areas of the Precinct.

5.4 Contamination and Remediation Options

With reference to the Preliminary Remediation Options Discussion Paper, Camellia Precinct, NSW dated 25 June 2012 prepared by Golder for Council, the following general summary of the available contamination remediation and management options, which may be suitable for the Medium and High Risk Sites, is provided. This summary is high level and conceptual based on the information available for the Precinct and does not include selection of specific remediation/management options for particular sites.
Several categories of technologies exist for the remediation of identified soil and water contaminants in the Precinct. These include:

- Isolation;
- Immobilisation;
- Toxicity reduction;
- Degradation or destruction;
- Physical separation; and
- Removal (excavation or extraction).

Remediation options can also be categorised into remediation methods which:

- Can be applied to remediate contaminants in soil, groundwater, or both soil and groundwater. It is also noted that stormwater at many sites within the Precinct is impacted by site contaminants, however, for the purposes of this summary it is assumed that addressing contamination issues in soil and groundwater will address this issue;
- Are applied in the ground (in situ) or out of the ground (ex situ);
- Are suitable for specific contaminants or a range of contaminants;
- Either:
  - Removes (or degrades) contaminants from the site; or
  - Does not remove contaminants from the site, but results in either transformation of the contaminants so they are less mobile or harmful, or isolation of contaminants to control exposure to humans or the environment.

The following is a description of remediation technologies potentially applicable at the Medium and High Risk Sites located within the Precinct.

### 5.4.1 Excavation

Excavation comprises digging up contaminated soil so that it can be disposed of in an appropriate engineered landfill (on-site or off-site) or treated and reused at site. Excavation is effective in removing/isolating contaminants from the site but is limited by accessibility, typically large volume of waste generated and the need to manage the excavated materials. Excavation can be physically limited by the practicable limit of excavation.

Excavated materials can be managed as follows:

- **On-site treatment** of excavated materials is the preferred option of the NSW Environment Protection Authority (EPA) subject to the availability of a suitable technology as it presents an opportunity to incorporate sustainability concepts and principles through minimisation of disposal to land fill and beneficial reuse of treated soils. On-site treatment methods (see description of technologies below) are proven and commercially available for identified contaminants including metals and hydrocarbons. However, treatment of asbestos containing materials is not likely achievable. Thus, it is most likely that excavated materials containing asbestos would be required to be disposed of at an engineered landfill or contained on site.
Off-site treatment options for hydrocarbon contaminants are proven and commercially available in Australia but only at one location in NSW. There are interstate thermal treatment facilities that may be suited to treatment of organic contaminants, but the transport effort to these facilities would be prohibitive.

On-site disposal of excavated materials at a containment cell designed to manage the waste.

Off-site disposal of excavated materials at an engineered landfill designed to manage the waste. This would not satisfy the current NSW Government objective of waste avoidance and resource recovery. It is also noted that there is currently an upward pressure on disposal costs. However, if on-site treatment or disposal of excavated soils is not feasible then off-site disposal may be the option most effective, least restricted by access constraints and would result in least disruption to future land use.

In summary, given the large extent of remediation potentially required within the Precinct, it is likely that significant volumes of materials would require excavation to reduce contamination risks to acceptable levels. It is most likely that excavated materials containing asbestos would be required to be disposed of at an engineered landfill. This landfill could either be at an appropriate off-site facility or at a containment cell constructed at Camellia. Ongoing management of an on-site containment cell(s) would be required.

5.4.2 Containment

Containment technologies attempt to prevent the movement of contaminants by isolating them within an area. Containment technologies including capping and subsurface barriers that are used to prevent exposure to site users and further contamination of groundwater when other treatment options are not physically or economically feasible for a site.

Capping systems are typically a constructed barrier at the ground surface to:

- Prevent contact with contaminated soils;
- Reduce surface water infiltration to contaminated soil for prevention of further groundwater contamination;
- Control vapour emissions from the soils; and
- Improve aesthetics and provide a suitable surface for ongoing land use.

Caps are typically constructed of layers of soil, clay, drainage materials and impermeable geomembranes. Depending of the intended land use they may also be concrete.

Subsurface barrier technology involves the installation of an engineered impermeable barrier wall (such as a slurry wall, a grout curtain or a sheet pile wall) around the contaminated material. This prevents groundwater from migrating through a contaminated area and prevents further impacts to non-contaminated areas. Subsurface barriers are commonly used in conjunction with surface caps to isolate a contaminated area.

Caps are potentially suitable to manage risks associated with all identified contaminants within the Precinct, though additional consideration would be required for control of vapours from some organic contaminants such as BTEX and volatile chlorinated hydrocarbons. Subsurface barriers are potentially suitable to manage risks associated with all identified contaminants and are mainly dependent on the subsurface conditions.

Caps and subsurface barriers are well developed technologies, commonly used throughout Australia and globally, and are relatively inexpensive for large sites.

Caps can be used to control risks to humans and the environment, and subsurface barriers prevent the spread of contamination in the subsurface, but these technologies do not result in removal of the contaminants. Ongoing management of the cap/barrier and residual contamination is required, which must be considered in land use planning.
The main issues for application within the Precinct will include accessibility, ongoing management and acceptance by regulators and community.

5.4.3 Immobilisation

5.4.3.1 Geochemical Fixation / Stabilisation

Geochemical fixation and stabilisation is the addition of chemicals or materials that bind or convert the contaminants into a form that is less mobile or less harmful to human health or the environment. It is a developed and commercially available technology, though it is applied more commonly to metals and recalcitrant organic contaminants than readily degraded organic compounds for which there are other remediation options. The physical nature and handling characteristics of the waste are not necessarily changed by fixation/stabilisation.

Geochemical fixation is a well-developed technique used to treat hexavalent chromium (Cr(VI)) by adding chemicals that either directly or indirectly reduce Cr(VI) in groundwater and contaminated soil to Cr(III) which is less toxic, relatively insoluble and is fixed onto aquifer solids under typical conditions. Typical reagents include naturally occurring reducing agents such as ferrous iron, zero valent iron, sulphur, organic matter and calcium polysulphide. Microbes in the subsurface can also reduce Cr(VI).

Fixation can also be used to treat arsenic and other metals, though typically oxidising conditions are necessary, which may not be compatible with fixation of hexavalent chromium (which requires reducing conditions).

Fixation/stabilisation is either applied by mixing reagents with excavated contaminated materials or mixing or injection of liquid reagents into the ground. Methods are available for immobilisation of most identified inorganic contaminants, though it is less effective for Cr(VI), arsenic, mercury (if present) and is not suitable for asbestos and volatile hydrocarbons. Immobilisation methods may not be compatible and there is unlikely to be a single method that is suitable for all contaminants. Stabilisation can be relatively inexpensive to perform on excavated materials and in the ground, though this is highly dependent on the subsurface conditions (i.e. the ability to get the reagents into the ground in the desired locations).

The main issues for application within the Precinct will include accessibility, ability to achieve effective treatment in the ground, uncertainty of durability of treated materials and uncertainty whether effective treatment of areas impacted by multiple contaminants can be achieved.

5.4.3.2 Solidification

Solidification is the addition of binders or materials to physically change the structure of a waste so that contaminants are immobilised within the waste, usually in a ‘solid block’. Contaminants are not removed or destroyed. Solidification usually occurs in conjunction with stabilisation.

5.4.3.3 Vitrification

Vitrification is a high temperature process designed to immobilise contaminants by incorporating them into a vitrified matrix (i.e. ‘melts’ the contaminated soil) formed in the process which is durable and leach resistant. Vitrification can be applied to excavated materials and in the subsurface by passing electric current through the impacted materials. Due to the associated significant energy use and high cost, vitrification is generally more suited to small sites or heavily contaminated sites with no other remediation alternatives.

Vitrification can be applied to most soils and most identified contaminants. Inorganic contaminants would not be removed. Petroleum hydrocarbons, other organic compounds and mercury (if present) would be removed via volatilisation (i.e. turned into vapour) or degradation. However, control and treatment of vapours produced would be required.

The main issues for application within the Precinct will include accessibility, high cost, high energy use, vapour issues during remediation, and durability of vitrified materials. Asbestos, Cr(VI), arsenic and other metals would not be removed, though organic contaminants would be degraded or destroyed.
5.4.4 Pump and Treat

‘Pump and treat’ is a developed and commercially available method for cleaning up polluted groundwater. It can also be used for containment of contaminated groundwater. Pump and treat can also clean up contaminated soils in the saturated zone, though it is an inefficient method to do so. Contaminated groundwater is extracted (pumped) to the surface where it can be treated. Pump and treat is most often used when other remediation methods are not feasible, as an interim remediation measure or a method of preventing migrating of contaminated groundwater. A treatment plant is required to treat extracted water.

‘Multi-phase’ extraction is a combination of pump and treat and soil vapour extraction whereby contaminated groundwater, vapours in the ground and liquid chemicals still present in the ground are pumped to the surface for treatment. This technology is commonly used for organic contaminants in areas where significant leaks/spill of petroleum products or chlorinated hydrocarbons have occurred.

A groundwater extraction system may include numerous pumps configured so that contaminated groundwater will not flow from a site (e.g. at the downgradient site boundary – towards the Parramatta River) or to reduce the mass of a contaminant in the ground (i.e. pumping from the ‘source’ area). Systems are relatively flexible in terms of accessibility, though an area of land and utility connections are required for the treatment plant.

Pump and treat is applicable to all contaminants in groundwater and results in removal of contaminants from the subsurface. It is not suitable for asbestos and contaminants in the ground above the groundwater table (unsaturated zone). It is less effective at cleaning up contaminant sources and contaminants bound to aquifer materials, in which case it often has to be operated for extended periods (often years or decades) if the source is still present. Pump and treat has been used at some sites in the Precinct to reduce migration of contaminated groundwater, but will likely have to operate for an extended period before actual clean-up of the site occurs.

5.4.5 Chemical Treatment

Chemical treatment involves the addition of chemical reagents into the ground or to excavated soil to degrade/transform contaminants to harmless products. Although the chemical reagents treat the contaminants in groundwater, it also treats soils. Commonly a contaminant ‘rebound’ effect occurs, which means that several reagent applications are required.

Categories of chemical treatment include:

- Chemical oxidation – oxidants, such as oxygen, peroxide, persulphate, permanganate and chlorine compounds, destroy many types of organic compounds including chlorinated hydrocarbons, petroleum hydrocarbons, BTEX and PAHs. Oxidation of metals to transform them to an immobile form is also possible; and

- Chemical reduction – reductants, such as calcium polysulphide, ferrous sulphate and zero valent iron, can be used to reduce Cr(VI) to Cr(III).

Chemical treatment is not suitable for asbestos and some heavy-end recalcitrant hydrocarbons.

Chemical oxidation of organic contaminants is a developed and commercially available technology. Chemical reduction of chromium is also a commonly used technology. Processes are rapid and robust, however, the main issues with this technology are potential geological constraints which mean it may be difficult to get chemicals into the ground in the desired areas, and changes to ground structure. Chemical treatment is most applicable to contaminants in the saturated zone.

A chemical treatment system may incorporate a series of injection wells or points for addition of reagents. Although the treatment process is rapid, typically a minimum of three applications are required. Chemical treatment is most efficient when applied to the contaminant source area, but can be used to treat a groundwater plume. Systems are relatively flexible in terms of accessibility, requiring minimal space.
Chemical oxidation may potentially be effective for treatment of organic contaminants, while chemical reduction may be effective for treatment of chromium. Due to the different treatment mechanisms application to multi-contaminant groundwater plumes would be difficult in parts of the Precinct. Although the treatment process is rapid and robust, consideration would need to be given to ‘rebound’ of contaminants, potential changes to ground conditions and handling of the chemicals.

5.4.6 Bioremediation

Bioremediation is the use of certain microbes (bacteria, fungi and archaea) to either directly degrade or consume a contaminant, or change the ground conditions to reduce the mobility or form of a contaminant. Thus, bioremediation can result in removal of contamination from a site or change it to a less harmful form. Typically, reagents or conditions are changed to optimise conditions for biological growth and remediation of contaminants. This may include addition of food (e.g. carbohydrates), nutrients, or other essential compounds (called electron donors or electron acceptors).

Bioremediation is a well proven technology for many volatile organic hydrocarbons, but is less well developed for heavy end organics and metals. Bioremediation is generally inexpensive relative to more active methods, but can be slow and generally needs significant work to show ‘proof of concept’. While when first developed bioremediation was thought to be best suited to treating low levels of contamination, it is now recognised that in many cases (e.g. for organic compounds) bioremediation is best suited to treatment of high levels of contamination.

Bioremediation can potentially be used for the following Precinct contaminants:

- Hexavalent chromium can be treated by addition of organic matter (such as molasses) into the ground so that reducing conditions are created and Cr(VI) is transformed to Cr(III);
- Chlorinated hydrocarbons and some heavy-end petroleum hydrocarbons and PAHs will degrade under similar conditions;
- BTEX and light-end petroleum hydrocarbons under certain conditions (generally when there is oxygen in the groundwater); and
- Bioremediation of other metals is possible but less common.

Bioremediation of soils typically involves either land farming of soils or construction of soil biopiles with the addition of nutrients and/or oxidising chemicals to assist in the breakdown of contaminants. Land farming usually involves excavating, stockpiling, turning and mixing soils. This process is limited where there is a presence of asbestos. Bioremediation using constructed biopiles can either be passive or active. Contaminated soils are placed in above ground stockpiles and slotted pipes are run through the pile, which is covered with a plastic membrane. Passive systems rely on natural convective currents to circulate air though the pile, active systems involve air being driven through the system. In the active system the air may also be heated. Biopiles are more suited to treatment of hydrocarbon impacted soils cross contaminated with asbestos as there less potential for fibre release as it is a covered system.

A groundwater bioremediation system may incorporate a series of injection wells or a Permeable Reactive Barrier (Section 5.4.8) for addition of reagents. Some systems may also incorporate groundwater pumping to speed up the remediation process. Application can either be to target contaminant source areas or to treat a groundwater plume. Systems are relatively flexible in terms of accessibility, requiring minimal space.

Bioremediation may potentially be effective for treatment of light-end organic contaminants, chlorinated hydrocarbons and chromium. At the Precinct it is probably most suited to the treatment of light-end organic contaminants in soils. Due to the different conditions required for the various contaminants, application of bioremediation to multi-contaminant groundwater plumes would be difficult in parts of the Precinct. The potentially long time frame and need to show ‘proof of concept’ of remediation must be considered in land use planning.
5.4.7 Phytoremediation
Phytoremediation involves the use of plants to remove, degrade, contain, or take up contaminants in shallow soils and sediments. Some deep-rooted plants (including some eucalypts) can be used to take up groundwater to provide hydraulic control of a groundwater plume in a similar method to pump and treat. The plants may also help with erosion control and controlling rainfall runoff.

Application of phytoremediation at the Precinct could potentially be used in conjunction with other remediation technologies as a passive, sustainable low cost method of managing low-level residual contamination in shallow soils.

5.4.8 Permeable Reactive Barrier
Permeable Reactive Barriers (PRBs) are a permeable wall (i.e. allows groundwater to flow through it easily) in the ground designed to intercept and treat contaminated groundwater as it flows passively through the wall. Reactive materials in the wall either trap contaminants or transform them to a less harmful form. Clean groundwater flows out the other side of the wall. They differ to subsurface barriers (Section 5.4.2) in that PRBs are designed to allow groundwater flow through them rather than prevent flow.

Common reactive materials include organic materials, a type of scrap iron (called ‘zero valent iron’), limestone and many other natural minerals. Zero valent iron is used as a reactive material in PRBs to treat hexavalent chromium and chlorinated hydrocarbons under similar (reducing) conditions, and will also treat arsenic and other metals but only under different (oxidising) conditions. Organic materials can be used to bind organic contaminants or promote bioremediation (see Section 5.4.6).

PRBs are installed downgradient of a source zone as either a ‘funnel and gate’ or ‘continuous trench’ system. They can be installed by trenching, a common construction technique, if the contaminated groundwater is shallow (as is inferred to be the case at The Precinct) and surface improvements do not interfere with access. PRBs at the Precinct could potentially be used to prevent the spread of contaminants in groundwater from a site towards the Parramatta River.

PRBs could potentially be used to treat most identified contaminants in groundwater, but is an inefficient method of cleaning up a source area and will be ineffective for contamination in the unsaturated zone and asbestos. Although there are some synergies in PRB types (e.g. potentially a zero valent iron barrier to treat chromium and chlorinated hydrocarbons), application of this technology at Camellia would likely require a ‘sequential PRB’ due to the different treatment mechanisms required.

5.4.9 Soil Vapour Extraction
Soil Vapour Extraction (SVE) removes contaminants, in the form of vapours, from the soil above the groundwater table (i.e. the unsaturated zone). Vapours are the gases that form when volatile organic contaminants or mercury evaporate. The vapours are removed from the ground by applying a vacuum to extraction wells in the ground to pull the vapours out for treatment. SVE is a developed and commercially available technology for volatile organic contaminants.

SVE systems typically are operated for medium duration (of the order of a year), though this can vary significantly depending on the contaminant and soil conditions, and may require several treatment ‘cycles’. SVE is often used in conjunction with thermal treatment (Section 5.4.11), air sparging (Section 5.4.10) and multi-phase extraction (Section 5.4.4) to improve treatment time and efficiency.

An SVE system would comprise of an array of vacuum wells to extract soil vapours, a cap to seal the ground surface and a vapour treatment system. SVE is applicable to volatile organic compounds (e.g. BTEX, light-end petroleum hydrocarbons, light-end PAHs and many chlorinated hydrocarbons) and mercury (to a lesser extent). SVE is not suitable for treatment of heavy-end organic compounds, chromium, metals or asbestos.

This option would be limited for application within the Precinct by site access restrictions, need for a vapour treatment system and subsequent regulatory approvals.
5.4.10 Air Sparging / In-well Air Stripping

Air sparging uses air to help remove vapours from contaminated soil and groundwater below the water table. The air helps volatilise certain contaminants, which can then be removed using SVE (Section 5.4.9). Air is pumped underground using air sparging wells, with air and vapours extracted using an SVE system. SVE and air sparging are often used at the same time to clean up both soil and groundwater.

In-well air stripping is a type of air sparging that helps volatilise certain contaminants in groundwater within a well.

5.4.11 Thermal Treatment

Thermal remediation methods work by heating contaminated soil and groundwater. The heat can destroy or volatilise (turn into a gas) some types of contaminants, or can help mobilise compounds in the ground so that they can be then be removed by collection wells for treatment. Thermal methods are generally expensive as they have significant energy requirements and produce secondary waste streams, but they can be cost effective when used to remediate source areas where non-aqueous phase liquids (NAPLs) may be present and treat compounds which are bound strongly to the soil and cannot be easily remediated otherwise.

Thermal treatment can be conducted on excavated soils (ex situ) or in the ground (in situ). Ex situ methods include high temperature incineration (typically exceeding 500 °C), whereby organic compounds are ‘burnt’ and destroyed, and thermal desorption using retorting or rotary kiln systems. In situ methods generally use thermal desorption using steam, hot water or electricity, which operate at relatively low temperatures (typically 100 to 300 °C) to volatilise and degrade contaminants, with the gases captured and treated aboveground.

A soil vapour extraction system (Section 5.4.9) and sometimes a way to control groundwater flow (either subsurface barrier or pump and treat) are necessary.

Ex situ thermal treatment of excavated soils requires a thermal plant and vapour treatment system. Treated soils can often be reused on-site. In situ systems require an array of heater wells and vapour collection wells installed in the ground, a surface cap to help capture vapours and a vapour treatment system. Due to high energy requirements, large system may require significant associated infrastructure to be developed (e.g. high voltage electricity supply).

Thermal treatment would be potentially applicable to petroleum hydrocarbons, BTEX, PAHs, chlorinated hydrocarbons and mercury. Chromium, metals and asbestos are not suitable for thermal treatment.

While thermal treatment is generally effective at achieving low residual contaminant levels and could likely treat to residential land use criteria, these technologies are expensive, of low sustainability values and have inherent risks from managing vapours and potential to further spread contaminants if not controlled properly.

Thermal options within the Precinct would be limited by site access restrictions, need for vapour treatment and require significant regulatory and planning approvals. While there are currently several commercial ex situ thermal system being developed in Australia, there is limited in situ thermal treatment technology.

5.4.12 Soil Washing / Flushing / Solvent Extraction

Soil flushing is used to mobilise organic compounds or metals in the ground by leaching contaminants from soils so that they can be extracted without excavating the contaminated materials. It can be used to enhance pump and treat remediation. A flushing liquid (commonly water, acid/base, surfactant or a solvent) is injected into or applied onto the area of contamination to mobilise the contaminants. There are various methods of application. After contact with the contaminated material, the flushing solution and contaminants are collected using a pump and treat system for disposal or treatment.

Soil flushing has been applied to organic contaminants, but is not well developed for application to metals.

Solvent extraction can be suited to treatment of organic chemicals that are strongly bound to soils (such as some heavy-end hydrocarbons) if they are not treatable via more cost effective ways.
Soil washing is similar to soil flushing but applied to excavated soils. Soil washing of excavated soils would require a slurry mixing process. Management of treated slurries would be required and likely take considerable effort. Soil flushing involves addition of water or a solvent using surface flooding, sprinklers, injection wells, or infiltration systems.

Soil flushing can be used to optimise pump and treat systems. However, given that many of the identified contaminants at the Precinct may be treated using alternate methods, and significant chemical use would be required, potential application would likely be limited to small areas.

5.4.13 Physical Separation

Physical separation is an ex situ process that attempts to separate contaminated material from the rest of the soil matrix based on physical characteristics of the contaminant or soil. Methods include washing, screening and gravity methods. Physical separation works best when contamination is associated with a particular soil type, e.g. many contaminants are found to bind more strongly to very fine soil particles and not large soil particles, and so can be separated somewhat on this basis. Physical separation is generally used as a pre-treatment process as part of another ex situ remediation method such as thermal treatment or chemical treatment.

5.4.14 Monitored Natural Attenuation

Monitored natural attenuation refers to the reliance on natural attenuation processes (such as degradation of organic contaminants, binding of inorganic compounds to soil) to remediate a site. In this way, natural attenuation processes have to be shown to be effective at controlling risk or cleaning up the contamination within a time frame that is reasonable compared to that offered by other more active methods. Natural attenuation is typically only acceptable to regulators when there is no current risk to humans or the environment and ongoing monitoring is possible.

Monitored natural attenuation would likely form part of remediation efforts at the Precinct, most likely for low-level contamination (asbestos excluded) that has been shown to not present a risk to human health and the environment, or after active remediation has been undertaken. However, the long time frame required and need for long-term management, including monitoring, may influence regulatory acceptance and must be considered in land use planning.

5.4.15 Emerging Technologies

Most of the identified contaminants have been recognised as compounds of concern for many years and, as such, the identified remediation technologies are relatively mature. This means that although improvements in our understanding of the science involved and application of these technologies will likely continue, improvement will be incremental and it is unlikely that completely new techniques will be developed.

Changes to non-technology based remediation factors may be just as significant as the effects of potential improvement to remediation technologies. These include reduction in remediation costs due to increased competition, increase in land value, changes to community attitudes, and regulatory and policy changes.

Nevertheless, several technologies that may offer significant development in the future are described below.

5.4.15.1 Nanoremediation

Nanoremediation involves the use of nano-scale reagents and materials, and has received considerable attention in recent years. Nano-scale chemical reagents and materials held much promise when first developed as they tend to be more reactive and effective than micro- or macro-scale equivalents. However, effective application of nano-scale products to remediation of soil and groundwater has since shown to be difficult due to the high reactivity. Nevertheless, improvements in the application of nano-scale reagents are likely.

5.4.15.2 Bioremediation

The understanding of bioremediation, including identification of microbes capable of degradation of specific compounds and genetically enhanced microbes, may improve the performance of bioremediation for
treatment of recalcitrant organic compounds. Bioaugmentation – the addition of cultured microbes into the subsurface to enhance degradation processes – may also be improved.

5.4.15.3 **Electrokinetics**

Electrochemical / electrokinetic recovery is an in situ process in which an electric field is applied across a section of contaminated soil or other material so encouraging the migration of contaminants towards one of the electrodes from where that contaminant can be recovered. The conductive medium is groundwater or an externally supplied fluid. Recovery would be undertaken using groundwater extraction. This technology may be applicable to chromium and other metals in sediments and clays.

5.4.16 **Remediation Options Summary**

The following general comments are noted regarding a potential remediation strategy at the Precinct:

- There are few remediation technologies that can address all identified contaminants.
- All remediation technologies will leave some level of residual contamination.
- Ongoing management, including monitoring, of residual contamination will be required to ensure that potential risks are controlled.
- Given the ubiquitous nature of asbestos and chromium contamination, which transcend individual property boundaries at the Precinct, it is likely that broad-scale development of the Precinct will require a holistic remediation approach to address legacy issues in areas of multiple properties, rather than on an individual site basis. There may be associated regulatory and planning implications, and cooperation between multiple property owners may be difficult to obtain.
- The technologies applicable to remediation of asbestos are removal (excavation), isolation (capping) or immobilisation (solidification). Given the ubiquitous nature of asbestos at the Precinct, remediation in the area would most likely incorporate one or all of these options. Isolation and immobilisation technologies mean that asbestos will remain on site, but that associated risks are controlled.
- These same technologies - removal (excavation of soil and ‘pump and treat’ of groundwater), isolation (capping) or immobilisation (solidification) – are applicable to the remaining contaminants. This is because they are ‘bulk’ remediation techniques which are largely not dependent on the type of contaminant but more the site conditions.
- While there are several other remediation technologies potentially applicable for contaminants (other than asbestos), due to the different properties and behaviour of the contaminants they generally rely on slightly different techniques or chemicals which may not be compatible. For example, chemical treatment is applicable to a range of contaminants, but the specific method used to treat hexavalent chromium will be different to that used to treat other metals or organic contaminants. Thus, treatability of contaminants (other than asbestos) can be broadly categorised into:
  - Organic contaminants – these compounds can be degraded or destroyed, can be volatile and can be present sorbed to soil/waste, in groundwater or as free product.
  - Inorganic compounds – these compounds cannot be destroyed, but they can be transformed to less harmful or mobile forms, they are generally not volatile and can be found sorbed to soil/waste and in groundwater.
- For this reason, unless ‘bulk’ remediation technologies are applied, combinations of one or more remediation approaches will be required for treatment of contaminated areas at the Precinct. As such, there is a need to better understand how to link technologies together to achieve site clean-up in the most cost-effective manner.
6.0 TASKS 2 AND 3 - REMEDIATION AND MANAGEMENT OPTIONS AND COSTS FOR CHANGES TO A MORE SENSITIVE LAND USE

6.1 Proposed Changes in Land Use

The current permitted land uses within the Precinct are defined in the *Parramatta Local Environmental Plan 2011* (LEP). The land use zones in the LEP comprise:

- Business Development – mostly on the western boundary between James Ruse Drive and the Carlingford Rail Line.
- Private Recreation – Rosehill Gardens Racecourse and Sydney Speedway.
- Heavy Industrial – The eastern two thirds of the Precinct and land north and south of Rosehill Gardens Racecourse.
- General Industrial – land either side of Sydney Speedway south of Duck Creek.

The Draft Land Use and Infrastructure Strategy prepared by the Department, which will replace the LEP, adopts some new land use categories as well as amends the areas of land subject to the some of the existing categories. A summary of the key changes to the land use categories and a high level evaluation of the significance of the change in land use and potential implications are summarised in Table 2.

Details of the specific land uses which will be permitted within the categories in the Draft Land Use and Infrastructure Strategy have not yet been developed. However, the key impacts of these changes with respect to land contamination risks apparent from the category titles are as follows (refer Figure 2):

- Residential development will now be permitted within part of the Precinct. The land categorised as Mixed Use / Residential has a long history of industrial development including asbestos manufacturing, arsenic herbicide manufacturing, asbestos landfilling, rubber tyre manufacturing and pharmaceutical manufacturing.
- Some of land previously used for heavy industrial, and potentially contaminating, activities will be limited to Employment uses. The specific nature of these uses has not yet been defined.
- Foreshore lands along the Parramatta River, Duck River and Duck Creek which had been adjacent to, and potentially contaminated by, heavy industrial and landfilling activities will become publicly accessible as Public Recreation. It is assumed that there will not be public access to foreshore lands categorised as Environmental Protection.

These changes represent an increase in the sensitivity of land uses which may be undertaken in these areas which will increase the potential for human health exposure to soil and groundwater contamination in those areas. The process of physical redevelopment of these areas may also increase the risks of exposure of the environment to the contaminants. An evaluation of the required remediation and management of such contamination will be required prior to redevelopment and long term management plans are likely to be required to be implemented during and after redevelopment.
### Table 2: Summary of Proposed Changes to Land Use (Refer to Figure 2)

<table>
<thead>
<tr>
<th>Location</th>
<th>Current Land Use Zoning</th>
<th>Proposed Land Use Category</th>
<th>Significance of Change in Land Use</th>
<th>Implications</th>
</tr>
</thead>
<tbody>
<tr>
<td>North-west corner of Precinct</td>
<td>Business Development and Heavy Industrial</td>
<td>Mixed Use / Residential</td>
<td>High</td>
<td>Residential development on former heavy industrial land use would create increased potential risk of human exposure to contamination.</td>
</tr>
<tr>
<td>East of Colquhoun Street/ West of Durham Street, between the Parramatta River and Duck River</td>
<td>Heavy Industrial</td>
<td>Employment</td>
<td>Moderate</td>
<td>Redevelopment may result in increased potential risk of human exposure to contamination depending upon the design of the development and use of the land.</td>
</tr>
<tr>
<td>South of Rosehill Gardens Racecourse / North of Duck Creek</td>
<td>Heavy Industrial</td>
<td>Employment</td>
<td>Moderate</td>
<td>Redevelopment may result in increased potential risk of human exposure to contamination depending upon the design of the development and use of the land.</td>
</tr>
<tr>
<td>Western third of the Rosehill Gardens Racecourse</td>
<td>Private Recreation</td>
<td>Mixed Use / Entertainment</td>
<td>Low</td>
<td>Not considered to represent a significant change to land use or contamination exposure risk.</td>
</tr>
<tr>
<td>Eastern two-thirds of Rosehill Gardens Racecourse</td>
<td>Private Recreation</td>
<td>Private Recreation</td>
<td>No change</td>
<td>No change to land use or contamination exposure scenario.</td>
</tr>
<tr>
<td>Narrow strip of land between James Ruse Drive and the Carlingford Railway line</td>
<td>Business Development</td>
<td>Mixed Use / Entertainment</td>
<td>Moderate</td>
<td>Potential significant change to land use and potential contamination exposure risk, depending upon what activities have been undertaken on the land historically.</td>
</tr>
<tr>
<td>Southern foreshore of the Parramatta River from James Ruse Drive in the west to Thackeray Street</td>
<td>Heavy Industrial</td>
<td>Public Recreation</td>
<td>High</td>
<td>Public access to previously inaccessible foreshore areas which may be impacted by historical nearby industrial activities significantly increases the potential contamination exposure risk.</td>
</tr>
<tr>
<td>Foreshore along the eastern and southern parts of the Precinct (along the Parramatta River, Duck River and Duck Creek)</td>
<td>Heavy Industrial</td>
<td>Environmental Protection</td>
<td>No change</td>
<td>There would be no change to the potential contamination exposure risk to the environment, assuming that there is no public access and no disturbance to vegetation and ground surface. It is noted that there may be a current potential contamination exposure risk which may increase or decrease over time.</td>
</tr>
<tr>
<td>Industrial land south of Duck Creek</td>
<td>General Industrial</td>
<td>Employment</td>
<td>Low</td>
<td>Not considered to represent a significant change to land use or potential contamination exposure risk.</td>
</tr>
<tr>
<td>Sydney Speedway and Rosehill Heliport</td>
<td>Private Recreation</td>
<td>Private Recreation</td>
<td>No change</td>
<td>No change to land use or potential contamination exposure scenario.</td>
</tr>
</tbody>
</table>
6.2 Preliminary Conceptual Site Models and Remediation and/or Management Options and Remediation Cost Estimates

In order to consider the potential implications of soil and groundwater contamination on potential changes to land use effected by the Draft Land Use and Infrastructure Strategy a high level desk-top assessment was undertaken of five representative sample sites in the Precinct.

The assessment of each site comprised:

- Preparation of a high-level preliminary Conceptual Site Model (CSM) identifying the site-specific environmental conditions, site history, and the known or potential type, extent and degree of contamination.

- Identification of remediation and/or management options for the site-specific contamination condition and selection of a preferred remediation and/or management option. For those sites subject to an existing Remediation Action Plan (RAP), the selected remediation and management option was that documented in the existing RAP(s).

- High level estimation of potential costs associated with the selected remediation and/or management option for the site.

The sites were selected as detailed in Table 1 to represent a range of land use changes and contamination scenarios which may occur throughout the Precinct.

6.3 181 James Ruse Drive, Camellia

The site at 181 James Ruse Drive, in the north-west corner of the Precinct, represents land formerly used for manufacture of asbestos-cement products and arsenic-based herbicides. The land contains capped mounds and areas of landfilled asbestos wastes and is also impacted by arsenic and petroleum hydrocarbon contamination. This site is proposed to be redeveloped for residential land use.

6.3.1 Previous Investigations

The following reports were available for review by Golder providing information on: the extent of contamination at the site; the proposed remediation/management approach; and the remediation approvals process:

- Australian Consulting Engineers (ACE) (November 2010). Camellia West, James Ruse Drive, Camellia, Containment Cell Engineering Plans, prepared for CEJ Constructions;

- Asset Geotechnical Engineering Pty Ltd (17 June 2011). Proposed Containment Cell, 181 James Ruse Drive, Camellia West: Geotechnical Investigation, Sydney, for CEJ Constructions;

- URS Australia Pty Limited (URS) (6 February 2012). Supplementary Site Investigation, Camellia West – 181 James Ruse Drive, Camellia, NSW, prepared for Statewide Planning Pty Ltd;

- URS (30 July 2012). Letter to Statewide Planning Pty Ltd, re: 181 James Ruse Drive, Camellia, NSW, Advice of Site Capability for Remediation;

- Benbow Environmental (September 2013a). Asbestos Safe Work Method Statement, Camellia Remediation Project*;

- Benbow Environmental (September 2013b). Alternative Asbestos Dust Controls for Large Scale Projects, Camellia Remediation Project;
The Remediation Action Plan (RAP) (URS, September 2013) and Addendum to the RAP (Sullivan Environmental Sciences, 2015) for the site were developed on the basis of results from previous investigations completed between 1994 and 2012. Several reports of previous investigations for the site, and the neighbouring property located at 1 Grand Avenue, were not sighted by Golder but were referenced in the RAP. These reports are listed below. Review of these documents may result in different conclusions regarding the extent and significance of contamination and appropriate remediation/management options and costs.

- URS, (2006). *Phase 2 Environmental Site Assessment, Sydney Water Camellia, Western Site, 1 Grand Avenue;*
- Environmental Investigations (2009). *Groundwater Assessment – Additional investigation, 1 Grand Avenue, Camellia, Western Site;* and

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3 Revised to address matters raised by various government agencies in response to EIS lodged with Parramatta City Council on 15 November 2013.
The investigation reports and RAP (URS, 2013) were subject to review by an accredited site auditor (Mr Rod Harwood of Environmental Strategies) with the objective of determining if the site could be made suitable for retail and residential land use with minimum access to soil. Environmental Strategies (27 June 2014) determined that the site could be made suitable for the proposed use if it is remediated in accordance with the RAP.

In response to concerns raised by the NSW EPA as part of the development application review, it was determined that remediation of the site should also incorporate remediation of the Foreshore Area.

A supplementary investigation of the Foreshore Area was completed by URS during 2014 and reported in the following document:

- URS (24 June 2014). Foreshore Supplementary Investigation – 181 James Ruse Drive, Camellia, NSW, prepared for Statewide Planning Pty Ltd.

The following RAP was developed for the remediation of the Foreshore Area and presented in the revised EIS:

- URS (7 November 2014). Foreshore Area, 181 James Ruse Drive, Camellia, NSW, Remediation Action Plan, prepared for Statewide Planning Pty Ltd.

The Foreshore Area RAP includes URS (June 2014) Supplementary Investigation Report and the following document as an attachment:

- Cumberland Ecology (September 2104). Riverbank Management Plan, prepared for Statewide Planning Pty Ltd.

The following summary of information for the site is based on the information presented in the reports made available to Golder for review.

### 6.3.2 Site Description

The site is located on the eastern side of James Ruse Drive and on the southern side of the Parramatta River, in the north-west corner of the Precinct. The key characteristics of the property at 181 James Ruse Drive are summarised in Table 3.

#### Table 3: Site Characteristics - 181 James Ruse Drive

<table>
<thead>
<tr>
<th>Address</th>
<th>181 James Ruse Drive, Camellia, NSW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Property Description</td>
<td>Lot 1 in Deposited Plan (DP) 724228</td>
</tr>
<tr>
<td></td>
<td>Lot 2-4 in DP 128720</td>
</tr>
<tr>
<td></td>
<td>Lot 2-17 in DP 6856</td>
</tr>
<tr>
<td></td>
<td>Lot 1 in DP 128720</td>
</tr>
<tr>
<td></td>
<td>Lot 1 in DP 927064</td>
</tr>
<tr>
<td></td>
<td>Lot 1-6 in DP 2737</td>
</tr>
<tr>
<td></td>
<td>Lot 7A in DP 418035</td>
</tr>
<tr>
<td></td>
<td>Lot 9A in DP 418035</td>
</tr>
<tr>
<td></td>
<td>Lot 10 in DP 610228</td>
</tr>
<tr>
<td></td>
<td>Lot 2 in DP 512655</td>
</tr>
<tr>
<td></td>
<td>Lot 1 in DP 499552</td>
</tr>
<tr>
<td></td>
<td>Lot 25 in DP 6856</td>
</tr>
<tr>
<td></td>
<td>Lot 2 in DP 549496</td>
</tr>
<tr>
<td></td>
<td>Part Lot 1 in DP 668318</td>
</tr>
<tr>
<td>Site Area</td>
<td>Approximately 60,950 m² (6.09 hectares) (main site) and c. 0.2 hectare (foreshore area).</td>
</tr>
<tr>
<td></td>
<td>The main site area excludes a Sydney Water sewer easement (247 m²) located...</td>
</tr>
</tbody>
</table>
Address 181 James Ruse Drive, Camellia, NSW

in the western portion of the southern, west-east access road. It also excludes the driveway (6,889 m²) extending southwards from the south east corner of the site towards Grand Avenue (known as “the Handle”).

Adjacent Land Uses

North: Parramatta River.
East: Clyde to Carlingford Railway Corridor and vacant land beyond which was historically the eastern portion of the former James Hardie manufacturing facility.
South: Northern wall of an adjoining industrial facility, which is constructed along the extent of the west-east aligned assess road which links the site to the entry point located on James Ruse Drive. The industrial facility includes mixed light industrial, retail and warehouse buildings, including a Sydney Water building.
West: James Ruse Drive, then warehouses and factories.

Historical Use

The historical use of the site was predominantly industrial and included use by Camellia Chemical Company, the James Hardie Decorated Boards Warehouse, Stewart Bros and Rheem Australia Pty. James Hardie manufactured asbestos-based products on the property east of the site (over the rail corridor) from around 1917 until the 1990s. The Camellia Chemical Company factory produced the arsenic-based Camellia Weed Killer from 1925 onwards.
From the late 1950s onwards, James Hardie progressively acquired and filled areas of the site with waste and set up operational facilities including a factory, asbestos product stores and a trade facility.
The site was decommissioned in 1993, with building demolition works undertaken between 1995 and 2001. Sydney Water undertook remediation activities and sealed the surface of the site between 2001 and 2002.

Current Infrastructure and Use

No buildings remaining.
Concrete paving covers approximately 75% of the site and bituminous paving approximately 20% of the site. The remaining 5% of the site is covered by unsealed garden areas.
The site is vacant.

Topography, Elevation and Drainage

Features of the site topography include a raised (waste fill) area in the south east corner of the site that drops to the south and east along a steep embankment (approximately 4m high). The lower ground in this area is bounded by eastern and southern site boundaries. The land alongside the central access road slopes down gently northwards to the former River Road. The adjoining lower area in the south west corner, although historically filled, has subsequently been excavated. The remainder of the site, being the northern portion along the river, is relatively flat. The northern boundary is a steep embankment down (approximately 3m) to the Foreshore Area.
The site elevation is approximately 2.5 to 6 m above sea level (<10m AHD). Surface water runoff and stormwater drainage flows toward the north to the Parramatta River. Stormwater drain pits are present at a number of locations across the site surface, predominantly in the northern portion.

Geology

The geology from ground surface downwards comprises:
- Fill material: ranging in approximate thickness from 0.0 to 4.0 metres below ground level (bgl) across the site, including:
  - 0.2 to 4.0 m bgl (maximum) of asbestos fill comprising fragments,
layered sheets of asbestos plaster board, broken piping and thick soft pulp – white, blue and grey in colour. Asbestos fill is mixed with varying proportions of poorly graded gravel, sand and clay (grey, orange and brown) and is mainly located on the eastern portion of the site. The waste in the south east corner for the site is also mixed with boiler waste including ash and clinker;

- 1.5 to 10.5 m bgl (unproven) of general fill consisting of reworked natural soil (clay, sand, various clay and shale gravel mixtures) and organic matter;
- Buried degraded concrete slab in north east corner of site.

- Quaternary-aged sedimentary alluvial deposits, including silty clay, sandy clay, clayey sand and silty sand (extending to depths of 6.3 to 18.1m below surface ground level). The presence of acid sulphate soils across the majority of the site in underlying natural soils has been confirmed.
- Bedrock: Hawkesbury Sandstone which is variably weathered and generally encountered at depths ranging between 11 m and 18.3 m bgl. Sandstone was encountered at the shallower depth of 6 m bgl in the north west of the site, in proximity to the site boundary.

**Groundwater**

The groundwater table is relatively shallow, located at approximately 2.4 - 4.5 m bgl with a northerly to north-easterly expected flow direction, towards the Parramatta River.

The groundwater is tidally influenced with up to 0.2 metre diurnal variation.

**Contaminants**

Asbestos (cement bonded and friable (pulp-mix fibrous material));
Polycyclic aromatic hydrocarbons (PAHs) (in clinker material);
Petroleum hydrocarbons – measured as total recoverable hydrocarbons (TRH), toluene, ethyl benzene and xylenes (TEX), monocyclic aromatic hydrocarbons (MAHs) and chlorinated benzenes (to a lesser extent). Petroleum hydrocarbon impacted soils and groundwater are primarily located in the north-east corner of site;
Metals – Lead and arsenic at isolated locations; and
Semi volatile organic compounds (SVOCs) – carbazole and dibenzofuran (in clinker material).

### 6.3.3 Site History

During the period 1816 to 1897 the site was reportedly used for mixed residential and rural land use after which time it was divided into private plots for various uses. During the 1920s to 1940s chemical manufacturing was associated with some of the Lots and later private Lots were purchased by private companies including chemical storage companies and drum reconditioning companies.

During the period 1957-58 the south east corner of the site was acquired by James Hardies Industries (James Hardie) (as part of their asbestos cement products manufacturing facility located to the east of the railway line) and developed as a decorated board factory after extensive filling of the area with coal ash and asbestos waste. During subsequent years (c.1959-mid-1960s) fill was progressively introduced to the eastern portion of the site, gradually filling towards the Parramatta River in the north and alongside the railway line to the east. During the period 1962-1966 the western portion of the site was acquired by James...
Hardie and used as an asbestos store and trading store. In 1971 the site roads were acquired by James Hardie and these were subsequently backfilled with coal ash and asbestos wastes.

During the 1970s until 1982 a coal stockpile and ash bins were located in the south-east corner of the site. In 1983 all the James Hardie activities were decommissioned.

Aboveground structures at the site were demolished between 1995 and 2001 to slab level. Approximately 95% of the site was left as sealed with either concrete or bituminous concrete pavements, with the remaining unsealed areas comprising landscaped areas and embankments.

Between 2000 and 2003 Sydney Water Corporation undertook works in accordance with a Voluntary Remediation Agreement (VRA) with NSW EPA to clean up surface asbestos contamination at the site and improve surface seals (concrete and bituminous concrete pavements) to ensure that buried asbestos waste was isolated so that exposure pathways to humans and the environment were not present.

The site is subject to a Positive Covenant (Notice. AA746178PC) registered on 6 July 2004 under Section 88E (3) of the Conveyancing Act 1919 and Section 29 of the Contaminated Land Management (CLM) Act 1997. Under the terms of the Positive Covenant the NSW EPA needs to be satisfied that any proposed works on the site involving the disturbance of the site’s existing surface will not pose a risk to human health and/or the environment.

Summer Hill Business Estate acquired the site in 2007.

### 6.3.4 Contamination, Exposure Pathways and Receptors

**Potential on-site sources of contamination at the site include:**

- Leaks and spills from a former underground storage tank (UST) and associated infrastructure (e.g. dispensers and filling points), previously reported in the north-east part of the site;
- Leaks and spills from former drum cleaning operations in the north-east part of the site;
- Potentially impacted soils around the former UST, any ASTs and associated infrastructure;
- Leaks and spills from historical site operations including the former arsenic-based Camellia Chemical Factory located centrally, close to the western boundary of the site;
- Land filling across most of the site using asbestos materials produced at the site; and
- Land filling in the south-east part of the site using combusted waste produced from former boiler operations (‘boiler waste’).

**Potential off-site sources of impact at the site include** the former industrial factory located immediately to the south of the site.

Previous investigations have confirmed that past industrial site uses, which include the manufacture of asbestos-containing materials by James Hardie, the Camellia Chemical factory close to James Ruse Drive, a drum cleaning operation in the north-east corner and a former boiler stationed close to the south-east corner, have resulted in asbestos filling across most of the site, and localised, metal and hydrocarbon-impacted shallow soils, with limited occurrences of buried materials containing high concentrations of PAHs. Localised Phase-Separated Hydrocarbons (PSH) have also been detected in perched groundwater at the north-east corner of the site, with elevated arsenic also identified in groundwater sampled close to the western site boundary.

A graphical representation of the sub-soil profile, highlighting the impacted zones within the north-east and south-east parts of the site is presented in the attached Conceptual Site Model (CSM) cross section as **Figure 3**. As illustrated in **Figure 3**, the existing data for the north-east area of the site indicates that the predominant volume of asbestos fill has been placed in raised containment areas and is typically unaffected by other contaminants. Hydrocarbon-impacted asbestos materials are considered to be concentrated within
the underlying, sandy estuarine sediment layer situated beneath the buried concrete slab, which formed the platform for the former drum washing facility at this part of the site. It is believed that the localised joints, cracks and degraded concrete in the former drum facility platform provided the conduit for deeper vertical migration of hydrocarbons to the underlying, estuarine, sandy sediment layer.

The CSM cross section (Figure 3) also illustrates the conceptual distribution of buried boiler waste (“clinker materials”), within the asbestos fill layer. The boiler waste has been shown to comprise ash and clinker material, and previous investigative drilling indicates that the material is limited to the south-east corner of the site, immediately to the south of a former, on-site boiler.

Most of the remainder of the site area is underlain by general fill material (estimated total 20,800 cubic metres) consisting of reworked natural soil (clay, sand, various clay and gravel mixtures), and does not contain elevated contaminant concentrations, beyond localised hot spots including lead (fill material located close to the northern site boundary at a depth of 1.3 mbgl is impacted by lead) and arsenic. Some of these materials do, however, also contain asbestos.

The total volume of buried asbestos waste present on the site reportedly was estimated to be 68,200 cubic metres. Boiler waste materials comprising ash and clinker from boilers on the southern boundary were also reportedly disposed of at the site. Ash was extensively used as sub-base for roads and pavement slabs across the site and may have been co-disposed with asbestos waste in the eastern part of the site. Clinker material (estimated 20,800 cubic metres) was predominantly observed to exist as pockets or thin layers within the various fill materials in the south-east corner of the site.

Groundwater quality appears to be relatively unaffected by historical operations or leaching of impacted fill material covering the majority of the site. No TRH or PAH detections were recorded in the groundwater across the majority of the site. There are elevated arsenic impacts which appear to be localised in the vicinity of the central western site boundary, the source of which was associated with the former Camellia Chemical Factory located in the area. Localised arsenic impacts in the soil are the likely source of the arsenic impacts to groundwater.

Contamination in the Foreshore Area between the site and the Parramatta River comprises soils impacted with asbestos and localised hot spots of PAHs. Acid sulfate soils are also evident in the Foreshore Area.

The areas of contamination and the potential exposure pathways and receptors at the site are summarised in Table 4.

Table 4: Areas of Contamination, Potential Exposure Pathways and Receptors – 181 James Ruse Drive

<table>
<thead>
<tr>
<th>Area</th>
<th>Contamination</th>
<th>Potential Exposure Pathways</th>
<th>Exposure Scenarios and Receptors</th>
</tr>
</thead>
</table>
| South-eastern corner of site. | Asbestos in fill to 4 m depth with some boiler waste including clinker⁴ which may contain petroleum hydrocarbons and polycyclic aromatic hydrocarbons (PAHs), and semi volatile organic compounds (SVOCs) carbazole and dibenzofuran. | Disturbance of airborne dust (PAHs)/ asbestos fibres if fill material is disturbed, such as for intrusive construction or maintenance works. | Environmental
|                           |                                                                               |                                                      | There are considered to be no environmental receptors in regards to the asbestos contamination. |
|                           |                                                                               |                                                      | Direct contact/ ingestion (PAHs) aquatic ecosystems and recreational users.          |
|                           |                                                                               |                                                      | **Human**                                                                                   |
|                           |                                                                               |                                                      | Direct contact (PAHs) and inhalation (PAHs/asbestos) by construction / maintenance workers on-site during intrusive works and future site users. |

⁴ Hydrocarbon and PAH concentrations demonstrated to be relatively non-leaching.
### CAMELLIA PRECINCT CONTAMINATION AND REMEDIATION STUDY - STAGE 2

<table>
<thead>
<tr>
<th>Area</th>
<th>Contamination</th>
<th>Potential Pathways</th>
<th>Exposure Scenarios and Receptors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>North-eastern corner of site, above former drum washing plant buried concrete slab.</strong></td>
<td>Asbestos in fill to 2.2 m depth.</td>
<td>Disturbance of airborne asbestos fibres if fill material is disturbed, such as for intrusive construction or maintenance works.</td>
<td>Environmental&lt;br&gt;SVOC contaminated / surface seeps groundwater discharge to surface water including the Parramatta River and mangrove foreshore impacting foreshore environment including aquatic ecosystems. Human&lt;br&gt;Inhalation of SVOC vapours following vapour intrusion into indoor/ outdoor environments by on/off-site workers, intrusive workers and/or residents. Direct contact/ inhalation/ ingestion of SVOC contaminated groundwater/ surface seeps by on/off-site workers, intrusive workers and/or residents.</td>
</tr>
<tr>
<td><strong>North-eastern corner of the site, below asbestos waste and buried concrete slab.</strong></td>
<td>Estuarine sediment layer from 2.2- 5.0 m bgl. Impacted with petroleum hydrocarbons, xylenes and PAHs. Some phase-separated</td>
<td>Exposure of hydrocarbon contaminated soil if surface pavement is disturbed, such as for intrusive construction or maintenance works. Migration of</td>
<td>Environmental&lt;br&gt;Hydrocarbon contaminated / surface seeps groundwater discharge to surface water including the Parramatta River and mangrove foreshore impacting foreshore environment including aquatic ecosystems.</td>
</tr>
<tr>
<td>Area</td>
<td>Contamination</td>
<td>Potential Pathways</td>
<td>Exposure Scenarios and Receptors</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>----------------------------------------</td>
<td>-------------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>hydrocarbons (PSH) in groundwater.</td>
<td>hydrocarbon (including volatiles) contamination in groundwater across/off-site.</td>
<td>ecosystems.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Leakage from underground tanks or sumps (if still present)</td>
<td>Human</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Inhalation of SVOC vapours following vapour intrusion into indoor/ outdoor environments by on/off-site workers, intrusive workers and/or residents</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Direct contact/ inhalation/ ingestion of hydrocarbon contaminated groundwater/ surface seeps environments by on/off-site workers, intrusive workers and/or residents</td>
</tr>
<tr>
<td>Western half of site.</td>
<td>General fill consisting of reworked natural soil (clay, sand, various clay and gravel mixtures). Asbestos in fill at some locations to approximately 0.7 m bgl.</td>
<td>Disturbance of airborne dust asbestos fibres if fill material is disturbed, such as for intrusive construction or maintenance works.</td>
<td>Environmental</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>There are considered to be no environmental receptors in regards to the asbestos contamination.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Human</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Direct inhalation (asbestos) by construction / maintenance workers on-site during intrusive works and future site users.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Direct inhalation (asbestos) by off-site persons such as pedestrians or nearby workers or residents.</td>
</tr>
<tr>
<td>Northern site boundary.</td>
<td>Lead impacted fill/soil hot spot.</td>
<td>Disturbance of airborne dust (lead) if fill material is disturbed, such as for intrusive construction or maintenance works.</td>
<td>Environmental</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lead contaminated surface seeps/ groundwater discharge to surface water including the Parramatta River and mangrove foreshores impacting foreshore environment including aquatic ecosystems.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Leaching to groundwater of lead and migration across and/or off-site.</td>
<td>Human</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lead ingestion and inhalation (dust) by construction / maintenance workers on-site during intrusive works and future site users.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lead ingestion and inhalation (dust) by off-site persons such as pedestrians or nearby workers or residents.</td>
</tr>
<tr>
<td>Area</td>
<td>Contamination</td>
<td>Potential Pathways</td>
<td>Exposure Scenarios and Receptors</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>--------------------------------------</td>
<td>----------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| Central western site boundary.   | Arsenic in groundwater.              | Migration of arsenic contamination in groundwater across/off-site.                | Environmental: Arsenic contaminated / surface seeps/ groundwater discharge to surface water including the Parramatta River and mangrove foreshore impacting foreshore environment including aquatic ecosystems.  
Human: Direct contact/ ingestion of arsenic contaminated groundwater/ surface seeps by on/off-site workers, intrusive workers and/or residents. |
| Foreshore Area                   | Asbestos in fill to approximately 0.5 m bgl. | Disturbance of airborne dust asbestos fibres if fill material is disturbed, such as for intrusive construction or maintenance works. | Environmental: There are considered to be no environmental receptors in regards to the asbestos contamination.  
Human: Direct inhalation (asbestos) by construction / maintenance workers on-site during intrusive works and future site users.  
Direct inhalation (asbestos) by off-site persons such as pedestrians or nearby workers or residents. |
| Acid sulphate soils (ASS)        |                                      | Exposure of ASS during excavation and/or dewatering works, such as for intrusive construction or maintenance works. | Generation of acid run-off and discharge to surface water including the Parramatta River and mangrove foreshore aquatic ecosystems.  
Direct contact of acidic runoff by on/off-site workers, intrusive workers and/or residents.  
Chemical attack on in ground services/ building materials. |
6.3.5 Proposed Remediation and/or Management Options

As noted previously remediation and/or management options for the contamination at the site was subject to preparation of a Remedial Action Plan (RAP) and Addendum to RAP which were reviewed by the NSW EPA and a NSW EPA accredited Site Auditor in 2014. As noted above a development application with an accompanying Environmental Impact Statement (EIS) was prepared for the voluntary remediation of the site. It was proposed to remediate the site then apply for rezoning to enable the land to be redeveloped for retail, commercial and residential development, including the construction of high rise residential buildings. In response to concerns raised by the NSW EPA as part of the development application review, it was determined that remediation of the site should also incorporate remediation of the Foreshore Area and a RAP for this area was also prepared.

Golder is not aware of the remediation works having been commenced on the site or in the Foreshore Area.

Areas of known contamination and proposed remediation and/or management methods reported in the RAPs and Addendum to RAP are detailed in Table 5. The RAPs considered a variety of remediation and/or management options for the site and Foreshore Area. The proposed asbestos and dust management procedures were revised in the Addendum to the site RAP principally to accommodate the NSW EPA’s request for the use of negative air pressure enclosure during asbestos waste disturbance works.

The preferred site remediation approach as defined in the RAPs and Addendum RAP include:

- Intermment of fill that consists of asbestos, ash fill and clinker material, including asbestos waste from the Foreshore Area, within three, purpose-built, concrete containment cells that will be integrated with the proposed site redevelopment infrastructure.

- Bioremediation of hydrocarbon-impacted soils utilising biopiling or landfarming technologies, after which the soils are to be beneficially reused on-site, or buried within the containment cells.

If space is available in the containment cells, then other fill materials are also proposed to be contained. The total estimated volume of fill materials on-site is 89,000 m$^3$.

Impacted groundwater including impacts by PSH, dissolved phase hydrocarbons and metals, is proposed to be ameliorated through the remediation of the soil contamination sources in localised areas, with the installation of monitoring wells at strategic locations, to monitor the quality of groundwater migrating across the site boundaries. Water accumulated in excavation pits, including impacted groundwater, will be subject to on-site treatment through a wastewater treatment system prior to discharge to sewer under a Trade Waste Agreement (TWA).

Both RAPs also propose that an ASS management plan be prepared to specify measures to mitigate acidic drainage during works where either: saturated zone natural soils are exposed to the atmosphere; or groundwater levels are reduced to expose natural soils.

To refine the proposed remediation approaches and reduce uncertainty associated with aspects of the remedial design, a program of preparatory investigative works is also proposed with the following objectives:

- Assess the migration potential and extent of PSH and dissolved phase impacts in groundwater at the north eastern site area.

- Assess the TPH-leaching capacity of clinker material.

- Assess the extent of lead-impacted soils at the northern boundary.

- Validate in-situ materials at designated containment cell locations.

- Implement trials to verify the proposed soil bioremediation approach can meet the remedial objectives.

The EIS addresses conditions set under the planning approval process, including air quality, community, waste, traffic, and soil and water management. In response to comments on the EIS, the remediation Soil
Water and Management Plan (URS, 2014) was revised to include an impermeable site perimeter, on site diversion and sediment controls, including a sediment basin, and construction and operation of a closed system waste water treatment plant with final discharge to sewer under a TWA.

Containment of the contaminated materials will be managed under a site specific Site Management Plan (SMP) such that contained materials can be monitored in the long term.

Table 5: Areas of Contamination and Proposed Remediation and/or Management Method – 181 James Ruse Drive

<table>
<thead>
<tr>
<th>Area</th>
<th>Contamination</th>
<th>Proposed remediation and/or management method</th>
</tr>
</thead>
<tbody>
<tr>
<td>South eastern corner of site.</td>
<td>Asbestos in fill to 4 m depth with some boiler waste including clinker(^3) which may contain petroleum hydrocarbons and polycyclic aromatic hydrocarbons (PAHs), and semi volatile organic compounds (SVOCs) carbazole and dibenzofuran.</td>
<td>Excavate asbestos and clinker impacted wastes and place in purpose built containment cells and maintain and monitor cell integrity through implementation of a long term environmental management plan.</td>
</tr>
<tr>
<td>North eastern corner of site, above former drum washing plant buried concrete slab.</td>
<td>Asbestos in fill to 2.2 m depth.</td>
<td>Excavate asbestos impacted wastes and place in purpose built containment cells and maintain and monitor cell integrity through implementation of a long term environmental management plan.</td>
</tr>
<tr>
<td>North eastern corner of the site, below asbestos waste and buried concrete slab.</td>
<td>Estuarine sediment layer from 2.2- 5.0 mbgl. Impacted with petroleum hydrocarbons xylenes and PAHs. Some PSH in groundwater.</td>
<td>Ensure no underground storage tanks remain, if present empty of hydrocarbons and other potential contaminants, remove and validate in accordance with WorkCover, NSW and NSW EPA requirements. Excavate hydrocarbon contaminated soil (estimated 10,000 cubic metres) for on-site bioremediation using biopiles (if impacted with asbestos) or landfarming (if asbestos free). Following bioremediation the fill/soil will be validated for reuse on-site, placed in the containment cells or classified for off-site disposal. No groundwater remediation is proposed beyond source removal and monitoring. Hydrocarbon impacted water generated during the works will be treated in the on-site waste water treatment plant prior to discharge to sewer under a TWA.</td>
</tr>
</tbody>
</table>

\(^3\) Hydrocarbon and PAH concentrations demonstrated to be relatively non-leaching.
### Area of Site

<table>
<thead>
<tr>
<th>Area</th>
<th>Contamination</th>
<th>Proposed remediation and/or management method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Western half of site.</td>
<td>General fill consisting of reworked natural soil (clay, sand, various clay and gravel mixtures). Asbestos in fill is some locations to approx. 0.7 m depth.</td>
<td>Excavate and reuse (if suitable) or place in containment cells if impacted with asbestos and maintain and monitor cell integrity through implementation of a long term environmental management plan.</td>
</tr>
<tr>
<td>Northern site boundary.</td>
<td>Lead impacted fill/soil hot spot.</td>
<td>Complete lead impact delineation works (estimated 2,500 cubic metres of lead impacted fill/soil) and classify for direct off-site disposal or consign for off-site treatment using immobilisation (under a NSW EPA exemption or Specific Immobilisation Approval) prior to off-site disposal at a suitably licensed landfill site.</td>
</tr>
<tr>
<td>Central western site boundary.</td>
<td>Arsenic in groundwater.</td>
<td>Excavate asbestos impacted fill co-contaminated with arsenic and place in containment cells and maintain and monitor cell integrity through implementation of a long term environmental management plan. No groundwater remediation proposed beyond source removal and monitoring.</td>
</tr>
<tr>
<td>Foreshore Area</td>
<td>Asbestos in fill to approximately 0.5 metre bgl.</td>
<td>Excavate asbestos impacted wastes and place in purpose built containment cells on main site and maintain and monitor cell integrity through implementation of the main site long term environmental management plan. Reinstall Foreshore Area in accordance with Riverbank Restoration Plan (Cumberland Ecology, 2014).</td>
</tr>
<tr>
<td>Acid sulphate soils</td>
<td></td>
<td>Implement Acid Sulphate Soils Management Plan.</td>
</tr>
</tbody>
</table>

### 6.3.6 Site Condition Post Remediation

#### 6.3.6.1 Long Term Site Management

It should be noted that the proposed remediation works have been based on the objective of making the site suitable for the proposed redevelopment for retail, commercial and residential land use, subject to a long term Site Management Plan (SMP). The site is subject to a statutory site audit by a NSW EPA accredited Site Auditor under the Contaminated Land Management Act 1997 (CLM Act) and after successful completion of site remediation it is envisaged that the Site Auditor will issue a Site Audit Statement (SAS) concluding on the suitability of the land for its proposed use subject to the implementation of the long term SMP for management of residual contamination. There will need to be a commitment by the site owner, or the notional site owner, to implement an SMP. The SMP would be developed post completion of the remediation to account for the following:

- Potential ongoing risks to future site users from residual contamination.
- Management of the containment cells.
- Monitoring and management of potential vapour and/or groundwater impacts.
The provisions to be considered for the SMP will need to include the following:

- Limitations on construction of any kind within a specified area of the containment cells, including new buildings and underground services/structures.

- A surveyed plan of the final cell location and dimensions is required and needs to be made available to relevant Title holders.

- Maintenance of the surface capping is required to ensure ongoing integrity. This may include regular inspections for cracking or movement.

- Procedures for subsurface works within the vicinity of the containment cell need to be established to limit potential for breaches.

- Management of appropriate on-going use of the capped area, consistent with its intended purpose as sealed vehicle roadway or access.

- An ongoing monitoring program of to ensure containment of the materials.

The long term ongoing site monitoring program component of the SMP will be required to assess the integrity of the containment cells and detect potential leaks or degradation in groundwater quality adjacent to the cells or along the eastern site boundary. The eastern boundary has been identified as an area of uncertainty whether groundwater impacts are potentially migrating on-site. The long term site monitoring programme should include as a minimum:

- A network of groundwater monitoring locations for ambient, on-site and flux boundary monitoring;

- Containment cell observation points to monitor cell leachate, groundwater seepage and vapour generation; and

- A scheduled program of environmental site monitoring, whereby sampling frequency is lowered over time if monitoring indicates negligible long term effects from on-site containment.

### 6.3.6.2 Governance

The site is currently maintained by the NSW EPA under a Public Positive Covenant, under section 88E (3) of the **Conveyancing Act 1919**. After site remediation, the site will be maintained under the Public Positive Covenant or the EPA will instruct orders of an Ongoing Maintenance Order under Section 29 of the **Contaminated Land Management Act 1997**.

The SMP will form the main document to communicate the status of the site and details of the containment of contamination, the final cell locations and dimensions, as well as relevant environmental safeguards and occupational health and safety measures.

Provisions will need to be made for updating the status of the site on **Environmental Planning & Assessment (EP&A) Act** Section 149 Planning Certificates administered by the local authority.

### 6.3.7 Remediation Cost Estimate

In summary the proposed scope of remediation works included in the cost estimate comprised the following:

- Construct sediment and water controls including waste water treatment plant to treat site water and discharge to sewer and sediment basin.

- Removal of surface pavements and crush on-site for off-site reuse/ on-site disposal.

- Excavation and construction of three purpose-built, in-ground, concrete and membrane lined containment cells. The RAP defines that the cells are to be excavated on the western portion of the site into underling soils to depths of between 6.5 and 8 m below ground level and have a combined total fill capacity of approximately 90,000 m$^3$. The cell construction costs include bored piled walls and anchors.
and base slab construction as per concept design. This cell volume provides a 20,000 m$^3$ buffer above the estimated 70,000 m$^3$ of waste material. Golder considers that this buffer volume may not be adequate and recommends that provision of an additional 10% of cell capacity by increasing the depths of the cells by a further 0.8 metres at an additional estimated cost of approximately $1.2 million would be prudent. Lateral extension of the cells once they have been constructed or off-site disposal of excess quantities of waste material would likely be a significantly more expensive option.

- Excavate asbestos and clinker impacted wastes (c. 70,000 m$^3$) from eastern portion of site and place in purpose built cells.
- All asbestos excavation and placement works to be completed with use of temporary emission control structures, with use of foam sprays and air monitoring.
- Construct surface concrete slabs on completed containment cells.
- Excavate, treat (stabilise on-site) lead impacted fill and dispose of off-site to landfill as Restricted Solid Waste. Includes cost for completion of a lead treatment trial.
- Remove vegetation from site and foreshore area and mulch for reuse on-site.
- Excavate asbestos impacted fill materials from foreshore area and place in on-site containment cells. Works to be completed using sediment controls for the Parramatta River and include an allowance for ASS treatment/ management.
- Placement of rock armour to stabilise the shore area from erosion.
- Remove surface asbestos from western portion of site and assess and classify for reuse or place in on-site containment cells. All excavation and placement works to be completed with use of temporary emission control structures.
- Excavate hydrocarbon contaminated soil north eastern corner of site and place in biopiles and remediate. The cost includes treatment of vapour and leachate collected from biopiles. Following bioremediation reuse materials on-site.

The cost estimates assume:

- The remediation of the site would be undertaken as a single exercise. Should remediation occur in sub-parcels and/or over a longer period of time, the costs may increase.

The cost estimates does not include the following:

- Rehabilitation/ revegetation of foreshore area.
- Contingency for vapour extraction and treatment from containment cells if required.
- Contingency for groundwater remediation in location of hydrocarbon impact in north east corner of the site.
- Allowance for off-site disposal of surplus wastes.
- Allowance for removal/ management of below ground tanks/ infrastructure.

For the proposed remediation works defined in Section above 6.3.7, the following assumptions were made in preparing the cost estimate in addition to those assumptions included in the methodology section (Section 4.3) of this report:

- The duration of remediation works would be 16 months.
The quantity of waste material at the river bank requiring excavation, treatment and encapsulation is 1600 m$^3$.

The volume of existing concrete slabs requiring removal, crushing and encapsulation is 10,000 m$^3$.

The area of concrete slabs on the encapsulation cells is 10,266 m$^2$.

The remediation works would be subject to review by a NSW EPA accredited Site Auditor.

For the proposed scope of remediation works and subject to the defined assumptions, the cost was estimated to be $24,500,000 (excluding GST, costs rounded to the nearest $0.5 million). For planning purposes it is recommended that a contingency 10% air space capacity of the containment cells to account for uncertainty in the amount of waste requiring disposal and a budget contingency of 20% be applied, resulting in an estimated cost of $30,500,000 (excluding GST, costs rounded to the nearest $0.5 million).

6.4 1 Grand Avenue, Camellia

The site at 1 Grand Avenue, in the north-west corner of the Precinct, represents land formerly used for manufacture of asbestos-cement products. The land comprises a largely level site containing buried asbestos waste and is also impacted by petroleum hydrocarbon contamination. This site is proposed to be redeveloped for residential land use.

6.4.1 Previous Investigations

The following reports were available for review by Golder providing information on the extent of contamination at the site and the proposed remediation/management approach:

- Consulting Earth Scientists Pty Ltd (26 March 2008). *Remediation Action Plan, 1 Grand Avenue, Camellia, NSW*, prepared for Billbergia Group; and

- Consulting Earth Scientists Pty Ltd (3 July 2008). *Addendum to RAP, 1 Grand Avenue, Camellia, NSW*, prepared for Billbergia Group.

The Remediation Action Plan (RAP) and Addendum to the RAP were developed on the basis of results from previous investigations completed between 1994 and 2007. The following Reports of previous investigations were not sighted by Golder but were referenced in the RAP. Review of these documents may result in different conclusions regarding the extent and significance of contamination and appropriate remediation/management options and costs.

- Consulting Earth Scientists Pty Ltd (December 2007). *Draft Targeted Environmental Site Assessment, 1 Grand Avenue, Camellia*, prepared by for Billbergia Group;

- ENVIRON Australia Pty Ltd (November 2006). *Site Audit Report and Site Audit Statement, Eastern Site, 1 Grand Avenue, Camellia*, prepared for Sydney Water Corporation;

- URS Australia Pty Ltd (October 2006). *Phase II Environmental Site Assessment, Sydney Water Camellia Eastern Site, 1 Grand Avenue, Camellia, NSW*, prepared for Sydney Water Corporation;


- AGC Woodward-Clyde Pty Ltd (July 1995). *Phase II Audit Site Investigations – James Hardie, Camellia*, prepared for James Hardie & Coy Pty Ltd; and

The investigation reports and RAP were subject to review by an accredited site auditor (Mr Graeme Nyland of Environ Australia Pty Ltd, 2006) with the objective of allowing the site to be developed for commercial/industrial land use. The Site Audit Report and Site Audit Statement proposed to be prepared for the site have not been sighted by Golder.

The following summary of information for the site is based on the information presented in the RAP and Addendum to the RAP.

### 6.4.2 Site Description

The site is located north of Grand Avenue, on the southern side of the Parramatta River, in the north-west corner of the Precinct. The key characteristics of the property at 1 Grand Avenue are summarised in Table 6.

#### Table 6: Site Characteristics - 1 Grand Avenue

<table>
<thead>
<tr>
<th>Address</th>
<th>1 Grand Avenue Camellia</th>
</tr>
</thead>
</table>
| Property Description | Lot 1, DP 226202  
Lots 1 and 2, DP 579735  
Lot 201, DP 669350  
Lot 1, DP721503 |
| Site Area | Approximately 7.8 hectares |
| Adjacent Land Uses | North: Parramatta River  
East: Light industrial property occupied by Australian Pharmaceutical Industries Pty Ltd  
South: Former railway line from the Carlingford line at Camellia Junction, just north of Rosehill station, to Sandown Station (formerly located in the eastern part of the Precinct), which operated from 1888 to 2010, and was electrified in 1959.  
West: Clyde-Carlingford Railway line |
| Historical Land Use | Former James Hardie asbestos cement products manufacturing facility |
| Current Infrastructure and Land Use | No buildings remaining.  
Concrete and bituminous paving covers 95% of the site.  
Site is occupied by trucking companies, including storage of shipping containers and assorted equipment. |
| Elevation | 3 to 5 m AHD. |
| Geology | The geology from ground surface downwards comprises:  
Fill material: asbestos fill to 5 metres depth in western part of site. Road base, sandstone and gravelly fill to 0.3 metres depth in eastern part of site.  
Natural soil: Quaternary silty clay, sandy clay, silty sandy clay and silty sand.  
Bedrock: Hawkesbury Sandstone. |
| Groundwater | Flow direction is north-eastwards to the Parramatta River.  
Depth generally less than 6 metres below ground level (details not provided).  
Tidally influenced with up to 0.2 metre diurnal variation. |
| Contaminants | Asbestos, boiler ash (which may contain metals and polycyclic aromatic hydrocarbons) and petroleum hydrocarbons. |
6.4.3 Site History

The site was previously owned by James Hardie Industries for the manufacture of fibrous cement products, including up until 1981, asbestos cement products.

Aboveground structures at the site were demolished between 1995 and 2001 to slab level and building rubble was used to level some stepped areas of the slabs. Approximately 95% of the site was left as sealed with either concrete or bituminous concrete pavements, with the remaining unsealed areas comprising landscaped areas and embankments.

Between 2000 and 2003 Sydney Water Corporation undertook works, in accordance with a Voluntary Remediation Agreement (VRA) with the NSW EPA, to clean up surface asbestos contamination at the site and improve surface seals (concrete and bituminous concrete pavements) to ensure that buried asbestos waste was isolated so that exposure pathways to humans and the environment were not present.

The site is subject to a Positive Covenant lodged by the NSW EPA under Section 88E (3) of the Conveyancing Act 1919. Annexure D of the Covenant reportedly comprises a document titled: “Site Management Plan – Eastern Portion Former James Hardie Site, Grand Avenue Camellia”, dated 17 March 2004 and provides the basis for long term management of the site. Golder has not sighted the Covenant or the Site Management Plan. The Addendum to RAP states that the Site Management Plan “provides procedures for maintenance of the existing cover on the site so that human and environmental health are protected from the presence of asbestos waste buried on the site”. Under the Site Management Plan extraction of groundwater would only be permitted for monitoring purposes.

6.4.4 Contamination, Exposure Pathways and Receptors

Most of the site area is underlain by fill material impacted with asbestos to varying degrees as follows:

- West part of site: Deep fill (approximately 5 metres below ground level) containing abundant asbestos wastes (friable pulp and bonded asbestos products, some of which may have been coated with bitumen, zinc silicate and other paints) and significant volumes of boiler ash in the western part,

- East part of site: Relatively shallow fill (approximately 0.2 metres below ground level) of road base, sandstone and gravelly materials.

The volume of asbestos waste present on the site reportedly was estimated to be 55,750 cubic metres. Asbestos containing materials remain (as of 2008) in bonded form at the ground surface in “localised areas of the site” which presents a risk of asbestos fibre being released resulting in a risk to human health, particularly during redevelopment.

Boiler ash from boilers located near the southern boundary of the site reportedly was used extensively as sub-base for roads and pavement slabs across the site and may have been co-disposed with asbestos waste in the western part of the site. Other chemicals, mainly hydrocarbon–based (diesel, hydraulic oil and petrol) were extensively used and stored on the site and may have been disposed on the site.

Petroleum hydrocarbon impacted soil and groundwater is present in limited areas of the site.

The areas of potential contamination, exposure pathways and receptors are summarised in Table 7.

<table>
<thead>
<tr>
<th>Area</th>
<th>Contamination</th>
<th>Exposure Pathways</th>
<th>Receptors</th>
</tr>
</thead>
</table>
| Western half of site| Asbestos in fill to 5 m depth with some boiler ash which may contain metals and polycyclic aromatic hydrocarbons | Airborne dust if fill material is disturbed, such as for intrusive construction or maintenance works. | Environmental
<p>|                     |                                                                               |                                                                                   | There are considered to be no environmental receptors in regards to the asbestos contamination |
| Eastern half of site| Asbestos in fill to 0.2 m depth with some boiler ash which                    |                                                                                   |                                     |</p>
<table>
<thead>
<tr>
<th>Area</th>
<th>Contamination</th>
<th>Exposure Pathways</th>
<th>Receptors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area A (in northern central part of the site)</td>
<td>Petroleum hydrocarbon contamination in soil and groundwater.</td>
<td>Erosion of contaminated soil if surface pavement is disturbed, such as for intrusive construction or maintenance works.</td>
<td>Human: Construction / maintenance workers on-site during intrusive works. Off-site persons such as pedestrians or nearby workers or residents</td>
</tr>
<tr>
<td>Area B (in the south-eastern part of the site)</td>
<td>Area B – petroleum hydrocarbon contamination in soil and groundwater and presence of underground storage tanks.</td>
<td>Migration of contamination through groundwater.</td>
<td>Environmental: Parramatta River including mangrove foreshore. Human: Construction / maintenance workers on-site during intrusive works. Off-site persons such as pedestrians or nearby workers or residents</td>
</tr>
<tr>
<td>Area C (in the south-eastern part of site)</td>
<td>Petroleum contaminated fill within a concrete sump (former bitumen dipping tank).</td>
<td>Leakage from underground tanks or sumps.</td>
<td></td>
</tr>
<tr>
<td>Area D (along central north-south axis of site)</td>
<td>Potential heavy oils and grease left in place along the axis of a former railway siding.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area F (in the north-eastern part of the site)</td>
<td>Petroleum hydrocarbon in the vicinity of a former UST.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 6.4.5 Proposed Remediation and/or Management Options

Development of remediation and/or management options for the contamination at the site was subject to preparation of a Remediation Action Plan (RAP) and Addendum to RAP which were reviewed by the NSW EPA and a NSW EPA Accredited Site Auditor in 2008. Golder is not aware of the remediation works having been undertaken.

Areas of known contamination and proposed remediation and/or management methods reported in the RAP and Addendum to RAP are detailed in Table 8. The RAP considered a variety of remediation and/or management options for the site. The options were revised in the Addendum to RAP to accommodate the NSW EPA’s “strong desire that the asbestos waste should not be disturbed but that the final decision should be based on the requirements of the accredited site auditor to allow him to prepare a SAS that would allow the site to be developed for, in this case, commercial/industrial land use”.

It was determined in the Addendum to RAP that petroleum hydrocarbon contamination in soil and groundwater would not be remediated unless there was a risk to human health or the environment. An evaluation of the risks presented by the petroleum hydrocarbons to human health and the environment was undertaken in the Addendum to RAP document to determine which areas of petroleum hydrocarbon impact required remediation and which could be left in situ. It was assessed that there was not likely to be a risk to human health from the petroleum hydrocarbon contamination (which predominantly comprised non-volatile heavy fractions) as long a complete and permanent seal was maintained for those areas.
An assessment of the likely rate of migration of petroleum hydrocarbon contamination in groundwater towards the Parramatta River concluded that risk to the Parramatta River was low except for one location – Area A, indicated as being in the vicinity of some former oil presses and an oil storage facility. The petroleum hydrocarbon contamination at Area A was represented in the RAP as comprising two partly overlapping approximately circular areas approximately 15 metres in diameter, though it should be noted that the extent of contamination has not been delineated. It was proposed that the contaminated soil at Area A be excavated and disposed off-site. The proposed extent of excavation was not specified and was proposed to be determined with reference to the findings of previous investigations (not sighted by Golder). The Addendum to the RAP recommended that further groundwater monitoring be undertaken at a down hydrogeological gradient monitoring well before any decision be made to undertake groundwater remediation.

For Area B the only remediation recommended was to remove residual liquid (if any) from any remaining underground storage tanks (number and size of tanks not specified) and decommissioning the tanks in situ in accordance with WorkCover, NSW and NSW EPA requirements.

With regards to asbestos wastes, it was recommended that the following be undertaken:

- Fill material immediately beneath the pavements in Area A should be assumed to be impacted with asbestos fibre and should be reburied in the excavation resulting from the remediation of Area A.
- Surface layers of asbestos containing materials across the site should be removed to the substrate (concrete pavements or visually clean soil).
- Embedded asbestos containing materials (such as fibre-cement pipes which extend to the surface of the pavements) across the site should be trimmed so that they are at least 50 mm below the level of the surrounding concrete pavements, followed by sealing of the resulting void with concrete to level with the surface.

The extent of asbestos materials at the surface or embedded asbestos across the site was estimated in the RAP to be approximately 150 square metres. It was proposed that asbestos containing materials collected from the ground surface would be buried in the backfilled excavation resulting from the remediation of Area A.

The remediation works would be subject to validation sampling, analysis and assessment to ensure remediation goals had been achieved.

**Table 8: Areas of Contamination and Proposed Remediation and/or Management Method – 1 Grand Avenue**

<table>
<thead>
<tr>
<th>Area</th>
<th>Contamination</th>
<th>Proposed Remediation and/or Management Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Western half of site</td>
<td>Asbestos in fill to 5 m depth</td>
<td>Remove surficial asbestos, bury on-site, keep remaining asbestos covered and subject to a long term environmental management plan.</td>
</tr>
</tbody>
</table>
| Eastern half of site | Asbestos in fill to 0.2 m depth | Remove surficial asbestos, bury on-site, keep remaining asbestos covered and subject to a long term environmental management plan.  
Note: extent of surficial asbestos contamination across the whole site has been estimated to be 150 square metres. |
| Area A (in northern central part of the site) | Petroleum hydrocarbon contamination in soil and groundwater. | Excavate hydrocarbon contaminated soil and dispose of to landfill. The soil was classified in the RAP as 'industrial' waste.  
Dose the base and walls of the excavation below the water table with an oxygen releasing compound |
Area | Contamination | Proposed Remediation and/or Management Method
---|---|---
Area B (in the south eastern part of the site) | Area B – petroleum hydrocarbon contamination in soil and groundwater and presence of underground storage tanks. | Ensure underground storage tanks area emptied of hydrocarbons and other potential contaminants, and decommissioned *in situ* in accordance with WorkCover, NSW and NSW EPA requirements. No soil or groundwater remediation proposed. Note: The number of underground storage tanks and volume of liquid requiring removal were not specified in the RAP.
Area C (in the south-eastern part of site) | Petroleum contaminated fill within a concrete sump (former bitumen dipping tank). | No remediation proposed.
Area D (along central north-south axis of site) | Potential heavy oils and grease left in place along the axis of a former railway siding. | Maintain cover and manage under a long term management plan.
Area F (in the north-eastern part of the site) | Petroleum hydrocarbon in the vicinity of a former UST. | No remediation proposed.

The RAP considered that the risk of acid sulphate soils did not warrant assessment as deep excavations, which may expose potential acid sulphate soils, or lowering of the water table were not expected to occur during redevelopment of the site.

In summary the proposed remediation works comprise:

- Remove surface asbestos from approximately $150 \text{ m}^2$ and bury on site, subject to a long term management plan.
- Excavate hydrocarbon contaminated soil from Area A and dispose to landfill as ‘industrial waste’.
- Dose the base and walls of the excavation below the water table with an oxygen releasing compound.
- Pump out contaminated groundwater seepage into the excavation void and dispose off-site as potentially contaminated with hydrocarbons.
- Empty underground storage tanks at Area B and decommission *in situ*.
- Cover whole of site (7.8 hectares) with a layer of clean fill and surface with impermeable capping, and implement long term site management plan.

The RAP considered that the risk of acid sulphate soils did not warrant assessment as deep excavations, which may expose potential acid sulphate soils, or lowering of the water table were not expected to occur during redevelopment of the site.

In summary the proposed remediation works comprise:

- Remove surface asbestos from approximately $150 \text{ m}^2$ and bury on site, subject to a long term management plan.
- Excavate hydrocarbon contaminated soil from Area A and dispose to landfill as ‘industrial waste’.
- Dose the base and walls of the excavation below the water table with an oxygen releasing compound.
- Pump out contaminated groundwater seepage into the excavation void and dispose off-site as potentially contaminated with hydrocarbons.
- Empty underground storage tanks at Area B and decommission *in situ*.
- Cover whole of site (7.8 hectares) with a layer of clean fill and surface with impermeable capping, and implement long term site management plan.
6.4.6 Site Condition Post Remediation

It should be noted that the proposed remediation works were based on the objective of making the site suitable for redevelopment for commercial/industrial land use, subject to an ongoing, long term, site management plan. The RAP stated that “given the extent of asbestos waste buried on site it is considered not to be feasible to treat it in any other way than to ensure that it remains securely isolated by complete and permanent surface seals in the form of concrete or bituminous concrete pavements”.

The recommended approach was to leave the existing pavements in place, cover the site with a layer of clean fill (of unspecified thickness), which in turn would be sealed with new concrete pavements for a new development. By placing a sufficiently thick layer of clean fill over the existing surface of the site, installation and ongoing maintenance of underground services could be carried out without disturbing the asbestos waste or asbestos impacted fill. This approach has been successfully adopted on other areas of asbestos waste landfilling in Camellia. The design of the footings buildings on the site will need to take into account the approach of not disturbing the asbestos fill material. It is also noted that construction of underground car parking would be precluded.

The RAP did not elaborate on the implications of the requirements of the long term site management plan on the design, methodology or cost of development of the site. The requirement of the RAP and site management plan to maintain a permanent cover over the site and not disturb buried asbestos will impose constraints on the design, construction methodology and cost of redevelopment and future use of the site. The construction of footings and services and earthworks which may be required to enable development of the site would need to be undertaken in a manner which manages the risks of encountering asbestos and hydrocarbon contamination remaining on the site.

6.4.7 Remediation Cost Estimate

For the proposed remediation works defined in Section 6.4.5, the following assumptions were made in preparing the cost estimate in addition to those assumptions included in the methodology section (Section 4.3) of this report:

- The duration of remediation works would be four months.
- The quantity of surficial asbestos requiring removal was 100 m$^3$ and these works would be undertaken using an excavator. The asbestos would be deposited in a cell on site (i.e. the void formed by the removal of hydrocarbon-impacted soil) and capped.
- The quantity of hydrocarbon impacted soil was 1,000 m$^3$.
- The quantity of hydrocarbon impacted groundwater requiring off-site disposal was 100,000 litres.
- The underground storage tanks requiring emptying comprised three 20,000 L tanks.
- The cap to be placed over the site comprises a 0.6 m thick layer of virgin excavated natural material; assumed to be readily available from current infrastructure projects.
- The remediation works would be subject to review by a NSW EPA accredited Site Auditor.

For the proposed scope of remediation works and subject to the defined assumptions, the cost was estimated to be $2,900,000 (excluding GST, rounded to two significant figures). For planning purposes it is recommended that a contingency of 20% be applied, resulting in an estimated cost of $3,400,000 (excluding GST, rounded to two significant figures).

6.5 Low Risk Site in Western Part of Camellia Precinct

There are some areas of the western part of the Precinct which have not been subject to industrial development. No specific reports have been sighted assessing the soil and groundwater contamination risks in these areas. In the absence of specific information for particular sites consideration has been given to the general characteristics of the environment and land uses in this area and potential contamination scenarios
which could have occurred and potential remediation and/or management options which may be utilised to enable development of the land.

These areas are considered to have a low risk of soil or groundwater contamination. Nonetheless the risk of such contamination would need to be considered and managed during the planning, development and post-development stages for these areas. This section provides a predictive assessment of the potential remediation and/or management requirements for low risk sites in the western part of the Precinct. This section deliberately avoids identifying any particular land parcels as the assessment is based conceptually on general historical land use in the area rather than at a particular location. The type of land considered in this assessment is that which is located in the topographically higher areas of the western part of the Precinct and located away from the waterways of the Parramatta River, Duck River, Duck Creek and A’Becketts Creek.

6.5.1 Previous Investigations

No site-specific soil or groundwater contamination investigations or remediation action plans have been sighted by Golder in relation to land in the western part of the Precinct.

6.5.2 Site Description

The key characteristics of the western part of the Precinct are described in Table 9.

Table 9: Site Characteristics – Western Part of Camellia Precinct

<table>
<thead>
<tr>
<th>Location</th>
<th>Non-Industrial Land East of James Ruse Drive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site Area</td>
<td>For the purposes of this assessment it is assumed that the area of the site is three hectares, as this is considered to represent a typical size of a site which may be redeveloped in the local area, having regard to the size of land parcels in the area and the types of redevelopment that may occur.</td>
</tr>
<tr>
<td>Adjacent land uses</td>
<td>Adjacent land uses would comprise a mix of light industrial, heavy industrial and private recreation, including open space. It is assumed that the adjacent land uses have not significantly impacted upon the site.</td>
</tr>
<tr>
<td>Historical use</td>
<td>Variety of light industrial and recreational land uses. Review of historical aerial photographs obtained from NSW Land &amp; Property NSW indicates that development of the site commenced in the early 1930s.</td>
</tr>
<tr>
<td>Current infrastructure</td>
<td>It is assumed that the land will not have been used for industrial purposes, however may it have been subject to a variety of open space, recreation, office or similar uses. It is assumed that areas external to the buildings are paved with concrete or asphalt or comprise grassed areas or garden beds.</td>
</tr>
<tr>
<td>Elevation</td>
<td>The area is assumed to be generally level to slightly sloping with an elevation generally in the range between 6 metres and 10 m AHD. Reference: Parramatta U0052 Orthophotomap, 1:10,000 Second Edition, Central Mapping Authority of NSW, 1985.</td>
</tr>
<tr>
<td>Stormwater</td>
<td>It is assumed that the area does not contain any natural drainage lines and that stormwater flows via overland flow or site-specific and municipal drainage systems to A’Becketts Creek, Duck Creek, Duck River and the Parramatta River. The area is assumed to be above the 1:100-Year Recurrence Interval Flood Level (based on flooding data supplied by Council).</td>
</tr>
<tr>
<td>Geology</td>
<td>The geology of the area from ground surface downwards is assumed to comprise: Soil: The soil at the site is mapped as the Glenorie Soil Landscape (<a href="http://www.environment.nsw.gov.au/eSpadeWebApp/">http://www.environment.nsw.gov.au/eSpadeWebApp/</a>, New South Wales Government, Department of Planning &amp; Environment) which is characterised by Podzolic soils (Red on crests grading to Red/Brown on upper slopes to Yellow/Gleyed along drainage lines) which have a moderate to high erosion...</td>
</tr>
</tbody>
</table>
## Location

<table>
<thead>
<tr>
<th>Location</th>
<th>Non-Industrial Land East of James Ruse Drive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundwater</td>
<td>Groundwater is assumed to be present in perched aquifers within the weathered horizons and in fracture systems within the bedrock, but not as perched aquifers as the soil horizon is considered likely to be too thin. The Ashfield Shale contains groundwater within fracture systems. The groundwater tends to be saline and of low yield. Given the high salinity and low yields, and availability of reticulated potable water supply, it is considered unlikely that groundwater would be locally extracted for use. Flow direction is inferred to be towards Duck Creek, Duck River or the Parramatta River. Groundwater has been encountered at a depth of 3 metres below ground level, within clay horizons, based on information from the NSW Natural Resources Atlas Groundwater Database and the NSW Office of Water groundwater bore database (<a href="http://www.allwaterdata.water.nsw.gov.au/water.stm">www.allwaterdata.water.nsw.gov.au/water.stm</a>).</td>
</tr>
</tbody>
</table>

### 6.5.3 Site History

It is assumed that land within this area has historically been used for a variety of public open space, recreation or office activities. It is assumed that no industrial activity has been undertaken.

It is assumed that the land has been subject to minimal earthworks disturbance, however may have been subject to localised shallow filling to facilitate use of the land.

### 6.5.4 Contamination, Exposure Pathways and Receptors

No specific details are available of contamination within the subject area. Based on the assumed history of development and land use the following conclusions are made with respect to potential contamination, exposure pathways and receptors.

The main sources of potential contamination are considered likely to be areas of localised filling, buildings/workshops, utilities and vehicle and equipment usage and parking. The potential sources of contamination and resulting exposure pathways and receptors are identified in Table 10.
### Table 10: Areas of Contamination, Exposure Pathways and Receptors - Western Part of Camellia Precinct

<table>
<thead>
<tr>
<th>Area</th>
<th>Contamination</th>
<th>Exposure Pathways</th>
<th>Receptors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Areas of filling (including demolition materials) with contaminated materials</td>
<td>Asbestos, Metals, Petroleum hydrocarbons, Polycyclic aromatic hydrocarbons</td>
<td>Airborne dust if fill material is disturbed, such as for intrusive construction or maintenance works. Erosion of contaminated soil if surface pavement is disturbed, such as for intrusive construction or maintenance works. Migration of contamination through groundwater. Leakage from underground tanks or sumps.</td>
<td>Environmental: There are considered to be no environmental receptors in regards to the asbestos contamination. Environmental receptors for the other contaminants comprise soil biota (including vegetation) and aquatic ecosystems (via stormwater/groundwater). Human: Construction / maintenance workers on-site during intrusive works. Off-site persons such as pedestrians or nearby workers or residents</td>
</tr>
<tr>
<td>Buildings / Workshops resulting in surface spills from areas of fuel, oil and chemical storage and use, and pesticide applications</td>
<td>Asbestos, Petroleum hydrocarbons, Metals, Pesticides - organochlorines such as aldrin and dieldrin, and arsenic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Utilities (pipes/cables, pits, electrical transformers) – oil leaks and damaged equipment residues in ground</td>
<td>Asbestos, Petroleum hydrocarbons, Polychlorinated biphenyl compounds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicle and equipment usage and parking – oil leaks</td>
<td>Petroleum hydrocarbons</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The following assumptions are made with respect to the following potential sources of contamination:

- The subject area has not been impacted by bulk disposal of asbestos or hexavalent chromium waste from historical industrial activities in the Precinct. However, there is potential for these materials to be present as co-contaminants in localised fill materials on the site.
- The quantities of herbicide and pesticides applied to land in the area would not have been sufficient to result in significant contamination of soil and/or groundwater.
- The extent of metal contamination in soil and groundwater from building materials and ancillary activities is not significant.

These assumptions would need to be tested when assessing the risk of contamination in the subject area prior to development. A preliminary site assessment would be required to be undertaken to assess contamination risks prior to development in accordance with relevant guidelines endorsed under Section 105 of the *Contaminated Land Management (CLM) Act 1997*, including the National Environment Protection (Assessment of Site Contamination) Measure 1999 (NEPC, 2013).

### 6.5.5 Potential Remediation and/or Management Options

The selection of remediation and management options would be driven by the nature and extent of contamination present and the proposed future use of the land.

The remediation and/or management options which are considered most likely to be applicable to contamination in the subject area are as listed in Table 11.
### Table 11: Remediation and/or Management Options - Western Part of Camellia Precinct

<table>
<thead>
<tr>
<th>Contamination</th>
<th>Media</th>
<th>Remediation and/or Management Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asbestos</td>
<td>Soil – fill material</td>
<td>Removal of surficial asbestos if minor&lt;br&gt;Cap and contain fill material&lt;br&gt;Implement a long term site management plan to prevent future disturbance of asbestos material</td>
</tr>
<tr>
<td>Metals</td>
<td>Soil – fill material</td>
<td>Cap and contain&lt;br&gt;Implement a long term site management plan to prevent future disturbance of metal impacted material</td>
</tr>
<tr>
<td>Groundwater</td>
<td></td>
<td>Chemical treatment&lt;br&gt;Hydraulic containment&lt;br&gt;Physical containment&lt;br&gt;Pump and treat system</td>
</tr>
<tr>
<td>Petroleum hydrocarbons</td>
<td>Soil</td>
<td>Excavation and off-site landfill disposal or land farming/ biopiling followed by reuse or off-site landfill disposal</td>
</tr>
<tr>
<td></td>
<td>Groundwater – free phase</td>
<td>Active/passive skimming and off-site disposal of skimmed fraction</td>
</tr>
<tr>
<td></td>
<td>Groundwater – dissolved phase</td>
<td>Enhanced in situ biodegradation, chemical oxidation or chemical reduction</td>
</tr>
<tr>
<td>Vapour</td>
<td>Soil – fill material</td>
<td>Cap and contain&lt;br&gt;Implement a site management plan to prevent future disturbance of asbestos material</td>
</tr>
<tr>
<td>Polychlorinated biphenyl compounds,</td>
<td>Groundwater</td>
<td>Chemical treatment&lt;br&gt;Hydraulic containment&lt;br&gt;Physical containment&lt;br&gt;Pump and treat system</td>
</tr>
<tr>
<td>pesticides</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The contamination considered most likely to trigger the need for remediation and/or management works is shallow soil contamination associated with localised contaminated fill material and utility structures. The remediation and/or management options for such contamination are considered to be the following, which would also be suitable for the other identified potential sources of contamination in the area (i.e. buildings and areas of vehicle/equipment usage and parking):

- Manage *in-situ* – undertake an ecological and human health risk assessment and subject to the outcome manage the contamination *in-situ* under a long term site management plan. This option may result in constraints over use of the impacted part of the site.
“Cap and Contain” – The contaminated material could be capped with clean soil or infrastructure such as concrete paving or buildings to prevent exposure to humans or the environment. This approach would require a long term site management plan to prevent future disturbance of the material. This option may result in constraints over use of the impacted part of the site.

“Dig and Dump” – This approach would involve excavation of the contaminated material and disposal to a suitably licensed landfill. The excavation void would need to be validated (via soil sampling and analysis) and the material disposed off-site would need to be classified in accordance with the NSW EPA’s (2014) Waste Classification Guidelines. This represents a high-cost approach to remediation, however, may eliminate a potential future constraint to use of the impacted part of the site.

6.5.6 Remediation Cost Estimate

The cost of the remediation options would be directly dependent upon the area of land and/or the volume of impacted soil requiring remediation. The extent of impacted soil and therefore remediation cost can vary by orders of magnitude between sites of apparently similar land use. For the purposes of this assessment the following assumptions have been made:

The site area is three hectares.

The area of contaminated soil from site activities is between 100 and 200 square metres to a depth of one metre (presenting low range and high range estimates).

The extent of contaminated fill material (separate to soil contaminated by site activities) is between 50 and 200 square metres to a depth of one metre (presenting low range and high range estimates).

Concrete paving is used as the physical barrier for the “Cap and Contain” remediation works.

The cost estimate provides for the following stages of investigation, remediation and management in accordance with relevant guidelines endorsed by the NSW EPA under Section 105 of the CLM Act 1997:

- Preliminary Site Investigation and Detailed Site Investigation to guide remediation scope and satisfy NSW EPA guideline requirements for redevelopment to a more sensitive land use.
- Remediation Action Plan.
- Remediation works implementation.
- Waste classification and disposal to landfill.
- Validation of remediated areas and preparation of a remediation validation report.
- NSW EPA accredited Site Auditor review of each phase of works to assess site suitability in the context of the proposed redevelopment being to a more sensitive land use.
- Long Term Site Environmental Management Plan.
- Project Management and Environmental Management during the proposed remediation works.

The cost estimates range as follows:

- Low range cost - $240,000 (excluding GST, rounded to two significant figures).
- High range cost - $690,000 (excluding GST, rounded to two significant figures).

These costs equate to between $80,000 and $230,000 per hectare.

These costs are generally consistent with Golder’s experience on redevelopment of low impacted land in urban areas. However, the wide range of the estimated costs for relatively modest changes in areas of contaminated fill material or contaminated soil from site activities demonstrates that these costs are highly
sensitive to the input assumptions regarding the extent of fill material or soil contamination at the site. If the extent of soil and groundwater contamination and fill material increases beyond localised areas there is potential for these costs to increase accordingly.

6.6 Low to Medium Risk Site in South-Western Part of Camellia Precinct

The south-western part of the Precinct is considered to comprise land south of Unwin Street and West of Shirley Street. In the absence of specific information for particular sites consideration has been given to the general characteristics of the environment and land uses in this area and potential contamination scenarios which could have occurred and potential remediation and/or management options which may be utilised to enable development of the land.

6.6.1 Previous Investigations

No site-specific soil or groundwater contamination investigations or remediation action plans have been sighted by Golder in relation to land in the south-western part of the Precinct.

6.6.2 Site Description

The key characteristics of the south-western part of the Precinct are described in Table 12.

Table 12: Site Characteristics – South-Western Part of Camellia Precinct

<table>
<thead>
<tr>
<th>Location</th>
<th>Land Bound by Unwin Street (north), Shirley Street (east), James Ruse Drive (west) and the M4 Motorway (south)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site Area</td>
<td>Approximately 35 hectares, of which approximately 21 hectares is south of Duck Creek and approximately 14 hectares is north of Duck Creek. The size of land allotments varies between approximately 0.1 hectare (ha) and 6 ha. The general size of the allotments north of Duck Creek is in the order of 2.5 ha. and south of Duck Creek is in the order of 0.2 ha.</td>
</tr>
<tr>
<td>Adjacent land uses</td>
<td>North: Unwin Street and then Rosehill Gardens (Racecourse).</td>
</tr>
<tr>
<td></td>
<td>East: Shirley Street and then light industrial property.</td>
</tr>
<tr>
<td></td>
<td>South: M4 Motorway.</td>
</tr>
<tr>
<td></td>
<td>West: Unwin Street, James Ruse Drive and then residential areas.</td>
</tr>
<tr>
<td>Historical use</td>
<td>Variety of light industrial and recreational land uses.</td>
</tr>
<tr>
<td></td>
<td>Review of historical aerial photographs obtained from NSW Land &amp; Property NSW indicates that development of the site commenced in the early 1930s.</td>
</tr>
<tr>
<td>Current infrastructure</td>
<td>Land used for light industrial uses generally contains various factory and office buildings which occupy large parts of the sites. Areas external to the buildings are typically paved with concrete or asphalt with some peripheral garden beds.</td>
</tr>
<tr>
<td></td>
<td>The land used for recreational purposes is variably paved with concrete or comprises bare ground which may be subject to vehicle traffic or grassed areas.</td>
</tr>
<tr>
<td>Elevation</td>
<td>The site surface is generally level with an elevation generally in the range between 4 metres and 8 m AHD.</td>
</tr>
<tr>
<td>Stormwater</td>
<td>The south-west part of the Precinct is bisected approximately by Duck Creek and a short section of A’Becketts Creek, which flow approximately from west to east through the middle of the area. Stormwater from the area is likely to discharge into these two Creeks.</td>
</tr>
<tr>
<td></td>
<td>Most of the area is located within the 1:100-Year Recurrence Interval Flood.</td>
</tr>
</tbody>
</table>
Location

Land Bound by Unwin Street (north), Shirley Street (east), James Ruse Drive (west) and the M4 Motorway (south)

Level (based on flooding data supplied by Council).

Geology

The geology from ground surface downwards comprises:

- Quaternary Alluvium: Silty to peaty quartz sand, silt, and clay. Ferruginous and humic cementation in places. Common shell layers.
- Bedrock: Ashfield Shale (shale and laminate) overlying Hawkesbury Sandstone.


The depth to bedrock (shale) appears to be generally greater than 6 metres below ground level and was encountered at a depth of approximately 14 metres below ground level on the banks of Duck Creek (based on records in the NSW Office of Water groundwater bore data base (www.allwaterdata.water.nsw.gov.au/water.stm)).

Fill material may be present in some areas, particularly adjacent to waterways and formerly lower lying areas.

Groundwater

Groundwater may be present as perched aquifers within the Quaternary Alluvium. The Ashfield Shale contains groundwater within fracture systems. The groundwater tends to be saline and of low yield. Given the high salinity and low yields, and availability of reticulated potable water supply, it is considered unlikely that groundwater would be locally extracted for use.

Flow direction is inferred to be towards Duck Creek and A’Becketts Creek which extend approximately west-east through the middle of the south-west part of the Precinct.

Depth to groundwater is generally in the range of 3.6 to greater than 6 metres below ground level, within clay horizons, based on information from the NSW Natural Resources Atlas Groundwater Database and NSW Office of Water groundwater database (www.allwaterdata.water.nsw.gov.au/water.stm).

6.6.3 Site History

Land in this area has been used for a variety of light industrial purposes since the 1930s.

A railway line extended east-west through the industrial land south of Unwin Street reportedly from 1886 onwards to serve the former oil refinery (now a fuel storage terminal) located in the eastern part of the Precinct.

Development included a Mains Road Depot and light industrial factories during the 1940s in the area south of Unwin Street.

Sections of Duck Creek, immediately downstream of A’Becketts Creek were realigned and filled during the 1940s and 1950s. Low lying land adjoins both Creeks was filled during this time.

The Sydney Speedway site which occupies a large of the area south of Duck Creek had been developed for recreational uses by the early 1940s and was redeveloped into its current layout during the 1970s.

Specific details of historical activities on each land parcel within the south-west part of the Precinct have not been identified. However, based on current known land uses the activities undertaken in this part of the Precinct may have included the following:
Storage of oil, diesel or petrol or other petroleum-based liquids in aboveground or underground storage tanks.

Storage of oil and chemicals in drums in bunded or unbunded areas.

Use of oil and chemicals such as paints and solvents in minor to moderate quantities within workshops and factory buildings.

Operation of equipment and vehicle maintenance workshops and wash bays including use of wash pads, oil/water separators (in-ground or above ground) and wastewater collection drains and collection sumps.

Operation of spray paint booths within workshops and small factory buildings.

Use of herbicides along former railway lines.

Disposal of demolition materials (including asbestos and metals) during site modification works.

Disposal of mixed solid fill material in low-lying areas, such as adjacent to Duck Creek and A’Becketts Creek. Such fill material may have included contaminants from other industrial activities in the Precinct such as asbestos and hexavalent chromium.

6.6.4 Contamination, Exposure Pathways and Receptors

No specific details are available of contamination within the south-west part of the Precinct. Based on the history of development and land use the following conclusions are made with respect to potential contamination, exposure pathways and receptors.

Areas of Filling

The areas of filling along Duck Creek and A’Becketts Creek may include the following contaminants, depending on the source of the fill:

Asbestos. The time of the filling coincided with the operations of the former James Hardie asbestos-cement manufacturing facility at Camellia. While no investigation reports into the presence of asbestos waste along Duck Creek and A’Becketts Creek have been sighted, based on known occurrences of asbestos in fill material elsewhere in the Precinct there is potential for the fill material in the low lying lands adjacent to the creeks to have included asbestos-cement waste. Such asbestos is unlikely to be mobile and present a risk to receptors unless disturbed via excavation or erosion.

Hexavalent chromium. The time of the filling coincided with the disposal of chrome ore process waste elsewhere in the Precinct, from chrome ore processing operations at Camellia. While no investigation reports into the potential presence of hexavalent chromium waste along Duck Creek and A’Becketts Creek have been sighted, based on known occurrences of hexavalent chromium waste in fill material elsewhere in the Precinct there is potential for the fill material in the low lying lands adjacent to the creeks to have included hexavalent chromium waste. Such hexavalent chromium is potentially mobile in groundwater, with potential to impact upon the creek ecosystems. If hexavalent chromium waste was present near ground surface it may present a risk of exposure to humans via airborne dust or direct contact during intrusive works.

Other contaminants in fill. There is potential for fill material to be impacted by various other contaminants commonly contained in fill in urban areas, such as metals and polycyclic aromatic hydrocarbons, however, no specific risk of such contaminants has been identified for filled areas along Duck Creek and A’Becketts Creek and is considered likely to be low relative to the risk of contamination by asbestos or hexavalent chromium.
Other Potential Sources of Contamination

The potential historical land uses within the south-west part of the Precinct identified in Section 0 have potential to have resulted in the following contaminants being present in soil or groundwater:

- **Petroleum hydrocarbons.** Facilities such as bulk fuel and oil storage and wash bays/oil-water separators have potential to result in volatile and non-volatile hydrocarbon contamination in soil, with potential to migrate in free and dissolved phase in groundwater, presenting a risk of exposure to humans during intrusive activities and to the environment in the event of discharge to local waterways. In addition, volatile fractions (such as from petrol) may present a vapour exposure risk to humans.

- **Solvents.** Solvents (including chlorinated hydrocarbons) may have been used in the area in a variety of activities including spray-painting and washing/degreasing metal items. For this hypothetical site scenario the extent of solvent contamination of soil or groundwater is considered assumed to be relatively localised to the point of use/storage on the assumption that the quantities used are assumed to have been relatively modest.

- **Organochlorine and organophosphate pesticides and herbicides.** Herbicides and pesticides may have been used along the former railway easement and on some industrial sites. However, based on the types of historical land use within the south-west portion of the Precinct it is considered likely that the quantities which may have been used would be low and the risk to human health and the environment would similarly be low.

- **Metals.** There is potential for metal contamination to have been associated with some industrial activities within the south-west part of the Precinct, however, in general the extent of impact if any is considered likely to be localised, and the risk to human health and the environment is considered to be low.

Potential sources of contamination and resulting exposure pathways and receptors are identified in Table 13.

**Table 13: Areas of Contamination, Exposure Pathways and Receptors – South-Western Part of Camellia Precinct**

<table>
<thead>
<tr>
<th>Area</th>
<th>Contamination</th>
<th>Exposure Pathways</th>
<th>Receptors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Areas of filling (including demolition materials) with contaminated materials</td>
<td>Asbestos, Metals, including hexavalent chromium, Petroleum hydrocarbons, Polycyclic aromatic hydrocarbons</td>
<td>Airborne dust if fill material is disturbed, such as for intrusive construction or maintenance works. Erosion of contaminated soil if surface pavement is disturbed, such as for intrusive construction or maintenance works. Migration of contamination through groundwater. Leakage from underground tanks or sumps.</td>
<td>Environmental receptors in regards to the asbestos contamination. Environmental receptors for the other contaminants comprise soil biota (including vegetation) and aquatic ecosystems (via stormwater/groundwater). Human receptors comprise construction / maintenance workers on-site during intrusive works.</td>
</tr>
<tr>
<td>Buildings / Workshops resulting in surface spills from areas of fuel, oil and chemical storage and use, and pesticide applications</td>
<td>Asbestos, Petroleum hydrocarbons, Metals, Pesticides - organochlorines such as aldrin and dieldrin, and arsenic, Chlorinated hydrocarbons (degreasers)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bulk fuel and oil storage</td>
<td>Petroleum hydrocarbons</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
CAMELLIA PRECINCT CONTAMINATION AND REMEDIATION STUDY - STAGE 2

<table>
<thead>
<tr>
<th>Area</th>
<th>Contamination</th>
<th>Exposure Pathways</th>
<th>Receptors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wash bays / oil-water separators</td>
<td>Petroleum hydrocarbons</td>
<td></td>
<td>Off-site persons such as pedestrians or nearby workers or residents</td>
</tr>
<tr>
<td>Railway easements</td>
<td>Arsenic-based herbicides</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Asbestos</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Utilities (pipes/cables, pits, electrical transformers) – oil leaks and damaged equipment residues in ground</td>
<td>Asbestos</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Petroleum hydrocarbons</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Polychlorinated biphenyl compounds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicle and equipment usage and parking – oil leaks</td>
<td>Petroleum hydrocarbons</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The contamination most likely to have resulted from historical land use within the south-west part of the Precinct and most likely to warrant remediation are petroleum hydrocarbon (including solvents) contamination of soil and groundwater, particularly on sites that contained underground bulk fuel or oil storage systems, and areas of filling where chromium and asbestos wastes may be present. This excludes the in-filled areas adjacent to the creeks where there is potential for chromium and asbestos wastes to be present.

### 6.6.5 Potential Remediation and/or Management Options

The selection of remediation and management options would be driven by the nature and extent of contamination present and the proposed future use of the land. The contamination considered most likely to trigger the need for remediation and/or management works are considered to be asbestos in fill material, hexavalent chromium in soil (fill) and groundwater, and petroleum hydrocarbons and chlorinated hydrocarbons (solvents) in soil and groundwater.

The remediation and/or management options which are considered most likely to be applicable to contamination in the south-west part of the Precinct are as listed in Table 14.

**Table 14: Remediation and/or Management Options - South-Western Part of Camellia Precinct**

<table>
<thead>
<tr>
<th>Contamination</th>
<th>Media</th>
<th>Remediation and/or Management Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>Petroleum hydrocarbons</td>
<td>Underground storage tanks</td>
<td>Empty tanks, remove and dispose of tank and backfill sands, validate tank pit and backfill with verified clean fill material</td>
</tr>
<tr>
<td>Soil</td>
<td></td>
<td>Excavation and land farming or off-site landfill disposal</td>
</tr>
<tr>
<td>Groundwater – free phase</td>
<td></td>
<td>Active/passive skimming and off-site disposal of skimmed fraction</td>
</tr>
<tr>
<td>Groundwater – dissolved phase</td>
<td></td>
<td>Enhanced in situ biodegradation, chemical oxidation or chemical reduction</td>
</tr>
<tr>
<td>Vapour</td>
<td></td>
<td>Soil vapour extraction following source remediation</td>
</tr>
<tr>
<td>Asbestos</td>
<td>Soil – fill material</td>
<td>Removal of surficial asbestos if minor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cap and contain buried asbestos</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Implement a site management plan to prevent future disturbance of asbestos material</td>
</tr>
</tbody>
</table>
### Contamination and Remediation Options

<table>
<thead>
<tr>
<th>Contamination</th>
<th>Media</th>
<th>Remediation and/or Management Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hexavalent chromium</td>
<td>Soil – fill material</td>
<td>Cap and contain Implement a site management plan to prevent future disturbance of hexavalent chromium impacted material</td>
</tr>
<tr>
<td></td>
<td>Groundwater</td>
<td>Chemical reduction to trivalent chromium Hydraulic containment Physical containment Pump and treat system</td>
</tr>
</tbody>
</table>

### 6.6.6 Remediation Cost Estimate

The cost of the remediation options would be directly dependent upon the area of land and/or the volume of impacted soil or type and extent of groundwater contamination requiring remediation. The extent of impact and therefore remediation cost can vary by orders of magnitude between sites of apparently similar land use. For the purposes of this assessment the following assumptions have been made:

- The site area is three hectares.
- The site boundary and remediation obligations do not extend to the embankments of Duck Creek or A’Becketts Creek.
- The site has been impacted by the following areas of contamination:
  - Underground storage tank(s) containing petroleum hydrocarbons, which leaked resulting in contamination of surrounding soil and potentially groundwater impact.
    - Low range cost scenario – one 5,000 litre underground storage tank with localised soil impact but no groundwater impact.
    - High range cost scenario – two 10,000 litre contiguous underground storage tanks with localised soil impact and groundwater impact.
  - Localised areas of hydrocarbon/solvent impacted soil to a depth of one metre from aboveground storage/usage requiring excavation and off-site disposal, followed by validation assessment and backfilling with clean soil, assuming 75% of the material classifies as General Solid Waste and $25% classifies as Restricted Solid Waste.
    - Low range cost scenario – 200 m$^2$ impacted to one metre depth, totalling 200 m$^3$.
    - High range cost scenario – 500 m$^2$ impacted to one metre depth, totalling 500 m$^3$.
  - Localised areas of fill material to a depth of one metre containing asbestos, hexavalent chromium and/or other contaminants requiring either excavation and off-site disposal, assuming 75% of the material classifies as General Solid Waste and $25% classifies as Restricted Solid Waste, followed by validation assessment and backfilling with clean soil, or retention on site beneath capping:
    - Low range cost scenario: assume localised excavation for a service line or service pit, totalling 50 m$^3$.
    - High range cost scenario: assume broader excavation for building footings encountering fill material, totalling 200 m$^3$.
  - Concrete paving is used as the physical barrier for the “Cap and Contain” remediation works option.
The estimate provides for the following stages of investigation, remediation and management in accordance with relevant guidelines endorsed by the NSW EPA under Section 105 of the \textit{CLM Act 1997}:

- Preliminary Site Investigation and Detailed Site Investigation to guide remediation scope and satisfy NSW EPA guideline requirements for redevelopment to a more sensitive land use.
- Remediation Action Plan.
- Remediation works implementation.
- Waste classification and disposal to landfill.
- Validation of remediated areas and preparation of a remediation validation report.
- NSW EPA accredited Site Auditor review of each phase of works to assess site suitability in the context of the proposed redevelopment being to a more sensitive land use.
- Long Term Environmental Management Plan.
- Project Management and Environmental Management during the proposed remediation works.

The cost estimates range as follows:

- Low range cost - $390,000 (excluding GST, rounded to two significant figures).
- High range cost - $1,700,000 (excluding GST, rounded to two significant figures).

The costs equate to between approximately $130,000 and $570,000 (excluding GST) per hectare.

These costs are generally consistent with Golder’s experience on redevelopment of low-moderate impacted land in urban areas. However, the wide range of the estimated costs for relatively modest changes in areas of contaminated fill material or contaminated soil from site activities demonstrates that these costs are highly sensitive to the in-put assumptions regarding the extent of fill material or soil contamination at the site. If the extent of soil and groundwater contamination and fill material increases beyond localised areas there is potential for these costs to increase accordingly.

### 6.7 Chromium Impacted Industrial Land in Northern Part of Camellia Precinct

The land in the north-eastern part of the Precinct has been subject to development and use for a variety of industrial purposes since the 1930s. Parts of the land, particularly lower-lying areas, were subject to filling with material of varied composition to raise the elevation of the land and provide level sites for industrial use. Monitoring of soil and groundwater, including seepages into the Parramatta River has detected the presence of elevated concentrations of hexavalent chromium. The source of the chromium is considered to be chromium waste in the fill material. Asbestos waste materials have also been identified in the ground in some locations.

In the absence of detailed information specific to soil and groundwater contamination on particular sites, and in order to provide guidance on the potential remediation costs which may be associated with contaminated industrial land in this part of the Precinct, consideration has been given to:

- the general characteristics of the environment and land uses in this area;
- potential contamination scenarios which could have occurred; and
- potential remediation and/or management options which may be utilised to enable development of the land and management of potential impacts of contaminant migration to the foreshore of the Parramatta River.
6.7.1 Previous Investigations
A number of investigations have been conducted into soil and groundwater contamination in the north-eastern part of the Precinct. Available information from these investigations was summarised in Section 5.3 of the Stage 1 report for this Study titled *Camellia Precinct High level Contamination Review*. The information from that summary has not been reproduced here but was considered where appropriate in this report.

6.7.2 Site Description
The general environmental characteristics of the north-eastern part of the Precinct are described in Table 15. It should be noted that these characteristics describe general conditions which will vary from location to location.

Table 15: Site Characteristics – North-Eastern Part of Camellia Precinct

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Land generally located east of Colquhoun Street and North of Devon Street.</td>
</tr>
<tr>
<td>Site Area</td>
<td>Approximately 140 hectares.</td>
</tr>
</tbody>
</table>
| Adjacent land uses | North: Parramatta River  
                      West: Light industrial property and Rosehill Gardens Racecourse  
                      South: Former oil refinery site, current fuel terminal facility  
                      East: Parramatta River and Duck River                                                                                                          |
| Historical use   | The area has been subject to a variety of light industrial, rail and heavy industrial land uses. Review of historical aerial photographs obtained from NSW Land & Property NSW indicates that development of the site commenced in the early 1930s. |
| Current infrastructure | Land used for light industrial uses contains various factory and office buildings which occupy large parts of the sites. Areas external to the buildings are typically paved with concrete or asphalt with some peripheral garden beds.  
                      The land used for heavy industrial purposes is paved with concrete or asphalt, or comprises hard-stand area with clay gravel or road base surface which may be subject to heavy vehicle traffic and industrial activities. |
| Elevation        | The ground surface is generally level with an elevation generally in the range between 3 metres and 6 m AHD. *Reference: Parramatta U0052 Orthophotomap, 1:10,000 Second Edition, Central Mapping Authority of NSW, 1985* |
| Stormwater       | The area drains via constructed drainage pipes and channels and overland flow to the Parramatta River (to the north) and Duck River (to the east).  
                      Portions of the area are known to have limited drainage capacity, with pooling and minor flooding common during extended periods of wet weather.  
                      Parts of the area are located within the 1:100-Year Recurrence Interval Flood Level (based on flooding data supplied by Parramatta City Council). |
| Geology          | The general geology of the area from ground surface downwards comprises:  
                      • Fill: These materials were used to raise the level of the low lying swampy areas. This layer is highly variable in thickness, commonly being in the order of two to three metres. The composition of the fill material is variably, including clay fill, gravelly clay fill, silty slag fill intermingled with areas of industrial wastes which may include asbestos wastes and chromium |
### Characteristic Description

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>processing wastes.</td>
</tr>
<tr>
<td>Quaternary Alluvium / Estuarine Sediments: Comprising both alluvial and estuarine sediments, comprising silty to peaty quartz sand, silt, and clay with occasional sandy lenses and shell layers.</td>
<td></td>
</tr>
<tr>
<td>Bedrock: Ashfield Shale (shale and laminate) overlying Hawkesbury Sandstone. The depth to bedrock (shale) appears to be generally greater than 10 metres below ground level.</td>
<td></td>
</tr>
<tr>
<td>Groundwater</td>
<td>Groundwater is present in some areas at a depth of between approximately 1 and 5 metres below ground surface as perched aquifers within the fill materials and quaternary alluvium sediments. Previous studies have indicated that the groundwater in some areas, including groundwater seepages to the Parramatta River, is contaminated with hexavalent chromium. The Ashfield Shale contains groundwater within a fractured system. The groundwater tends to be saline and of low yield. Given the high salinity and low yields, and availability of reticulated potable water supply, it is considered unlikely that groundwater would be locally extracted for use. There are no known users of groundwater in the Precinct. Flow direction is inferred to be generally northwards and north-eastwards towards the Parramatta River.</td>
</tr>
</tbody>
</table>

#### 6.7.3 Site History

Land in the north east part of the Precinct has been used for a variety of light and heavy industrial purposes since the 1880’s.

An industrial railway line extended west-east from just north of Rosehill Station through the industrial land north of Grand Avenue from approximately 1888 with simple stations servicing industrial sites. The railway line terminated at Sandown Station on the southern banks of the Parramatta River, north of the alignment of Durham Street. A later branch-line extended further east into industrial land south of Grand Avenue to the east of Durham Street.

Specific details of historical activities on each land parcel within the northern eastern part of the Precinct have not been identified during this Study. However, based on current known land uses, the activities undertaken in this part of the Precinct may have included the following:

- Storage of oil, diesel or petrol or other petroleum-based liquids in aboveground and / or underground storage tanks.
- Storage of oil and chemicals in drums in bunded or unbunded areas.
- Use of oil and chemicals such as paints and solvents in minor to moderate quantities within workshops and small factory buildings.
- Operation of equipment and vehicle maintenance workshops and wash bays including use of wash pads, oil/water separators (in-ground or above ground) and wastewater collection drains and collection sumps.
- Operation of wastewater treatment and storage facilities, including ponds.
- Use of herbicides along former railway lines.
Disposal of mixed solid fill material in low-lying areas, including but not limited to areas adjacent to Parramatta River. Such fill material may have included contaminants from other industrial activities in the Precinct such as asbestos and hexavalent chromium.

### 6.7.4 Contamination, Exposure Pathways and Receptors

Based on the history of development and land use the following conclusions are made with respect to potential contaminants, exposure pathways and receptors.

#### Contaminants in Areas of Filling

The areas of filling may include the following contaminants, depending on the source of the fill:

- **Asbestos.** The time of the filling coincided with the operations of the former James Hardie asbestos-cement manufacturing facility at Camellia. Evidence of disposal of asbestos waste is evident along the banks of the Parramatta River, and based on known occurrences of asbestos in fill material elsewhere in the Precinct there is potential for the fill material in the low lying lands adjacent to the River to have included asbestos-cement waste. Asbestos present at depth (i.e. greater than 0.5m depth) in the fill materials is unlikely to be mobile and therefore not considered to present a risk to receptors unless disturbed via excavation. However, asbestos present in the river bank fill materials is subject to disturbance through river bank erosion, and in areas not completely submerged may present a risk of exposure to humans via airborne dust.

- **Hexavalent chromium.** Known occurrences of hexavalent chromium waste in fill material have been identified, and hexavalent chromium impacted water seeps have been identified along the Parramatta River. Such hexavalent chromium is mobile in groundwater, with potential to impact upon the surface water ecosystems. If hexavalent chromium waste were present near ground surface it may present a risk of exposure to humans via airborne dust or direct contact during intrusive works.

- **Other contaminants.** There is potential for fill material to be impacted by various other contaminants commonly contained in fill, such as metals and polycyclic aromatic hydrocarbons, however, no specific risk of such contaminants has been identified for filled areas in the north-eastern part of the Precinct and is considered likely to be low relative to the risk of contamination by asbestos or hexavalent chromium.

#### Contaminants From Other Sources

The potential historical land uses within the north-east part of the Precinct identified in Section 6.7.3 have potential to have resulted in the following contaminants being present in soil or groundwater:

- **Petroleum hydrocarbons.** Facilities such as bulk fuel and oil storage, and wash bays/oil-water separators have potential to result in volatile and non-volatile hydrocarbon contamination in soil, with potential to migrate in free and dissolved phase in groundwater, presenting a risk of exposure to humans during intrusive activities and to the environment in the event of discharge to local waterways. In addition, volatile fractions (such as from petrol) may present a vapour exposure risk to humans.

- **Solvents.** Solvents may have been used in the area in a variety of activities including spray-painting and washing/degreasing metal items.

- **Organochlorine and organophosphate pesticides and herbicides.** Herbicides and pesticides may have been used along the former railway easement and on some industrial sites. However, based on the types of historical land use within the north-east portion of the Precinct it is considered likely that the quantities which may have been used would be low and the risk to human health and the environment would similarly be low.

- **Metals.** There is potential for metal contamination to have been associated with some industrial activities (other than chromium waste) within the north-east part of the Precinct, however, in general the
extent of impact if any is considered likely to be localised, and the risk to human health and the environment is considered to be low.

In summary the contamination most likely to have resulted from historical land uses within the north-east part of the Precinct and most likely to warrant remediation is hexavalent impacts of soil and groundwater, asbestos impacts in soil, and petroleum hydrocarbon contamination of soil and groundwater, particularly on sites that contained underground bulk fuel or oil storage systems.

Potential areas of contamination, exposure pathways and receptors for the contaminants are summarised in Table 16.

**Table 16: Areas of Contamination, Exposure Pathways and Receptors – North-Eastern part of Camellia Precinct**

<table>
<thead>
<tr>
<th>Media</th>
<th>Contaminants</th>
<th>Exposure Pathways</th>
<th>Receptors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil / Fill</td>
<td>Asbestos, Hexavalent chromium, Other metals, Polycyclic aromatic hydrocarbons, Petroleum hydrocarbons, Organic solvents, Herbicides and pesticides</td>
<td>Direct contact, such as for intrusive construction or maintenance works, Airborne dust, particularly asbestos and hexavalent chromium if at surface or if soil/fill material is disturbed, such as for intrusive construction or maintenance works, Vapour inhalation (petroleum hydrocarbons and organic solvents), Wicking of hexavalent chromium into building materials presenting a risk of exposure via direct contact and/or airborne dust</td>
<td>Environmental Foreshore Area mangroves and Parramatta River Human Construction / maintenance workers on-site during intrusive works, Off-site persons such as pedestrians or nearby workers or residents</td>
</tr>
<tr>
<td>Groundwater</td>
<td>Hexavalent chromium, Other metals, Polycyclic aromatic hydrocarbons, Petroleum hydrocarbons, Organic solvents, Herbicides and pesticides</td>
<td>Direct contact, such as for intrusive construction or maintenance works, or discharge to the Parramatta River, Vapour inhalation (petroleum hydrocarbons and organic solvents)</td>
<td>Environmental Foreshore Area mangroves and Parramatta River Human Construction / maintenance workers on-site during intrusive works, Off-site persons such as pedestrians or nearby workers or residents</td>
</tr>
</tbody>
</table>
6.7.5 Potential Remediation and/or Management Options

The selection of remediation and management options would be driven by the nature and extent of contamination present and the proposed future use of the land. The contamination considered most likely to trigger the need for remediation and/or management works are asbestos in fill material, hexavalent chromium in soil (fill), stormwater and groundwater, and petroleum hydrocarbons in soil and groundwater.

The remediation and/or management options which are considered most likely to be applicable to contamination in the north-east part of the Precinct are as listed in Table 17.

<table>
<thead>
<tr>
<th>Contamination</th>
<th>Media</th>
<th>Remediation and/or Management Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asbestos</td>
<td>Soil – fill material</td>
<td>Removal of surficial asbestos</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cap and contain buried asbestos, in-situ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Implement a site management plan to prevent future disturbance of asbestos material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Excavation and off-site landfill disposal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Excavation and on-site containment cell disposal</td>
</tr>
<tr>
<td>Hexavalent chromium</td>
<td>Soil – fill material, wicking through pavements contaminating pavement and building materials, and generating dust and pooled leachate</td>
<td>Cap and contain, in-situ, with impermeable barrier to prevent wicking of chromium</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Implement a site management plan to prevent future disturbance of impacted materials</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Excavation and off-site landfill disposal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Excavation and on-site containment cell disposal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Excavation and treatment (encapsulation/stabilisation)</td>
</tr>
<tr>
<td>Groundwater</td>
<td>In-situ chemical reduction to trivalent chromium</td>
<td>Implement a site management plan to prevent extraction and future disturbance of impacted materials</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hydraulic containment</td>
</tr>
</tbody>
</table>
### CAMELLIA PRECINCT CONTAMINATION AND REMEDIATION STUDY - STAGE 2

<table>
<thead>
<tr>
<th>Contamination</th>
<th>Media</th>
<th>Remediation and/or Management Options</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Physical containment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pump and treat system</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Permeable reactive barrier system</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Natural attenuation</td>
</tr>
<tr>
<td>Petroleum</td>
<td>Underground storage tanks</td>
<td>Empty tanks, remove and dispose of tank and backfill sands, validate tank pit and backfill with verified clean fill materials</td>
</tr>
<tr>
<td>hydrocarbons</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soil</td>
<td></td>
<td>Cap and contain, in-situ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Implement a site management plan to prevent future disturbance of impacted materials</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Excavation and off-site landfill disposal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Excavation and on-site containment cell disposal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Excavation and treatment /bio-remediation (land farming)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In-situ treatment</td>
</tr>
<tr>
<td>Groundwater</td>
<td>Groundwater – free phase</td>
<td>Active/passive skimming and off-site disposal of skimmed fraction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In-situ enhance bioremediation (i.e. bio sparge)</td>
</tr>
<tr>
<td></td>
<td>Groundwater – dissolved</td>
<td>Enhanced in-situ biodegradation, chemical oxidation</td>
</tr>
<tr>
<td></td>
<td>phase</td>
<td>Pump and treat system</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Natural attenuation</td>
</tr>
<tr>
<td>Vapour</td>
<td></td>
<td>Soil vapour extraction following source remediation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Implementation of a site management plan and building designs including vapour barrier and vapour mitigation designs</td>
</tr>
</tbody>
</table>

### 6.7.6 Site Condition Post Remediation

#### 6.7.6.1 Employment Zone

It should be noted that the proposed remediation works were based on the objective of making the site suitable for redevelopment for Employment Zone land use, subject to an ongoing site management plan. The scenario being considered is hypothetical, and may not be an accurate representation of the actual conditions in the north-east of the Precinct. The actual conditions at a particular location/site and the level of effort required to remediate will determine which approaches are economically and technically feasible. It is plausible that the extent of asbestos and chromium contamination in the fill materials may warrant an approach similar to that proposed for 1 Grand Avenue, where the RAP stated that "given the extent of asbestos waste buried on site it is considered not to be feasible to treat it in any other way than to ensure that it remains securely isolated by complete and permanent surface seals in the form of concrete or bituminous concrete pavements".

Adopting this approach would involve removing underground storage tanks, and remediating the hydrocarbon impacted soil, and subsequently leaving as much of the existing pavements in place as possible, and covering the site with a layer of clean fill, which in turn would be sealed with new concrete pavements for a new development. It is assumed that an additional requirement would be installation of an
impermeable barrier to prevent upwards wicking of hexavalent chromium into the pavement. The design of the building footings on the site would need to take into account the approach of limiting the disturbance the contaminated fill materials.

It is also noted that construction of underground car parking would be precluded. The capping and sealing of the site may reduce the groundwater infiltration rates, and subsequently reduce the rate at which chromium impacted groundwater may migrate towards the Parramatta River. However, it is possible that direct remediation action would be required to reduce the mass of hexavalent chromium migrating into the Parramatta River. Within this scenario, the most effective method of remediation is considered to be the installation of a Permeable Reactive Barrier on the northern boundary of the site. The Barrier would provide an in situ treatment method to chemically reduce the hexavalent chromium to the less toxic trivalent form of chromium prior to impacting the Parramatta River.

These remedial methods would require implementation of a long term site management plan. The site management plan would aim to maintain a permanent cover over the site and not disturb buried impacted materials. The plan may impose constraints on the design, construction methodology and cost of redevelopment and future use of the site. The construction of footings and services and earthworks which may be required to enable development of the site would need to be undertaken in a manner which manages the risks of encountering contaminated soil and groundwater remaining on the site.

6.7.6.2 Public Recreation Zone

The remediation works proposed for the proposed Public Recreation Zone along the Parramatta River are based on the objective of making the area suitable for development for public recreational land use, subject to an ongoing site management plan. The scenario being considered is hypothetical, and may not be an accurate representation of the actual conditions in the north-east of the Precinct. The proposed Public Recreation Zone is considered to be a shared use trail extending parallel and adjacent to the Parramatta River. It is envisioned that to maximise the amenity of the area, access to the river would not be directly restricted (i.e. restricted through fencing or the like), however, direct access routes would not be provided and recreational use of the river would not be encouraged.

The actual conditions along the River frontage and the level of effort required to remediate would determine which approaches are economically and technically feasible. The scenario adopted is focused on controlling the potential exposure of recreational users to asbestos and chromium impacted materials, through either direct contact and/or dust inhalation. The remediation approach includes the excavation and replacement of shallow fill materials along the river bank, with the excavation extending from the top on the river bank down the mean low tide mark. Materials removed would be replaced with low permeability clays, protected with heavy rock armouring to provide stability against bank erosion. Ongoing seepage of contaminated groundwater through the river bank would be addressed within the remediation of the adjoining land on a ‘site by site’ basis, rather than as part of the river bank remediation works.

The adopted remedial method would require implementation of a long term site management plan. The management plan would aim to maintain a permanent river bank cover and not disturb buried impacted materials. The management plan would also need to consider maintenance of appropriate controls to limit the public accessing the sediments in the Parramatta River which have not been considered within the Remediation Scope.

6.7.7 Proposed Remediation Scenario

The proposed remediation scenario is based on a hypothetical contamination scenario on an industrial site with an area of five hectares (typical of land holdings in the north east part of the Precinct) and comprising the following remediation works:

- Remove surface asbestos from approximately 300 m² x 0.25 m depth and bury on site, subject to a long term site management plan.
- Removal of petroleum hydrocarbon underground storage tanks (USTs, assume 2 x 25 kL), one bowser island and associated lines / pipes etc.
Excavate hydrocarbon contaminated soil from UST pits and aboveground source areas (such as drum stores and aboveground storage tanks) and treat on site (land farming / bio piles) prior to reuse. It is assumed that the UST excavation is 15 m x 10 m and up to 4 m depth, and assumed that the above ground source footprints are 25 m x 20 m up to 1m depth. The base and walls of the excavation below water table would be dosed with an oxygen releasing compound. Contaminated groundwater seepage into the excavation void would be pumped-out and disposed off-site as potentially contaminated with hydrocarbons.

Installation of a Permeable Reactive Barrier (PRB) through high flux hexavalent chromium seepage zones. It is assumed that the PRB would be installed along the northern site boundary and target zones of high flux for chromium contaminated perched groundwater. The PRB will comprise installation of low permeability gravels mixed with a chromium reducing agent such as zero-valent iron. It is assumed that a total length of 200 m of PRB is required. The PRB will be up to 5 m deep, and keyed into underlying low permeability clay, up to 10 m wide and keyed in to low permeability soil material located adjacent to high flux zone and up to 1.0 m thick.

Cover whole of site (assume 5 hectares) with a layer of clean fill and surface with capping material, including an impermeable barrier to prevent upwards wicking of hexavalent chromium, and implement long term management plan.

The proposed river bank remediation works would comprise the following:

Excavation and replacement of asbestos wastes and chromium-impacted soil/fill along the Parramatta River Bank. It is assumed that the width of river bank requiring remediation is 3 m, and that the wastes are up to 1 metre deep. The waste would be removed and replaced with low permeability capping, and armoured with heavy rock to prevent wash erosion along river frontage.

Assume remediation works are required along 500 metres length of river bank.

Assume that the wastes are disposed off-site as Restricted Waste / Special Wastes - Asbestos.

6.7.8 Remediation Cost Estimate
Remediation costs have been estimated separately for the industrial site and the river bank works.

6.7.8.1 Industrial Site
For the proposed scope of remediation works and subject to the defined assumptions, the cost for the industrial site was estimated to be $4,600,000 (excluding GST). For planning purposes it is recommended that a contingency of 20% be applied, resulting in an estimated cost of $5,500,000 (excluding GST).

6.7.8.2 River Bank
For the proposed scope of remediation works and subject to the defined assumptions, the cost for the industrial site was estimated to be $2,000,000 (excluding GST). For planning purposes it is recommended that a contingency of 20% be applied, resulting in an estimated cost of $2,400,000 (excluding GST).

All cost estimates are rounded to two significant figures.

7.0 TASK 4 - PRECINCT-SPECIFIC DCP OR GUIDELINE
The Department requested recommendations for matters to be included in a Precinct-specific Development Control Plan (DCP) or guideline to be prepared by the Department and used by Council regarding the staging/timing of remediation and the ongoing management of potential conflicts resulting from active remediation works adjoining redeveloped or acquired sites.

It is noted that controls relating to contaminated land remediation are outlined in State Environmental Planning Policy 55 – Remediation of Land (SEPP 55), which is supplemented by the 1998 publication, by the then NSW Department of Urban Affairs and Planning (now known as the NSW Department of Planning &
Environment) and the NSW Environment Protection Authority, titled *Managing Land Contamination: Planning Guidelines SEPP55 – Remediation of Land.*

Parramatta City Council has implemented additional controls to manage contamination risks during development as documented in the following:

- Parramatta Development Control Plan;
- Parramatta City Council’s Contaminated Land Policy;
- Parramatta City Council’s Asbestos Management Policy; and
- Parramatta City Council’s Asbestos Management Guidelines.

It is considered that these controls provide Council with appropriate mechanisms to address contamination risks during development within the Precinct.

Golder has not identified specific documented controls which could be applied to the staging/timing of remediation to facilitate the ongoing management of conflicts. It is noted that the land allotments within the Precinct are individually owned by multiple parties and that development of adjoining land allotments may occur at different times, creating the risk of impacts from future remediation works being undertaken on neighboring sites. Golder has not identified a mechanism by which development on one site may be restrained or otherwise controlled to take into account an unspecified future impact of remediation on an adjoining or nearby site. It is considered that such risks would need to be evaluated on a ‘case by case’ basis and strict environmental management controls applied to mitigate risks.

It is recommended that a Precinct-specific Development Control Plan (DCP) or guideline to be developed and used by Council include a statement requiring development proposals to have particular regard to the potential impact of the following Precinct-specific contamination risk factors during the construction and post-construction stages of development:

- Shallow groundwater environment.
- Low lying land within the 1:100 year average recurrence interval flood level.
- Acid sulphate soils.
- Fill materials of variable and unknown composition.
- Hexavalent chromium contamination in fill materials, soil, groundwater and stormwater, including the potential for hexavalent chromium to wick upwards through soil and fill materials into surface pavements and building structures.
- Asbestos wastes in soil and fill materials, including asbestos pulp.
- Hydrocarbon contamination in fill materials, soil and bedrock, soil vapour and groundwater.

In particular, these risks should be considered with respect to the design of in-ground structures and building services, structures at ground level and landscaping plans.
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9.0 IMPORTANT INFORMATION

Your attention is drawn to the document titled - “Important Information Relating to this Report”, which is included in Appendix A of this report. The statements presented in that document are intended to inform a reader of the report about its proper use. There are important limitations as to who can use the report and how it can be used. It is important that a reader of the report understands and has realistic expectations about those matters. The Important Information document does not alter the obligations Golder Associates has under the contract between it and its client.
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TC/CMV/tc

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4. PERMITTED LAND USES MAY CHANGE FROM BUSINESS DEVELOPMENT AND PRIVATE RECREATION TO MIXED USE / ENTERTAINMENT

AREAS WHERE LAND USES MAY CHANGE TO A MORE SENSITIVE CATEGORY

CLIENT
NEW SOUTH WALES DEPARTMENT OF PLANNING AND ENVIRONMENT

PROJECT
CAMELLIA PRECINCT CONTAMINATION STUDY

TITLE
AREAS WHERE LAND USES MAY CHANGE TO A MORE SENSITIVE CATEGORY

CONSULTANT

PREPARED

DESIGN

REVIEW

APPROVED

YYYY-MM-DD

2015-08-27

RHH

TC

TC

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PROJECT No.
1523328

CONTROL
002-R

Rev.
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FIGURE
2
FORMER ASBESTOS CEMENT MANUFACTURING FACILITY

Clyde - Carlingford Railway Line

Site Boundary

Site Workers

Dust

Asbestos at ground surface

Road-base, Sandstone, Gravelly Fill (depth approximately 0.2m)

Asbestos Waste (friable pulp / bonded product) and Boiler Ash (depth approximately 5m)

Quaternary Alluvium (sand, silt and clay)

Asbestos Shale Bedrock

Groundwater Present in Fracture Systems

Hawkesbury Sandstone Bedrock

Groundwater Present in Fracture Systems

Asbestos Waste

Former Press (Hydrocarbons)

Underground Storage Tank

Inferred Perched Groundwater Table

Hydrocarbon Contaminated Soil

Hydrocarbon Contaminated Groundwater

Parramatta River

Mangroves

Clyde - Carlingford Railway Line

NOTES

1. BASED ON INFORMATION IN DOCUMENT TITLED:
   REMEDIATION ACTION PLAN, 1 GRAND AVENUE, CAMELLIA, NSW
   PREPARED BY CONSULTING EARTH SCIENTISTS PTY LTD FOR BILLBERGIA GROUP
   DATED 26 MARCH 2008 AND LETTER FROM CONSULTING EARTH SCIENTISTS PTY LTD TO
   BILLBERGIA GROUP DATED 3 JULY 2008.

2. DETAILS MAY CHANGE IF ADDITIONAL INFORMATION BECOMES AVAILABLE.
HYPOTHETICAL CHROMIUM CONTAMINATED SITE

Hawkesbury Sandstone Bedrock
Groundwater Present in Fracture Systems

Ashfield Shale Bedrock
Groundwater Present in Fracture Systems

Quaternary Alluvium
(sand, silt and clay)

Asbestos Waste
(friable / bonded product)

Chromium Waste

Former ASTs
(Hydrocarbons/Organics)

Underground Storage Tank

Road-base, Concrete, Sandstone, Gravelly Fill
(depth approximately 0.2m)

Site Boundary
Site Workers
Chromium Dust
Asbestos Dust
Chromium Contaminated Groundwater

Site Boundary

Asbestos at ground surface

Inferred Perched Groundwater Table

Hydrocarbon Contaminated Soil

Chromium Contaminated Seepage Water

Mangroves
Mangroves

Chromium Contaminated Groundwater

CHROMIUM CONTAMINATED SITE

Site Boundary

Site Workers

SITE WORKERS

Asbestos Dust

Asbestos Waste

Inferred Perched Groundwater Table

Asbestos at ground surface

Quaternary Alluvium
(sand, silt and clay)

Asbestos Waste
(friable / bonded product)

Chromium Waste

Former Santown Rail Siding

Former ASTs
(Hydrocarbons/Organics)

Asbestos Waste

Asbestos Dust

Chromium Dust
APPENDIX A
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