

## 13 Multi-Criteria Matrix Assessment

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A multi-criteria matrix assessment approach has been adopted for the comparative assessment of all measures identified using a similar approach to that recommended in the Floodplain Development Manual (2005). This approach uses a subjective scoring system to assess the merits of various measures. The principal merits of such a system are that it allows comparisons to be made between alternatives using a common index. In addition, it makes the assessment of alternatives “transparent” (i.e. all important factors are included in the analysis). However, this approach does not provide an absolute “right” answer as to what should be included in the plan and what should be omitted. Rather, it provides a method by which stakeholders can re-examine measures and, if necessary, debate the relative scoring assigned.

Each measure is given a score according to how well the measure meets specific considerations. A framework for scoring has been developed for each criterion as shown in **Table 13-2**.

### 13.1 Scoring System

A scoring system was devised to subjectively rank each measure for a range of criteria considering the background information on the nature of the catchment and floodplain as well as the outcomes of a stakeholder workshop. The scoring is based on a triple bottom line approach, incorporating economic, social and environmental criterion.

A workshop with stakeholders was undertaken to determine appropriate criteria and relative weightings for each criteria and assessment categories (economic, social and environmental). During the workshops, participants were asked to identify criteria, and then score these criteria from 1 to 5 (1 being lowest importance, 5 being highest importance). **Table 13-1** shows the average scores from the two workshops that were undertaken. Note that there will also be an opportunity to update these scores following input from stakeholders and the community during the exhibition of the draft report.

Weightings for each of the criteria were based on the scoring system that was adopted. The scores were scaled to a weighting for each criteria on the following basis:

- A score of 1 is equivalent to 10% weighting
- A score of 5 is equivalent to 100% weighting
- Scores in between these values are on a linear slide scale

The weightings of each of the scores are provided in **Table 13-1**. These weightings have been utilised in the MCA to determine the relative importance of each of the criteria.

The weightings also provide some insight into the inferred importance of each of the overall categories of Economic, Social and Environmental. These overall category weightings are provided in **Table 13-1**.

**Table 13-1 Criteria for Matrix Assessment**

Category	Effective Category Weighting	Criteria	Average Scores - Workshops	Weightings
Economic	49.6%	Benefit Cost Ratio	4.3	84%
		Reduction in Risk to Property	3.8	73%
		Essential Infrastructure	3.8	73%
		Future Development	3.4	63%
		Capital Cost	3.2	59%
		Operating Costs	3.1	56%
		Constructability	2.9	54%
		Implementation Timeframe	2.7	48%
Social	30.7%	Reduction in Risk to Life	4.8	95%
		Reduction in Social Disruption	3.5	66%
		Compatibility with Council Policies & Plans	3.3	62%
		Community & Stakeholder Support	3.0	55%
		Urban Design	2.8	51%
		Governance	2.7	47%
Environment	27.5%	Compatibility with Water Quality Objectives	3.3	62%
		Groundwater	3.2	59%
		Heritage	3.0	55%
		Compatibility with Water Reuse Schemes	3.0	55%
		Fauna/Flora Impact - including street trees	2.9	54%
		Contaminated Land & Acid Sulfate Soils	2.8	51%

The scoring system is shown in **Table 13-2** for the above criteria.

Each measure is assigned a score for each criterion. The score for each category (i.e. economic, environment and social) is determined by the score for each criterion, factored by a weighting as shown in **Table 13-1**.

It is noted that the economic category is given more weight than either the environment or social categories. This is due to the economic category being the most direct measure of both the effectiveness of the measure on flooding as well as its affordability. Measures that rank highly on environmental or social categories do not necessarily provide significant flooding benefits.

A rank based on the total score is calculated to identify those measures with the greatest potential for implementation. A summary of the MCA is provided in **Appendix G**.

It is noted that both structural and non-structural measures have been considered separately. Generally, it is difficult to directly compare these types of measures. Furthermore, funding sources and implementation timeframes for the two different types of measures are typically different. Therefore, they have been considered separately and ranked as such.

Table 13-2 Criteria Scoring System

Category	Category Weighting	Criteria	Criteria Weighting	Metric	Score								
					-4	-3	-2	-1	0	1	2	3	4
		Benefit Cost Ratio	84%	BCR	0 to 0.25	0.25 to 0.5	0.5 to 0.75	0.75 to 0.9	0.9 to 1.1	1.1 to 1.25	1.25 to 1.5	1.5 to 1.75	>1.75
		Reduction in Risk to Property	73%	Change in Annual Average Damage (AAD)	>+\$1 million	+\$500,000 to +\$750,000	+\$250,000 to +\$500,000	\$0 to +\$250,000	0	-\$250,000 to \$0	-\$500,000 to -\$250,000	-\$750,000 to -\$500,000	< -\$1 million
		Essential Infrastructure	73%	For flood affected rail and road areas. Metric = Total area of flood reduction x average water level reduction in this area for the 100 year ARI (ha.m)	Increase road and rail flooding of 0.75 - 1.00	Increase road and rail flooding of 0.50 - 0.75	Increase road and rail flooding of 0.20 - 0.50	Increase road and rail flooding of 0 - 0.25	No Change	Decrease road and rail flooding of 0 - 0.25	Decrease road and rail flooding of 0.25 - 0.50	Decrease road and rail flooding of 0.50 - 0.75	Decrease road and rail flooding of 0.75 - 1.00
		Future Development	63%	For flood affected future development areas. Metric = Total area of flood reduction x average water level reduction in this area for the 100 year ARI (ha.m)	Decrease in future development potential of 1.5 - 2	Decrease in future development potential of 1 - 1.5	Decrease in future development potential of 0.5 - 1	Decrease in future development potential of 0 - 0.5	No Change	Increase in future development potential of 0 - 0.5	Increase in future development potential of 0.5 - 1	Increase in future development potential of 1 - 1.5	Increase in future development potential of 1.5 - 2
		Capital Cost	59%	Capital cost of measure	>\$10 million	\$6 million - \$10 million	\$4 million - \$6 million	\$2 million - \$4 million	\$1 million - \$2 million	\$500,000 - \$1 million	\$100,000 - \$500,000	\$50,000 - \$100,000	\$0 - \$50,000
		Operating Costs	56%	Operating cost of measure	>\$100,000 per year	\$75,000 - \$100,000 per year	\$50,000 - \$75,000 per year	\$25,000 - \$50,000 per year	\$20,000 - \$25,000 per year	\$15,000 - \$20,000 per year	\$10,000 - \$15,000 per year	\$5,000 - \$10,000 per year	\$0 - \$5,000 per year
Economic	49.6%	Constructability	54%	Difficulty in construction / implementation of measure. Including difficulties in construction, number of constraints, engineering challenges and uncertainties	Very low constructability with major constraints, challenges and uncertainties which may render the measure unfeasible	Very low constructability with some significant constraint, challenges and uncertainties which may increase costs or timeframes significantly	Low constructability with some significant constraints and challenges which may increase costs or timeframes significantly	Low constructability with some significant constraints and challenges which may increase costs or timeframes slightly	NA	Medium constructability with some likely constraints during construction and inception (but able to be overcome)	Medium constructability with some likely constraints at inception (but able to be overcome)	Very easy to construct / implement with only minor likely constraints	Very easy to construct / implement with no known constraints
		Implementation Timeframe	48%	Construction timeframe and impacts on transport and surrounding services	Long-term construction timeframe (>1 year) with significant impacts on transport and surrounding services during construction	Long-term construction timeframe (>1 year) with minor impacts on transport and surrounding services during construction	Medium-term construction timeframe (6 months - 1 year) with significant impacts on transport and surrounding services during construction	Medium-term construction timeframe (6 months - 1 year) with minor impacts on transport and surrounding services during construction	Medium to long-term construction timeframe (>6 months) with minimal impacts on traffic and surrounding services	Short-term construction timeframe (<6 months) with minimal impacts on services and traffic on major roads.	Short-term construction timeframe (<6 months) with minimal impacts on services and traffic on minor roads.	Short-term construction timeframe (<6 months) with no impacts on traffic and surrounding services	Planning related measure
		Reduction in Risk to Life	95%	FM Measures: Change in 100 year ARI high hazard area Other Measures: Subjective impacts	>9% increase in 100 Year ARI High Hazard extent OR Likely localised increase in risk to life	6-10% increase in 100 Year ARI High Hazard extent OR Likely localised increase in risk to life	3-6% increase in 100 Year ARI High Hazard extent OR Possible widespread increase in risk to life	1-3% increase in 100 Year ARI High Hazard extent OR Possible localised increase in risk to life	No change to 100 Year ARI Hazard OR No change in risk to life	1-3% decrease in 100 Year ARI High Hazard extent OR Possible localised decrease in risk to life	3-6% decrease in 100 Year ARI High Hazard extent OR Possible widespread decrease in risk to life	6-10% decrease in 100 Year ARI High Hazard extent OR Likely localised decrease in risk to life	>9% decrease in 100 Year ARI High Hazard extent OR Likely widespread decrease in risk to life
Social	30.7%	Reduction in Social Disruption	66%	Changes in social disruption	Major, widespread increase in social disruption	Slight, widespread increase in social disruption	Major, localised increase in social disruption	Slight, localised increase in social disruption	No change to social disruption	Slight, localised decrease in social disruption	Major, localised decrease in social disruption	Slight, widespread decrease in social disruption	Major, widespread decrease in social disruption
		Compatibility with Council Policies & Plans	62%	Level of compatibility	Very Strong disagreement	Strong disagreement	Moderate Disagreement	Minor Disagreement	Neutral/No response	Minor Support	Moderate Support	Strong support	Very Strong support

Category	Category Weighting	Criteria	Criteria Weighting	Metric	Score											
					-4	-3	-2	-1	0	1	2	3	4			
Community & Stakeholder Support	55%	Level of agreement	Majority strong disagreement, no positive responses	Majority strong disagreement, isolated positive responses	Majority strong disagreement, isolated positive responses	Majority strong disagreement, isolated positive responses	Majority strong disagreement, isolated positive responses	Majority strong support, isolated negative responses	Majority strong support, isolated negative responses	Majority very strong support, no negative responses						
											Major conflicts with wide urban design considerations already in place or planned for the catchment	Major conflicts with localised urban design considerations already in place or planned for the catchment	Minor conflicts with localised urban design considerations already in place or planned for the catchment	Neutral or limited responses provided	Some urban design considerations could be incorporated in measure	Majority support, no negative responses
Urban Design <sup>2</sup>	51%	Urban design considerations	Major conflicts with wide urban design considerations already in place or planned for the catchment	Major conflicts with localised urban design considerations already in place or planned for the catchment	Minor conflicts with localised urban design considerations already in place or planned for the catchment	Neutral or limited responses provided	Some urban design considerations could be incorporated in measure	Majority support, no negative responses	Majority very strong support, no negative responses	Significant urban design considerations have been incorporated in measure						
Governance	47%	Level of support by government agencies and Council	Majority strong disagreement, no positive responses	Majority strong disagreement, isolated positive responses	Majority strong disagreement, isolated positive responses	Majority strong disagreement, isolated positive responses	Majority strong support, no negative responses	Majority strong support, no negative responses	Majority very strong support, no negative responses	Majority strong support, no negative responses						
Compatibility with Water Quality Objectives <sup>3</sup>	62%	Compatibility with objectives	Very Strong disagreement	Strong disagreement	Moderate disagreement	Minor disagreement	Neutral/No response	Minor Support	Moderate Support	Very Strong support						
Groundwater	59%	Impact on groundwater	Very high potential to negatively impact groundwater quality and/or flow	High potential to negatively impact groundwater quality and/or flow	Moderate potential to negatively impact groundwater quality and/or flow	Slight potential to negatively impact groundwater quality and/or flow	No impact	Possible minor benefit	Likely minor benefit	Very high potential to positively impact groundwater quality and/or flow						
Heritage	55%	Impacts to heritage items, including consideration of heritage items as identified in Appendix C.	Destruction of State or National heritage item	Likely impact on State or National heritage item	Likely impact on local heritage item <sup>5</sup>	Possible impact on local heritage item <sup>5</sup>	No impact	Possible minor benefit	Likely minor benefit	Likely considerable benefit						
Environment	27.5%	Compatibility with Alternative Water Schemes <sup>4</sup>	Very Strong disagreement	Strong disagreement	Moderate disagreement	Minor disagreement	Neutral/No response	Minor Support	Moderate Support	Very Strong support						
Fauna/Flora Impact - Including Street Trees	54%	Impacts to floral/ fauna	Likely impacts on threatened species	Likely broad-scale vegetation / habitat impacts	Likely isolated vegetation / habitat impacts	Possible isolated vegetation / habitat impacts	No impact	Possible isolated vegetation / habitat benefits	Likely isolated vegetation / habitat benefits	Broad-scale vegetation / habitat benefits for threatened species						
Contaminated Land & Acid Sulfate Soils	51%	Works within PASS or contaminated land.	Significant excavation within areas identified as PASS or Contaminated Land	Minor excavation within areas identified as PASS or Contaminated Land	Significant surface works within areas identified as PASS or Contaminated Land	Minor surface works within areas identified as PASS or Contaminated Land	No impact	NA <sup>6</sup>	NA <sup>6</sup>	NA <sup>6</sup>						

<sup>1</sup> Values of likely AAD reduction assumed where calculations were not able to be undertaken.

<sup>2</sup> Urban design considerations include elements such as underground basins, open space and road upgrades.

<sup>3</sup> DCP 2012 Objectives (for sites greater than 1,000m<sup>2</sup>):

- a) reduce the baseline annual pollutant load for litter and vegetation larger than 5mm by 90%;
- b) reduce the baseline annual pollutant load for total suspended solids by 85%;
- c) reduce the baseline annual pollutant load for total phosphorous by 65%. and

d) reduce the baseline annual pollutant load for total nitrogen by 45%.

<sup>4</sup> Compatibility with Decentralised Water Master Plan 2012–2030.

<sup>5</sup> Local heritage items have not been specifically identified as part of this study. The Sydney Local Environment Plan (LEP) 2011 also lists 559 heritage items of significance that are found within or around the catchment under Schedule 5 of the LEP.

<sup>6</sup> For the purposes of this assessment the rehabilitation of ASS or Contaminated Sites has not been considered.

## 14 Conclusions

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This Floodplain Risk Management Study provides Council with critical information pertaining to floodplain management in the catchment including:

- Provisional Flood Hazard and additional hazard considerations such as effective flood access and rate of rise of flood waters.
- Hydraulic Categorisation.
- A review of existing emergency response arrangements and recommendations for updates.
- A review of planning considerations and recommendations for updates.
- The economic damages incurred in the catchment as a result of existing flood behaviour.

In order to assist Council and the relevant agencies in managing flood risk within the Alexandra Canal Catchment, an assessment of potential floodplain risk management options has been undertaken. The outcome of the assessment identified a key role for planning related measures to manage the existing flood risk. Several flood modification (structural) measures were also identified as viable measures for implementation.

The following measures were ranked as the top 20 and should be considered for further assessment and / or implementation:

### Non-Structural Measures-

- FM15 Liveable Green Network
- FM23 Increased pit cleaning and maintenance
- EM1 Information Transfer to SES
- EM2 Preparation of District DISPLAN
- EM3 Preparation of Local Flood Plan
- PM3 Opportunities related to Large Scale Future Development
- PM2 Development Controls and Policies
- EM5 Public awareness and education
- PM1 LEP Update
- EM6 Flood warning signs at critical locations
- PM9 Flood Proofing Guidelines
- EM4 Flood Warning System and Temporary Refuge

### Structural Measures-

- FM9 Link Road to Alexandra Canal Upgrade – Maddox Street Alignment
- FM6 Additional pipes from Macdonald Street and Coulson Street to Alexandra Canal (alternatively FM21 Detention Basin in Sydney Park – Offset Storage from Macdonald Street)
- FM7 Detention basins in Redfern Park.
- FM18 Additional Drainage Network at Harcourt Parade to Gardeners Road

- FM17 Detention basin in Turruwul Park
- FM20 Sheas Creek Channel Flood Walls

The implementation strategy resulting from the assessment undertaken in this Floodplain Risk Management Study is outlined in the Floodplain Risk Management Plan.

## 15 References

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- OEH (2012a) NPWS Atlas of NSW Wildlife, NSW Government.
- OEH (2012b) Aboriginal Heritage Information Management System, NSW Government.
- OEH (2012c) State Heritage Register, NSW Government.
- SES (2012) Business FloodSafe Toolkit and Plan – Flash Flooding, State Emergency Services and Flood Safe
- WMA Water (2013) Green Square Catchment Floodplain Risk Management Plan.



Alexandra Canal Floodplain Risk  
Management Study and Plan

**APPENDIX A**  
COMMUNITY BROCHURE, SURVEY  
AND PHOTOGRAPHS



# Alexandra Canal Catchment Floodplain Risk Management Study and Plan

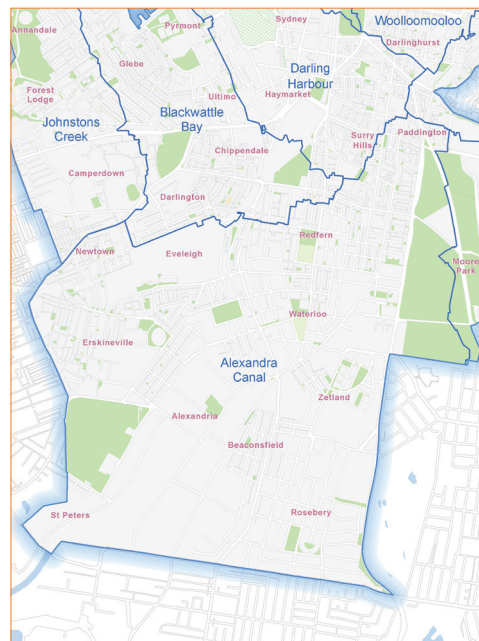
March 2013



**The City of Sydney is preparing a Floodplain Risk Management Study and Plan for the Alexandra Canal Catchment area and we would like your help.**

**The study will tell us about the type of flood mitigation solutions feasible for the catchment and help us plan for and manage any flood risks.**

**Good management of flood risks can help reduce damage and improve social and economic opportunities.**





The City of Sydney has engaged Cardno to assist with the preparation of the Alexandra Canal Floodplain Risk Management Study and Plan.

The Alexandra Canal Flood Study was completed by Cardno in 2011, giving the City of Sydney a better understanding of the nature of flooding in your area. The next step in the NSW Government Flood Management Process is the preparation of a Floodplain Risk Management Study and Plan. The purpose of this study and plan is to identify and recommend appropriate actions to manage flood risks in the Alexandra Canal floodplain.

This brochure provides an introduction to the Floodplain Risk Management Study and Plan and informs you of its objectives.

### Stages of the NSW Government Flood Prone Land Policy

1. Formation of a Committee – complete
2. Data Collection – complete
3. Flood Study – complete
4. Floodplain Risk Management Study
5. Floodplain Risk Management Plan
6. Implementation of Plan.

### Study area and flooding issues

The Alexandra Canal catchment includes the suburbs of Alexandria, Rosebery, Erskineville, Beaconsfield, Zetland, Waterloo, Redfern, Newtown, Eveleigh, Surry Hills and Moore Park.

The majority of the catchment includes residential, commercial and industrial land uses. Open spaces within the catchment include Moore Park playing fields, Moore Park Golf Course, the Australian Golf Course, Sydney Park, Redfern Park, Waterloo Park and Alexandria Park.

Much of the flooding in the catchment occurs due to natural depressions and low points. In the past, flooding has caused property damage and posed a hazard to people and property located near drainage areas. The Floodplain Risk Management Study and Plan currently being undertaken is to manage these flood risks.

### Have your say

We want your comments about previous flood experiences and potential mitigation options.

The local knowledge of residents and business operators, including your personal experiences of flooding is a valuable source of information.

The information you provide in the accompanying questionnaire will help the City of Sydney determine how to manage the floods in your area.

For more information about this project, please contact the City of Sydney or Cardno via the details provided.

### Floodplain risk management options

The following list of floodplain risk management options are examples of the type of strategies that could be considered to minimise risk and reduce the impact of flooding in the catchment. These options will be investigated in more detail during the preparation of the Management Study and Plan. There are general categories of options.

#### Flood modification options.

Examples include:

- Construction of detention/retarding basins to reduce the peak flow downstream;
- Upgrading of drainage systems, upgrade of existing pipes or construction of new pipes, or
- Regrading of roads to provide better overland flowpaths.

#### Property modification options and planning control.

Examples include:

- Building and development controls,
- Flood-proofing measures, such as flood barriers.

#### Response modification options.

Examples include:

- Revision of the Local Disaster Plan (DISPLAN);
- Public awareness and education – locality based flooding information for residents;
- Public awareness and education – flooding information for schools;
- Flood depth markers at major (flood affected) road crossings;
- Continuation of existing public awareness and education campaigns; and
- Data collection strategies for future floods.

### For more information please contact:

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# Local Resident/Land Owner Survey

The City of Sydney is carrying out a Floodplain Risk Management Study and Plan for the Alexandra Canal catchment. Please return your completed questionnaire in the reply paid envelope by Friday 19 April 2013.

We appreciate you taking the time to assist us. Please return your completed questionnaire in the reply paid envelope by Friday 19 April 2013.

## 1

Please provide the following details as we may contact you to discuss some of the information you have provided us.

Name: .....

Address: .....

Contact phone number:.....

Email: .....

## 2

What is the best way to contact you?

Letter (post)

Email

Phone

## 3

How many people regularly live/work on this property?

.....  
.....  
.....

## 4

What are the number of permanent residents/workers at this address aged?

0-4 years

5-14 years

15-64 years

65+ years

## 5

What is the main language spoken at this address?

English

Other (please specify) .....

6

Is your property (please tick)

- Owner occupied
- Occupied by a tenant
- Business
- Other (please specify) .....

7

What type of structure is your property/business? (please tick)

- Freestanding house .....
- Apartment .....
- Dual occupancy .....
- Industrial .....
- Commercial .....

8

How long have you lived, worked at and/or owned your property?

Years .....

Months .....

9

Have you ever experienced flooding since living and/or working in the Alexandra Canal catchment? (please tick relevant boxes)

- Yes, floodwaters entered my house/business
- Yes, floodwaters entered my yard/surrounds of my business
- Yes, the road was flooded and I couldn't get to my car
- Yes, other parts of my neighbourhood were flooded
- No, I haven't experienced flooding

10

Do you have any materials or photos you can provide to evidence the flooding you experienced? If yes, when did this flood occur?

- No
- Yes – the flooding occurred on: .....

As a local resident who may have witnessed flooding/drainage problems, you may have your own ideas about how to reduce flood risks. Which of the following management options would you prefer for the Alexandra Canal catchment (1=least preferred, 5=most preferred)?

Proposed option	Preference
Stormwater harvesting, such as rainwater tanks — Suggested location/other comments:	1 2 3 4 5
Retarding or detention basins (these temporarily hold water and reduce peak flood flows) — Suggested location/other comments:	1 2 3 4 5
Improved flood flow paths — Suggested location/other comments:	1 2 3 4 5
Culvert/bridge enlarging — Suggested location/other comments:	1 2 3 4 5
Pit and pipe upgrades — Suggested location/other comments:	1 2 3 4 5
Levee banks or flood walls — Suggested location/other comments:	1 2 3 4 5
Strategic planning and flood related development controls — Suggested location/other comments:	1 2 3 4 5
Education of the community, providing greater awareness of potential hazards — Suggested location/other comments:	1 2 3 4 5
Flood forecasting, flood warnings, evacuation planning and emergency response measures — Suggested location/other comments:	1 2 3 4 5

Other (please specify any options you think are suitable):.....  
 .....  
 .....

If you have any further comments that relate to the Alexandra Canal Flood Management Study and Plan, please write them in the space below. Feel free to attach additional pages if necessary.

.....  
 .....  
 .....

### Glossary

- Culvert** – a piped drain or covered channel that passes under a road or railroad.
- Levee bank/flood wall** – An embankment or wall, usually constructed from earth or concrete, built along the banks of a watercourse to help prevent overflow of its waters.
- Retarding/detention basin** – Depression in the land surface that captures and holds stormwater runoff allowing it to slowly drain out of the basin into the adjoining natural drainage line or creek.
- Stormwater harvesting** – the collection, storage, treatment and use of stormwater run-off from urban areas.

**Privacy notice:** The information obtained from the survey will be used by staff from the City of Sydney Council and Cardno only. The information supplied will remain completely confidential.



Photograph 1 – Botany Road – Buckland Street Intersection Alexandria 14<sup>th</sup>/15<sup>th</sup> February 2010 (H. Gelbart)



Photograph 2 – At Ashmore Street, Erskineville (D. McCrudden)



Photograph 3 – At Ashmore Street, Erskineville (D. McCrudden)



Photograph 4 – Septimus Street Erskineville – 8/11/2011 5:34PM (D. Adams)





Photograph 5 – Hunter Street Waterloo - May 2011 (J. Chaytor)



Photograph 6 – Hunter Street Waterloo - May 2011 (J. Chaytor)

Alexandra Canal Floodplain Risk  
Management Study and Plan

**APPENDIX B**  
COMMITTEE AND STAKEHOLDER  
WORKSHOP OUTCOMES

## Alexandra Canal Floodplain Risk Management Study and Plan



**Meeting:** Management Options Workshop 1 – Internal Council – 15 April 2013  
Management Options Workshop 2 – Committee Members and Stakeholders – 29 April 2013

**Location:** City of Sydney

Cardno (NSW/ACT) Pty Ltd  
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Telephone: 02 9496 7700  
Facsimile: 02 9439 5170

**File No:** W4948

Floodplain management options workshops for committee members and stakeholders were held on the 15<sup>th</sup> and 29<sup>th</sup> April 2013. These workshops presented a preliminary review of flood management options and their assessment to allow feedback and discussion from participants. The workshops included:

- An introduction;
- A presentation on project progress and preliminary management options;
- Discussion on options;
- A presentation on the multi-criteria assessment for evaluating options;
- Discussion on option assessment; and
- A project schedule.

### Attendees

The combined workshops consisted of the following number of representatives who were present at the meetings:

- Community Representatives = 3;
- State Emergency Service = 1;
- Office of Environment & Heritage = 1;
- City of Sydney = 14; and
- Cardno = 3.

### General Comments

- Options include property modification, planning, response modification as well as structural.
- Option hierarchy - not just structural first, because they have time and cost constraints. Therefore, need to be looked at a combined approach including planning and response modification.
- Structural options have been modelled to identify additional capacity that is required. They do not necessarily represent the final solution, but the capacity identified can inform the refinement of the design moving forward. Funding mechanisms for options, such as a special levy, not in scope of this study.
- Community questionnaire listed options generally (rather than specific options). Additional feedback on specific options will be gained during the public exhibition of the draft study.
- LEP gazetted and DCP adopted for City of Sydney.

### Floodplain Modification Options – Interim Paper

Preliminary structural options were described in the Interim Paper dated 11 April 2013 and options discussed are referenced to this previous document.

### FM6

- Consider option of using Sydney Park as a basin to offset ponding in Coulson Street. This will save having to connect a pipe from here through to Alexandra Canal.

- A water reuse project has been constructed in the vicinity to pump water to Sydney Park. The system has capacity of about 1 to 2m<sup>3</sup>/s. May have limited influence on flooding.
- Ashmore Estate development will take time. Should take into account development time for potential options.
- An on-site park is currently within the Ashmore Street Masterplan. This park, from a flooding point of view, acts to slow the waters rather than specifically as a detention basin. It is not sufficient to control the flooding at Coulson Street.

#### FM7

- Council has prepared a design for an underground storage at Redfern Park / Redfern Oval. The system was designed to provide offset storage to drain the street to the west. The high water table in this location may limit application of underground storage.
- Works in this area are difficult as Danks Street development already happened.

#### FM8

- There is a water reuse scheme option for water of this park. A high groundwater level and possible contamination were issues. Review water reuse scheme to add into the FRMSP. Should consider a collection system and above-ground storage for feasibility.

#### FM9-FM10

- An option for the Green Square Town Centre area needs to be listed in the FRMSP.

#### FM11

- The 20 year strategy will introduce additional flows to Alexandra Canal. Consider potential resuspension and mobilisation of pollutants from Alexandra Canal sediment which has not had a flushing event in years.
- Review the existing system and determine if there are particular pipe sections restricting the capacity. A pipe capacity assessment could identify under-utilised section/reach or a particular choke point.
- If Arthur St does not have much overflow flooding the 20 year capacity system may not be required at this location. This will be reviewed further with the analysis of the floor level survey.

#### FM12

- Consider Kippax Lake (between Anzac Parade and SCG) as an offset storage (potentially for irrigation purposes) noting it is a relatively significant distance from the site. Lake could be dredged to create additional airspace.
- Proposed light-rail system on Devonshire St may be a constraint or opportunity. The light-rail system may go underground.

#### FM14

- Potentially Railcorp is already using this land. This is likely to reduce the feasibility of this option.

#### FM16

- Estimate potential monetary damage due to flooding at this location to evaluate its relative importance within the overall catchment.
- Proposed alignment of M5-East expansion comes near here.
- The regional metro strategy identifies urban development, south of FM16, around Mascot station

#### FM18

- Rosebery B Subcatchment needs a viable option.
  - Potentially purchase a couple of properties for overland flowpath.
  - Floor level survey will be able to ascertain the relative damage / importance.
  - Recharge may be an option since this area is sandy with high infiltration.
- Location has a high water table as used to be a swamp area.
- Hydrocon permeable pipes have been installed in Harcourt Parade which is working well, though adjacent residents are still complaining about flooding where they are not installed. Should consider aquifer reinjection option instead of FM18.
- Review floor level survey and flood damages to evaluate the relative importance of flood inundation in this subcatchment.

#### FM20

- Liveable Green Network (LGN) is part of Council's plans.

#### Other Options and Comments

- The desalination pipe goes up Euston Road thus constricts options which cross this location.
- Regarding land acquisitions to the north of Bowden Street – contact Mike Brown for further details.
- Site acquired at Mandible St and Bowden St – detention basin considered for Liveable Green Network (LGN) and Green Square Town Centre (GSTC) assessments.
- Raising the bridges at Huntley St, Maddox St, and Bowden St Etc. to increase culvert capacity.
- Consider options from an environmental perspective as the potential acceleration of flows may result in contamination of Cooks River, Botany Bay.

## Floodplain Management Options

### Pit maintenance

- Cleaning of stormwater pits to remove debris blocking inflow should be done on a more strategic basis. That is to focus on locations with high potential flooding impact, such as in trapped low points and high debris load areas.
- A component of the FRMSP is to review the pit cleaning strategy in consideration of identified high risk areas. The Flood Study modelled pits as 0% blocked as well as a sensitivity assessment for potential blockages.

### Flood Injection

- Reinjection of flood waters into the aquifer should be considered. The southern area of the catchment has a high infiltration rate which Council has examined. Infiltration has only been looked at in small-scale (development) but should be reviewed holistically across the catchment. Compare the City of Botany Bay, Randwick City Council and Office of Water policies.

## Property Modification Measures

### Draft Flood Policy

- Council has a draft flood policy that will be submitted for the Floodplain Committee Meeting of 5 June 2013.

### Water Management Plan

- A decentralised water management plan has been developed and implementation is in progress. It is available online from Council's website.

## Emergency Response Modification Measures

### Flood Warning System

- A flood warning system (like in Venice) may not be suitable for this catchment due to the limited time available prior to inundation.
- There is a safety risk in a flash-flooding environment where people may try to move cars when flood waters are rising rapidly.

### Education

- Use of S149 certificates can provide information on the flooding in the catchment.

## General Comments

### Eastern Distributor

- The FRMSP should refer to potential inundation of the Eastern Distributor noting the pumps servicing this roadway are the responsibility of RMS.

### CSG Fracking

- The potential impact on flooding of coal seam gas fracking around St Peters is not within the scope of the FRMSP.

### Pollution Issues

- The focus of the FRMSP relates to flood inundation and mitigation. Assessment of water quality treatment of floodwaters and pollutant release from sediments are factored into the FRMSP but not in significant detail. Water Sensitive Urban Design focuses on the 3 month storm event for the most efficient removal of pollutant loads.

## Liability

- Council is obligated to notify residents, even in cases where a study identifies a pre-existing condition that was not previously well known. Insurance companies have specific definitions of flooding and the provision of financial coverage. The intent of the FRMSP is to find a partial solution rather than be able to solve all flooding problems.

## Climate Change

- The study may need to evaluate impacts of climate change. An assessment was undertaken in the Flood Study indicating that sea level rise has a limited impact to the majority of the catchment.

## Multi-Criteria Assessment

### Introduction

A multi-criteria matrix assessment (MCA) approach is proposed for the comparative assessment of all options identified using a similar method to that recommended in the Floodplain Development Manual (2005). This approach uses a subjective scoring system to assess the merits of various options. The principal merits of such a system are that it allows comparisons to be made between alternatives using a common index. In addition, it makes the assessment of alternatives “transparent” (i.e. all important factors are included in the analysis). However, this approach does not provide an absolute “right” answer as to what should be included in the Plan and what should be omitted. Rather, it provides a method by which stakeholders can re-examine options and, if necessary, debate the relative scoring assigned. Each option is given a score according to how well the option meets specific considerations.

A preliminary set of criteria was refined following discussions during the workshop. Each of the revised criteria was rated by each participant for importance – from 1 (being of low importance) to 5 (being of high importance). Table 1 lists the criteria in the three assessment categories (Economic, Social and Environmental) with the average rating based on the 17 responses.

## MCA Assessment Methodology

### General Comments

- Need to use this multi-criteria assessment (MCA) method because State Government grant applications are dependent on using this system to review funding across NSW.
- The criteria weighting needs to account for the number of criteria under each category because more criteria in one category may present a bias.
- It is important not to have too many criteria in the MCA.
- The weighting of criteria determines the outcome.
- The criteria and weightings need to be able to evaluate different options in the one area. For example, a storage option compared to a pipe upgrade option. Potentially only a planning option may be feasible as structural can't be done or not viable at this time.
- The weighted value may be based on a subcatchment basis. That is, evaluating an option in one subcatchment compared to evaluating a different option in a different subcatchment. Also acknowledging that in some areas there may be a lower number of people/land owners.

Table 1 Multi-Criteria Table

Category	Criteria	Average	Relative Weighting (based on overall criteria)	Relative Weighting (based on overall criteria)
Economic (35%)	Benefit Cost Ratio	4.29	6.6%	15.8%
	Reduction in Risk to Property	3.82	5.9%	14.1%
	Essential Infrastructure	3.78	5.8%	13.9%
	Future Development	3.35	5.1%	12.3%
	Capital Cost	3.18	4.9%	11.7%
	Operating Costs	3.06	4.7%	11.3%
	Constructability	2.94	4.5%	10.8%
	Implementation Timeframe	2.71	4.2%	10.0%
Social (34%)	Reduction in Risk to Life	4.76	7.3%	23.8%
	Reduction in Social Disruption	3.47	5.3%	17.4%
	Compatibility with Council Policies & Plans	3.29	5.0%	16.5%
	Community & Stakeholder Support	3.00	4.6%	15.0%
	Urban Design	2.82	4.3%	14.1%
	Governance	2.65	4.1%	13.3%
Environment (31%)	Compatibility with Water Quality Objectives	3.29	5.0%	18.0%
	Groundwater	3.18	4.9%	17.4%
	Heritage	3.00	4.6%	16.5%
	Compatibility with Water Reuse Schemes	3.00	4.6%	16.5%
	Fauna/Flora Impact - including street trees	2.94	4.5%	16.1%
	Contaminated Land & Acid Sulfate Soils	2.82	4.3%	15.5%

### Ranking Methodology

- An objective ranking system would be required.
- Required to check whether council has an existing ranking system. There is a procurement ranking system recently developed for drainage / stormwater projects.
- Department of Planning has a system.

### Option Funding

- Sydney Water ownership – may not support a detention basin but would a trunk main.
- Identify the funding source for prioritised options, e.g. Sydney Water 50%, Council 50%. Noting that the end result is that the community pays, it just depends on which agency.
- Application for funds is not within the scope of the FRMSP.

## Comments on Criteria

Comments from workshop participants related to each criterion are summarised as follows.

### Economic - Benefit Cost Ratio

- Criteria for capital cost and operating cost may need to be separate. This may be better than using net-present value.
- The benefit-cost ratio looks at costs, generally being the insurance replacement cost.
- Although cost may be accounted twice (as capital cost and B/C ratio), but need to know if B/C same for \$100 million job compared to a \$1 million job.
- Benefit cost ratio should consider the number of residences that benefit to put the cost into perspective for how many people the option helps.
- Costing for the Green Square reach to be included in the 20 year strategy (FM11).
- The cost for blockage to roads due to flooding should be accounted.

### Economic – Reduction in Risk to Property

- The main concern of OEH in these studies is primarily residential losses.
- Residential property damage is calculated based on a relationship prepared by OEH. Industrial and commercial damages are similarly determined but not precisely.

### Economic – Essential Infrastructure

- Criteria should consider state infrastructure, such as rail lines, Eastern Distributor and trunk road. RMS has a road categorisation/hierarchy procedure.

### Economic – Future Development

- Potential additional development potential due to improved flooding conditions.

### Economic – Capital Cost

- No comments.

### Economic – Operating Costs

- Costs should consider maintenance – noting cleaning of underground storages.

### Economic – Constructability

- Consider traffic impact - including disruption during construction.
- Also the light-rail path and other services.

### Economic - Implementation Timeframe

- Practical results in short-term would rate better than a longer-term option.
- Consideration of the time for development to occur within the catchment.
- Structural options would have time and cost constraints, therefore planning and response modification options would be preferred.

### Social – Reduction in Risk to Life

- Safety of life and property is a prime concern to OEH.

### Social – Reduction in Social Disruption

- No comments.

### Social – Compatibility with Council Policies & Plans

- Compatibility of the option (or alignment) with Council's strategies / visions, policies, and obligations (i.e. governance). For example, the Sustainability Strategy 2030.

### Social – Community & Stakeholder Support

- A consideration for community support is that affected residents would be supportive of a mitigation option but those who are not affected would not be supportive.
- Consider the potential benefit to people who have bought into a flood prone area (knowing it was flooded) to which council providing flooding relief (i.e. improving \$ valuation) but other areas not getting a benefit for their money.
- How does this criterion reflect the range of options as vocal residents will focus attention on their area, but if there aren't people some sub-catchments may be underrated?
- Council's attitude should match that of its community.
- Council support - incorporate a factor to normalise any identified options that Council would not be able to support.



### Social – Urban Design

- For example, the developer wants pipes or offset with higher storeys which some other residents don't want.
- Aesthetic and urban design considerations, such as underground basins, open space, and traffic.

### Social – Governance

- Add criteria for interdependency.
- E.g. one option may provide an opportunity for other options / reaches.

### Environment – Compatibility with Water Quality Objectives

- Potential dual-use facilities, such as integration with a wetland.
- Need to consider an alternative to quantify groundwater levels.

### Environment – Groundwater

- Compatibility with water reuse scheme / harvesting / aquifer could be accounted for in groundwater criteria.
- Groundwater criteria should consider depth to groundwater.

### Environment – Heritage

- Need to reference both heritage items and conservation areas.

### Environment – Compatibility with Water Reuse Schemes

- (Compatibility with water reuse scheme / harvesting / aquifer could be accounted for in groundwater criteria).

### Environment – Fauna/Flora Impact - including street trees

- Catchment is highly developed so may have a low weighting as potentially not a big community issue.
- Fauna in this catchment would comprise street trees for example.

### Environment – Contaminated Land & Acid Sulfate Soils

- Consider management of waste and spoil.
- To assess something inaccurately is not worthwhile. Consider how to evaluate if marginally affected.

### Project Schedule

A preliminary draft report of the FRMSP will be prepared for the Floodplain Management Committee meeting of 5th June. It is noted that some components will not be finalised, such as flood damage costs and average annual damage, as field survey data is still being collated.

Alexandra Canal Floodplain Risk  
Management Study and Plan

**APPENDIX C**  
ENVIRONMENTAL AND SOCIAL  
ASSESSMENT

## C1 Environmental and Social Assessment

Environmental and social characteristics of the study area may influence the type and extent of flood modification measures able to be implemented. Environmental characteristics, such as habitats, threatened species, topography and geology are constraints of structural flood modification sites.

Social characteristics such as housing and demographics may impact the community's response to flooding and therefore affect the type of flood modification measures proposed.

### C1.1 Geology, Soils, Geomorphology and Groundwater

#### C1.1.1 Topography

Sydney lies over two topographic regions: the Cumberland Plain, a relatively flat region lying to the south and west of the harbour, and the Hornsby Plateau, a sandstone plateau lying mainly to the north of the harbour and dissected by steep valleys.

#### C1.1.2 Geology

When developing floodplain management options it is important to understand the geology of the catchment to ensure appropriate locations for management options are selected and to assist with the planning of suitable foundations and other constructions to cope with the geology present.

Sydney is situated on low, rolling hills with wide valleys, situated in a rain-shadow zone below the Blue Mountains. Sydney is mostly comprised of Triassic rock, with some recent igneous dykes and the volcanic neck. The Hawkesbury sandstone is approximately 200m thick with shale lenses and fossil riverbeds dotted throughout (OEH, 2011). The majority of exposed rocks around Sydney are sandstone, and sand that was to become this sandstone that was washed from Broken Hill and laid down in the Triassic period, approximately two hundred million years ago (OEH, 2011).

The Sydney Basin sits on the east coast of Australia, which is made up of a basin filled with near horizontal sandstones and shales of Permian to Triassic age that overlie older basement rocks of the Lachlan Fold Belt. The sedimentary rocks have been subject to uplift with gentle folding and minor faulting during the formation of the Great Dividing Range. Erosion by coastal streams has created a landscape of deep-cliffed gorges and remains of plateaus (OEH, 2011).

**Figure C1** shows the geology found in the Alexandra Canal catchment. The geological constraints on floodplain management depend on the management options selected. However, no significant geological constraints have been identified which would impact the preliminary assessment of options undertaken in this FRMSP.

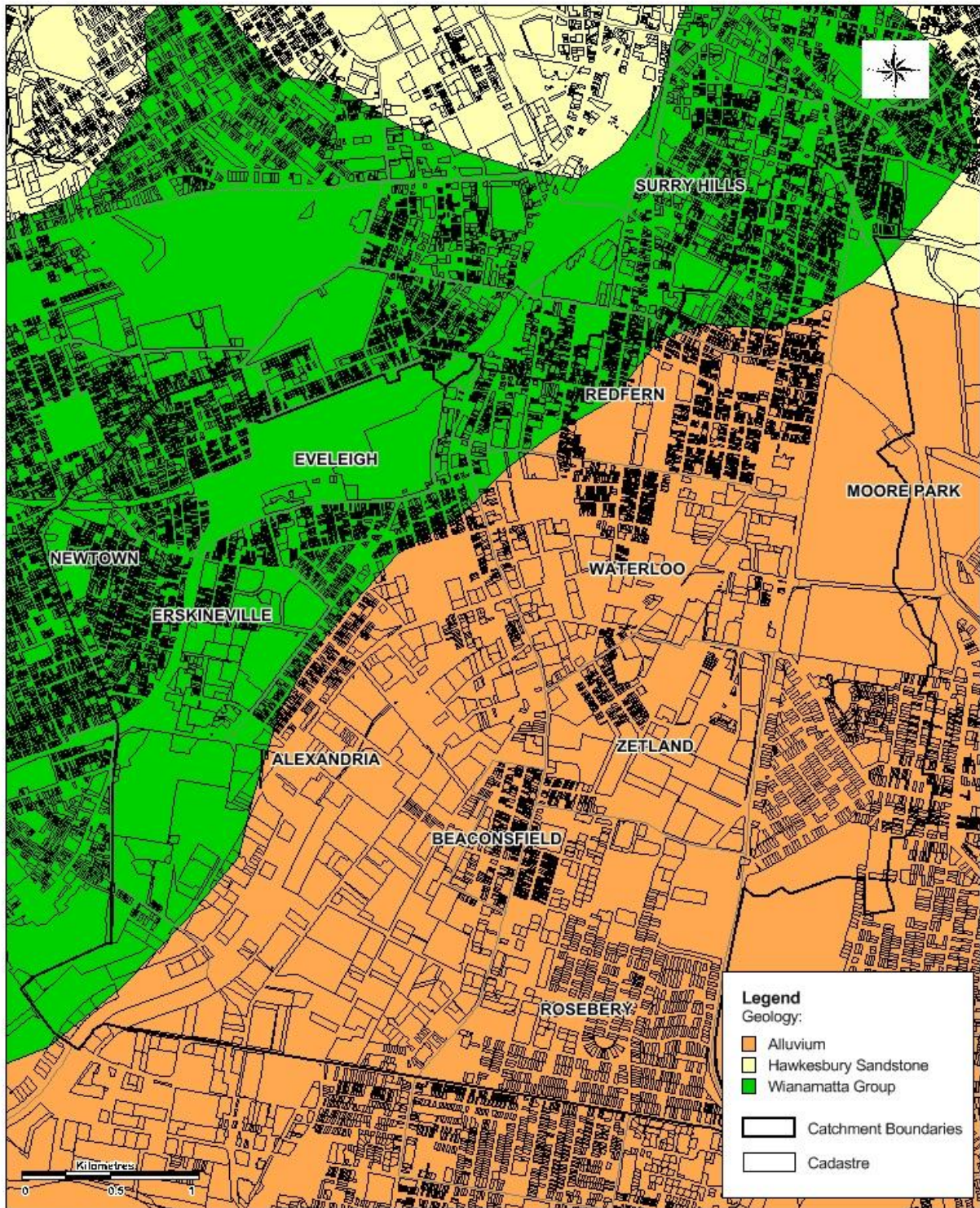


Figure C1 Geology

### C1.1.3 Soils

The Soil Landscape Map of Sydney (Scale 1:100,000) (Chapman et al., 2009) shows the catchment is located on the Tuggerah (tg), Blacktown (bt) and Gymea (gy) soil landscape groups (**Figure C2**).

The Tuggerah landscape group is characterised by gently undulating plains to rolling coastal dunefields, local relief to 20m and slope gradients of generally 1-10%, but occasionally up to 35%. The limitations of the Tuggerah landscape group include extreme wind erosion hazard, non-cohesive, highly permeable soil, very low soil fertility, localised flooding and permanently high water tables.

The Blacktown soil landscape group usually occurs on gently undulating rises over Wianamatta Group shales. The ground slopes are usually less than 5% and the vegetation typically comprises partly cleared eucalypt, woodlands and tall open forests. The soils range from shallow to moderately deep (less than 1m thick) and are hard setting, mottled textured clay soils. The soils are typically moderately reactive with highly plastic subsoil, have a low soil fertility and poor soil drainage.

The Gymea soil landscape is present on broad, convex ridge-tops on Hawkesbury Sandstone with little outcropping rock (<25%). Slopes are mostly 10-25%. The soils are yellow earths and earthy sands and are shallow stony, moderately acidic and highly permeable, with very low nutrient levels. The soil is subject to high erosion risk when exposed.

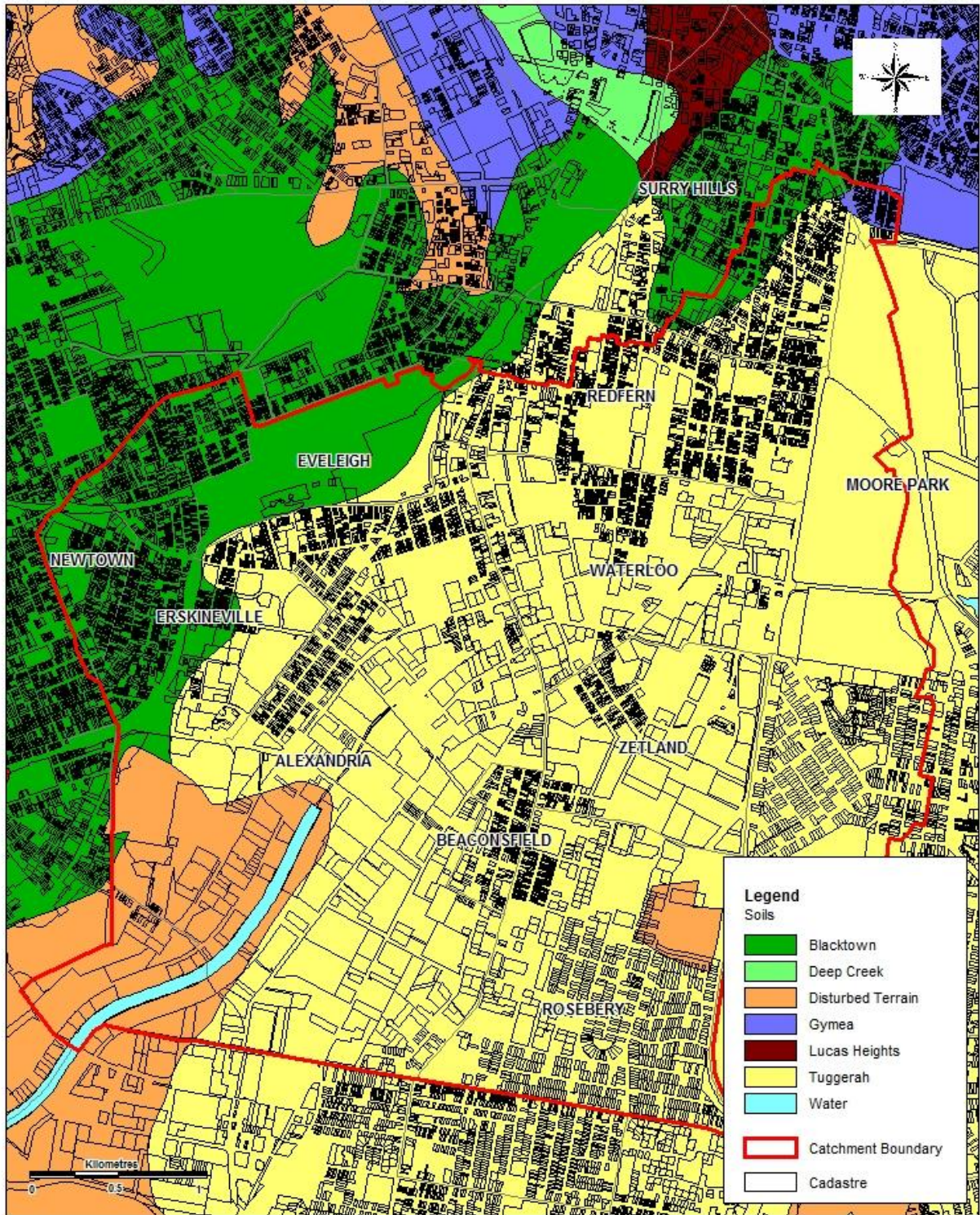


Figure C2 Soil Landscape Map

### **C1.1.2.1      Acid Sulfate Soils**

Acid Sulfate Soils (ASS) occur when soils containing iron sulfides are exposed to air and the sulfides oxidise producing sulphuric acid (DECC, 2008). This usually occurs when soils are disturbed through excavation. The production of sulfuric acid results in numerous environmental problems. It is therefore important to be aware of the distribution of ASS within the catchment (**Figure C3**), so that potential management options are developed and assessed in a manner that is sensitive to the problems of ASS (potential and actual ASS).

The area adjacent to Alexandra Canal has a high probability of ASS, within 1m of the ground surface (severe environmental risk if ASS materials are disturbed by activities such as shallow drainage, excavation or clearing). There are severe threats to the surrounding environment (e.g. the release of acid and/or the mobilisation of heavy metals) if high risk materials are disturbed. Soil investigations would be necessary to assess these areas for acid sulfate potential should any flood management works be proposed.

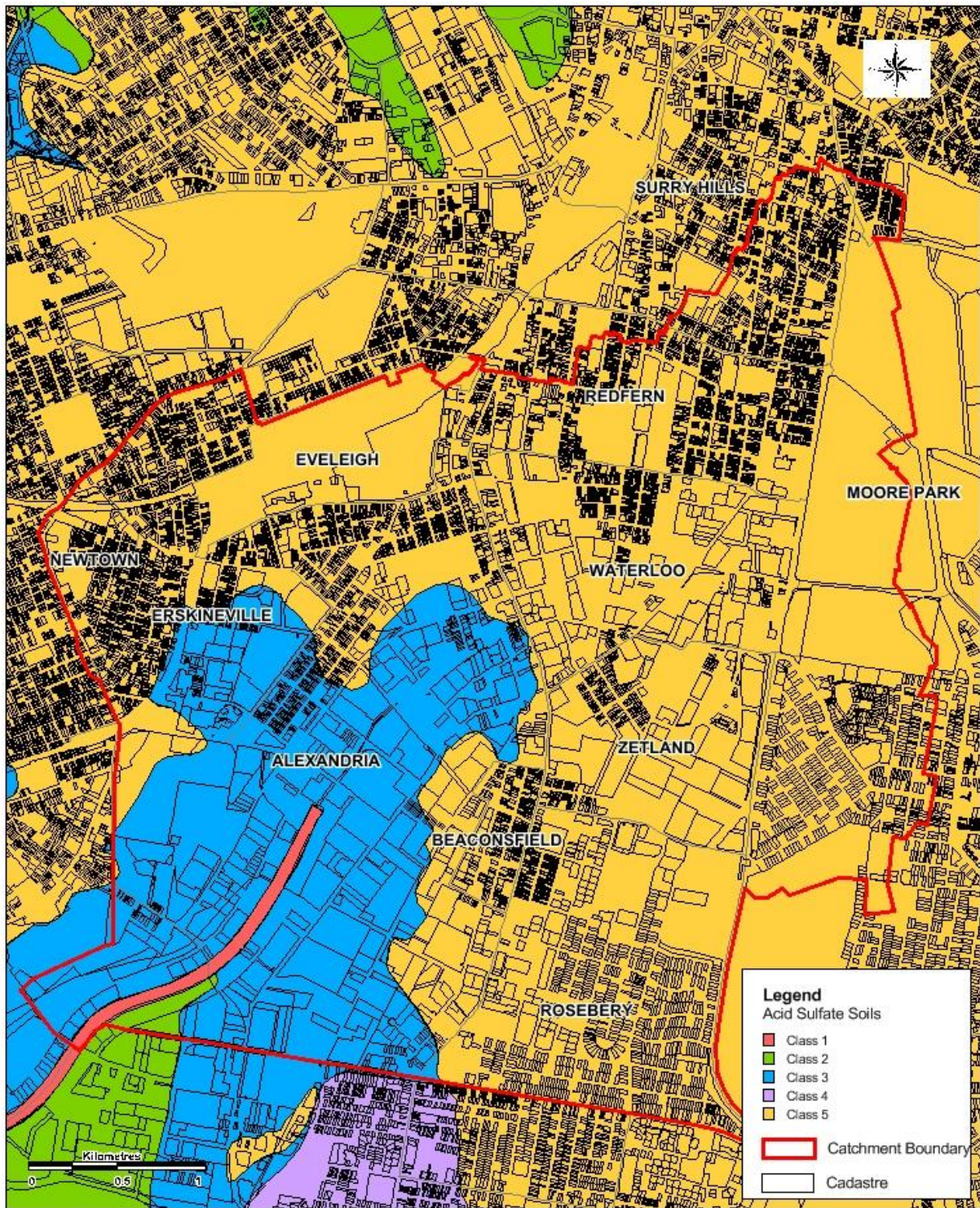


Figure C3 Acid Sulfate Soils



### C1.1.3 Contaminated Land and Licensed Discharges

Contaminated land refers to any land which contains a substance at such concentrations as to present a risk of harm to human or environmental health, as defined in the Contaminated Land Management Act 1997. The Office of Environment and Heritage (OEH) is authorised to regulate contaminated land sites and maintains a record of written notices issued by the Environment Protection Authority (EPA) in relation to the investigation or remediation of site contamination. A search of the OEH Contaminated Land Record on 21 November 2012 found 28 known contaminated sites within the catchment area as shown in **Figure C4**, **Table C1** and **Table C2**. Flood modification works within the catchment should consider the impacts that may be caused due to these contaminated sites and further investigation may be necessary.

Table C1 Items Listed on the OEH Contaminated Land Record (OEH, 2012)

Suburb	Site Description and Address	Activity that Caused Contamination	No. on Figure 7.4
Alexandria	Alexandria Canal sediments	Unclassified	1
Alexandria	Alexandria GoGas, 562 Botany Road	Service Station	2
Alexandria	Australia Post, 10-24 Ralph Street	Other industry	3
Alexandria	Australian Refined Alloys 202-212 Euston Rd	Metal Industry	4
Alexandria	Caltex Service Station, 133 Wyndham St, cnr McEvoy St	Service Station	5
Alexandria	Former Cadbury Schweppes , 49-59 O'Riordan Street	Other industry	6
Alexandria	Former Mobil Service Station, 20 O'Riordan Street	Service Station	7
Alexandria	Mascot Developments, 494-504 Gardeners Rd	Other industry	8
Erskineville	36/1A Coulson Street	Unclassified	9
Erskineville	Department of Housing, 52 John St	Other Industry	10
Erskineville	RailCorp land, Coulson Street	Other industry	11
Moore Park	Area 2, Driver Avenue	Unclassified	12
Newtown	Adjacent to Former Service Station, 79 Wilson Street	Service Station	13
Newtown	Aluminium Enterprises, 66 Brocks Lane	Metal Industry	14
Newtown	Caltex Service Station, 26 Enmore Rd	Service Station	15
Newtown	Former Service Station, 81 Wilson Street	Service Station	16
Redfern	BP Service Station, 116 Regent Street	Service Station	17
Redfern	King Walsh Holdings, 101a Marriott St	Other Industry	18
Rosebery	Autofoil P/L, 2 Mentmore Ave	Other industry	19
Rosebery	Caltex Service Station, 321 Gardeners Rd	Service Station	20
Rosebery	Rosebery Service Station, 395 Gardeners Road	Service Station	21
Surry Hills	Legion Cabs (Trading) Cooperative, 69-81 Foveaux Street	Service Station	22
Surry Hills	Woolworths Caltex Service Station, 475 Cleveland Street	Service Station	23

Suburb	Site Description and Address	Activity that Caused Contamination	No. on Figure 7.4
Waterloo	Lawrence Dry Cleaners, 887-893 Bourke Street	Unclassified	24
Waterloo	Proposed Construction Site, 2 John Street	Other Industry	25
Waterloo	Shell Coles Express Service Station, 867-877 South Dowling Street	Service Station	26
Waterloo	Waverley Woollahra Process Plant, 355 Botany Road	Other Industry	27
Zetland	Energy Australia Zetland Depot, 120 Joynton Avenue	Other industry	28

A search of the public register under section 308 of the Protection of the Environment Operations Act 1997 (the POEO Act) on 21 November 2012 identified three licenced premise within the catchment as shown in **Table C2**.

Table C2 Items Listed on the PoEO Licenced Premises Register (EPA, 2012)

Suburb/City	Organisation Name and Address	Fee Based Activity
Alexandria	Monroe Springs (Australia) Pty Ltd, 52 O'Riordan Street	Metal coating, metal waste generation
Alexandria	Australian Refined Alloys, 202-212 Euston Road	Non-ferrous metal production (scrap metal), Non-thermal treatment of hazardous and other waste, Recovery of hazardous and other waste, Waste storage - hazardous, restricted solid, liquid, clinical and related waste and asbestos waste
Alexandria	Dial-A-Dump Industries Pty Ltd, 76-82 Burrows Rd	Non-thermal treatment of general waste, Waste storage - other types of waste

Flood modification works within this vicinity should consider both the protection of these facilities from flood damages and the compatibility of the flood works with the operations of the facilities.

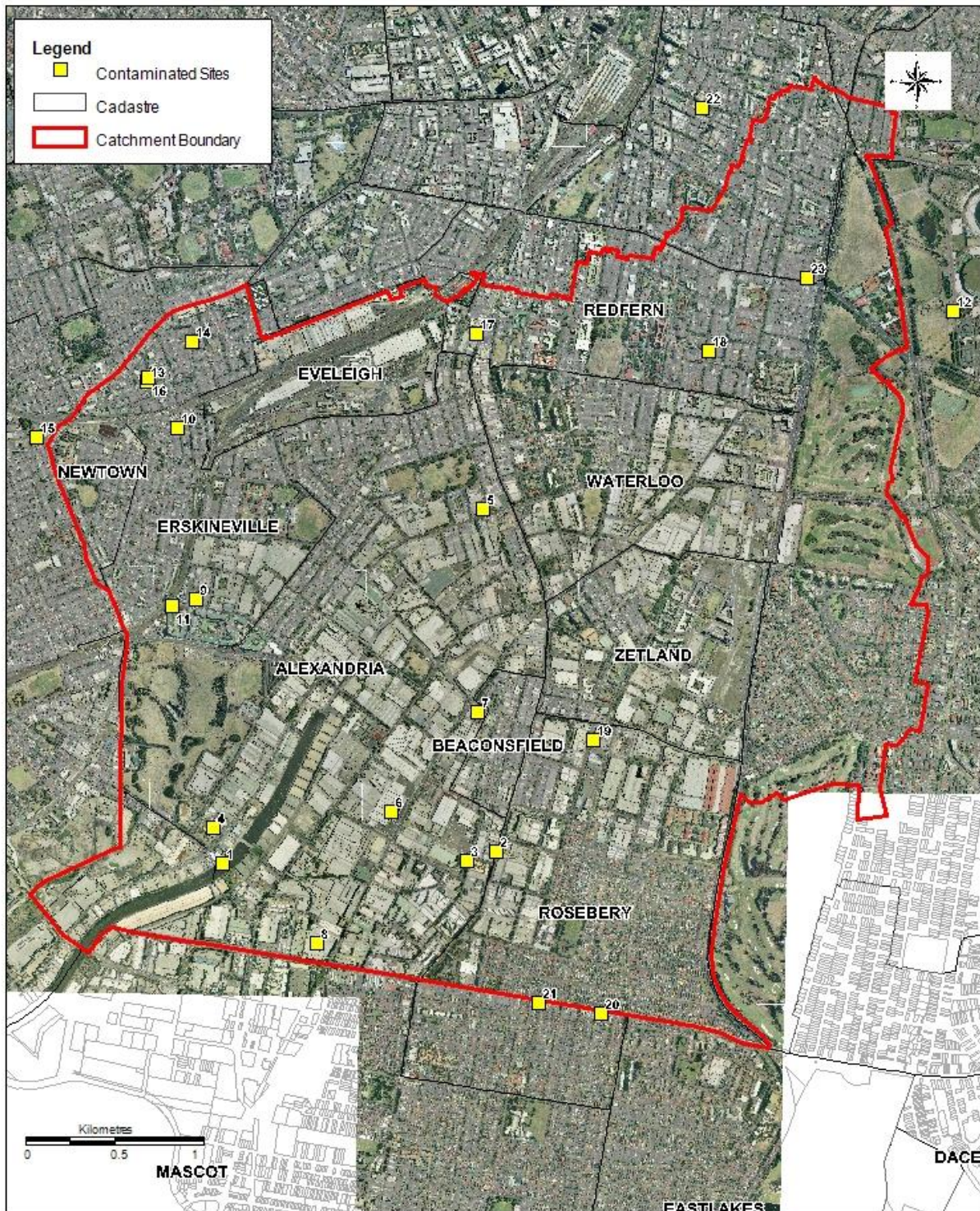


Figure C4 Contaminated Sites

**C1.1.4 Groundwater**

The Alexandra Canal Catchment is located on the Botany Sand Beds aquifer, which is a large volume of underground water present on the sandy ground surrounding Botany Bay (NSW DPI, 2011).

The aquifer is highly vulnerable to contamination due to the permeability of the sands and the generally shallow water table. Any contamination from land use activity that escapes or is spilled

onto the ground is likely to accumulate in the earth and leach into the groundwater (NSW DPI, 2011).

Due to the history of heavy industrial use throughout the catchment, the potential for groundwater impacts to have occurred is considered to be high. Chemicals such as chlorinated hydrocarbons and other solvents, petroleum hydrocarbons (such as petrol and diesel), and some heavy metals such as chromium, nickel, lead and arsenic, may have contaminated the aquifer (NSW DPI, 2011).

The investigation and remediation of groundwater in the Botany Sand Beds aquifer is regulated under some of the most robust contaminated-land legislation in Australia. The NSW Government manages groundwater use in areas that sit above the Botany Sand Beds aquifer. A precautionary approach was adopted as a number of contaminated sites have resulted in the contamination of groundwater in the aquifer and there was an increase in groundwater use in the area due to the recent extensive drought (NSW DPI, 2011).

The Alexandra Canal Catchment falls within the Botany Groundwater Management Zone 2 (**Figure C5**). All domestic bore water use is banned in this zone, including using groundwater for drinking, watering gardens, washing cars and other domestic purposes. The purpose of this ban is to minimise the risk to bore water users and to prevent the spread of contamination through pumping.

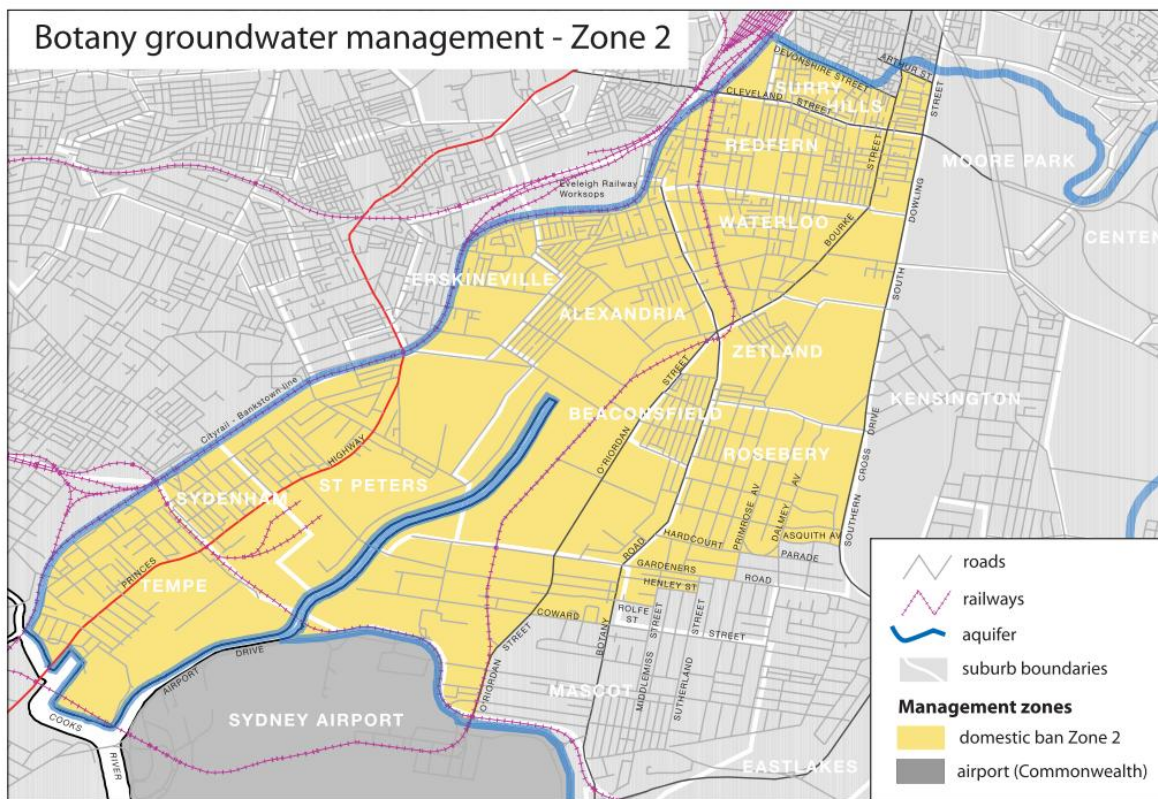


Figure C5 Established Groundwater Management Zone (NSW DPI, 2011).

Flood modification works within the catchment should consider the impacts that may be upon groundwater and further investigation may be necessary.

**C1.2**

## Demographic Characteristics

A knowledge of demographic character assists in the preparation and evaluation of flood management options which are appropriate for the local community. For example, the data is relevant in the consideration of emergency response or evacuation procedures (e.g. information may need to be presented in a range of languages and special arrangements may need to be made for less mobile members of the community).

The demographic characteristics of the Alexandra Canal catchment presented in this report includes the suburbs of Alexandria, Rosebery, Erskineville, Beaconsfield, Zetland, Waterloo, Redfern, Newtown, Eveleigh, Surry Hills and Moore Park. Population data for was sourced primarily from the Australian Bureau of Statistics (ABS) 2011 Census and aggregated to produce an overall synopsis for the catchment/region. A summary of the demographic data is:

- Almost a third of people living in the Alexandra Canal catchment are within the 25-34 year age range (**Table C3**). In fact, 72% of the population are aged below 55 years. This indicates a community which may be primarily able-bodied, able to evacuate effectively and/or assist with evacuation procedures.
- In the Alexandra Canal Catchment 50.2% of people were born in Australia. The most common countries of birth outside of Australia were the United Kingdom 5.62%, China 4.1% New Zealand 3.4% and Indonesia 1.32%.
- English was the only language spoken in approximately 62% of homes in the Alexandra Canal catchment. The most common languages spoken at home other than English are Greek, Chinese languages, Indo-Aryan languages, South-east Asian languages, Russian and Spanish (**Table C4**).
- The average median weekly income for individuals in the region was \$904, compared to the NSW average of \$561. This trend of well above average income for the region compared to the NSW average was also evident for family and household incomes (**Table C5**). This may have implications for the economic damages incurred on property contents during a flood event.
- In the catchment, the median house price is \$819,167, and the unit price is \$520,068 (**Table C6**). In NSW, the median house price is \$440,000, and unit price is \$445,000 (APM, 2012). In the Sydney LGA, the median house price is \$860,000, and unit price is \$565,000. This information has implications for the economic damages incurred during a flood event.

Table C3 Age Structure of the Alexandra Canal Catchment (ABS, 2011)

Age Group (Years)	Persons in the Catchment	% of Total Persons in the Catchment	% of Total Persons in NSW
0-4 years	3,543	4	6.63%
5-14 years	3,528	4	12.63%
15-19 years	2,376	3	6.41%
20-24 years	8,156	10	6.50%
25-34 years	24,231	30	13.61%
35-44 years	15,208	19	14.05%
45-54 years	9,402	12	13.74%
55-64 years	6,388	8	11.71%
<b>TOTAL</b>	<b>79,751</b>	<b>100</b>	<b>100</b>

Table C4 Languages Spoken at Home in the Alexandra Canal Catchment (ABS, 2011)

Languages Spoken at Home	Persons in the Catchment	% of Total Persons in the Catchment	% of Total Persons in NSW
English Only	49,382	62.17%	76.33%
Arabic	941	1.18%	2.81%
Assyrian	10	0.01%	0.32%
Australian Indigenous languages	38	0.05%	0.02%
Chinese languages	5,387	6.78%	4.50%
Croatian	177	0.22%	0.35%
Dutch	133	0.17%	0.14%
French	647	0.81%	0.29%
German	486	0.61%	0.36%
Greek	2,053	2.58%	1.32%
Hungarian	120	0.15%	0.11%
Indo-Aryan languages	1,026	1.29%	2.43%
Iranic languages	232	0.29%	0.42%
Italian	701	0.88%	1.27%
Japanese	410	0.52%	0.22%
Khmer	32	0.04%	0.16%
Korean	747	0.94%	0.72%
Macedonian	142	0.18%	0.45%
Maltese	108	0.14%	0.20%
Polish	256	0.32%	0.23%
Portuguese	477	0.60%	0.25%
Russian	1,395	1.76%	0.25%
Samoan	54	0.07%	0.23%
Serbian	292	0.37%	0.34%
South-east Asian languages	1,455	1.83%	1.33%
Spanish	1,149	1.45%	0.85%
Tamil	74	0.09%	0.33%
Thai	830	1.04%	0.24%
Turkish	370	0.47%	0.34%
Vietnamese	791	1.00%	1.33%
Other	1,418	1.79%	1.89%

Table C5 Average Median Income within the Catchment (ABS, 2011)

Income (For Population Aged 15 Years and Over)	Catchment (\$)	NSW (\$)
Average Median Individual Income (weekly)	904	561
Average Median Family Income (weekly)	2,133	1,477
Average Median Household Income (weekly)	1,711	1,237

Table C6 Median House and Unit prices within the Catchment (realestate.com.au, 2012)

Suburb	Median House Price (\$)	Median Unit Price (\$)
Alexandria	805,000	445,000
Beaconsfield	709,000	660,000
Erskineville	780,000	555,000
Eveleigh	-	550,000
Moore Park	-	945,000
Newtown	788,500	428,000
Redfern	835,000	542,000
Rosebery	932,500	530,500
Surry Hills	897,500	562,750
Waterloo	675,000	511,500
Zetland	950,000	585,000
Catchment	819,176	-

## C1.2 Flora and Fauna

Due to the highly urbanised nature of the catchment, most of the original native vegetation has been cleared and modified and no substantial undisturbed areas remain. Many of the plant and animal species that used to occur in this area are no longer present.

A search of the NSW Bionet Wildlife Atlas (OEH, 2012a) on 20 November 2012 for threatened flora species recorded since 1980 showed four known threatened flora species with a 10 by 10km search area surrounding the catchment (**Table C7**). Most of the plant species found within the catchment are introduced species or species that are not indigenous to the Sydney Area. As shown in **Figure C6**, only the *Syzygium paniculatum* (Magenta Lilly Pilly) is known to occur within the immediate catchment area. Any proposed flood modification measures or flood protection works should consider if this species would be affected.

Table C7 Threatened Flora Recorded (Source: NSW Bionet Wildlife Atlas)

Family Name	Scientific Name	Common Name	Legal Status	Count
Fabaceae (Mimosoideae)	<i>Acacia terminalis</i> subsp. <i>terminalis</i>	Sunshine Wattle	Endangered	2
Myrtaceae	<i>Eucalyptus nicholii</i>	Narrow-leaved Black Peppermint	Vulnerable	2
Myrtaceae	<i>Eucalyptus scoparia</i>	Wallangarra White Gum	Endangered	1
Myrtaceae	<i>Syzygium paniculatum</i>	Magenta Lilly Pilly	Endangered	3

A search of the NSW Bionet Wildlife Atlas (OEH, 2012a) on 20 November 2012 for threatened fauna species recorded since 1980 showed 28 known threatened fauna species with a 10km by 10km search area surrounding the catchment (**Table C8**). Most of the animals present are common native and introduced species that are well-adapted to urban areas. As shown in **Figure C6**, only a small number of threatened species have been recorded within the immediate catchment area including the endangered Green and Golden Bell Frog. Any proposed flood modification measures or flood protection works should consider the number and type of species potentially affected.

Table C8 Threatened Fauna Recorded (Source: NSW Bionet Wildlife Atlas)

Family Name	Scientific Name	Common Name	Legal Status	Count
<b>Birds</b>				
Anseranatidae	<i>Anseranas semipalmata</i>	Magpie Goose	Vulnerable	9
Columbidae	<i>Ptilinopus superbus</i>	Superb Fruit-Dove	Vulnerable	3
Diomedidae	<i>Diomedea exulans</i>	Wandering Albatross	Endangered	1
Ardeidae	<i>Botaurus poiciloptilus</i>	Australasian Bittern	Endangered	1
Haematopodidae	<i>Haematopus fuliginosus</i>	Sooty Oystercatcher	Vulnerable	1
Haematopodidae	<i>Haematopus longirostris</i>	Pied Oystercatcher	Endangered	3
Charadriidae	<i>Charadrius leschenaultii</i>	Greater Sand-plover	Vulnerable	3
Charadriidae	<i>Charadrius mongolus</i>	Lesser Sand-plover	Vulnerable	4
Scolopacidae	<i>Calidris alba</i>	Sanderling	Vulnerable	2
Scolopacidae	<i>Calidris ferruginea</i>	Curlew Sandpiper	Endangered	148
Scolopacidae	<i>Calidris tenuirostris</i>	Great Knot	Vulnerable	5
Scolopacidae	<i>Limicola falcinellus</i>	Broad-billed Sandpiper	Vulnerable	2
Scolopacidae	<i>Limosa limosa</i>	Black-tailed Godwit	Vulnerable	6
Scolopacidae	<i>Xenus cinereus</i>	Terek Sandpiper	Vulnerable	4
Laridae	<i>Sternula albifrons</i>	Little Tern	Endangered	114
Psittacidae	<i>Lathamus discolor</i>	Swift Parrot	Endangered	1
Strigidae	<i>Ninox strenua</i>	Powerful Owl	Vulnerable	2
Meliphagidae	<i>Anthochaera phrygia</i>	Regent Honeyeater	Endangered	1
<b>Mammals</b>				
Pteropodidae	<i>Pteropus poliocephalus</i>	Grey-headed Flying-fox	Vulnerable	367
Vespertilionidae	<i>Miniopterus australis</i>	Little Bentwing-bat	Vulnerable	1
Vespertilionidae	<i>Miniopterus schreibersii oceanensis</i>	Eastern Bentwing-bat	Vulnerable	4
Vespertilionidae	<i>Myotis macropus</i>	Southern Myotis	Vulnerable	199
Otariidae	<i>Arctocephalus forsteri</i>	New Zealand Fur-seal	Vulnerable	1
Otariidae	<i>Arctocephalus pusillus doriferus</i>	Australian Fur-seal	Vulnerable	4
Balaenidae	<i>Eubalaena australis</i>	Southern Right Whale	Endangered	1
<b>Reptiles</b>				
Myobatrachidae	<i>Crinia tinnula</i>	Wallum Froglet	Vulnerable	1
Myobatrachidae	<i>Pseudophryne australis</i>	Red-crowned Toadlet	Vulnerable	4
Hylidae	<i>Litoria aurea</i>	Green and Golden Bell Frog	Endangered	153



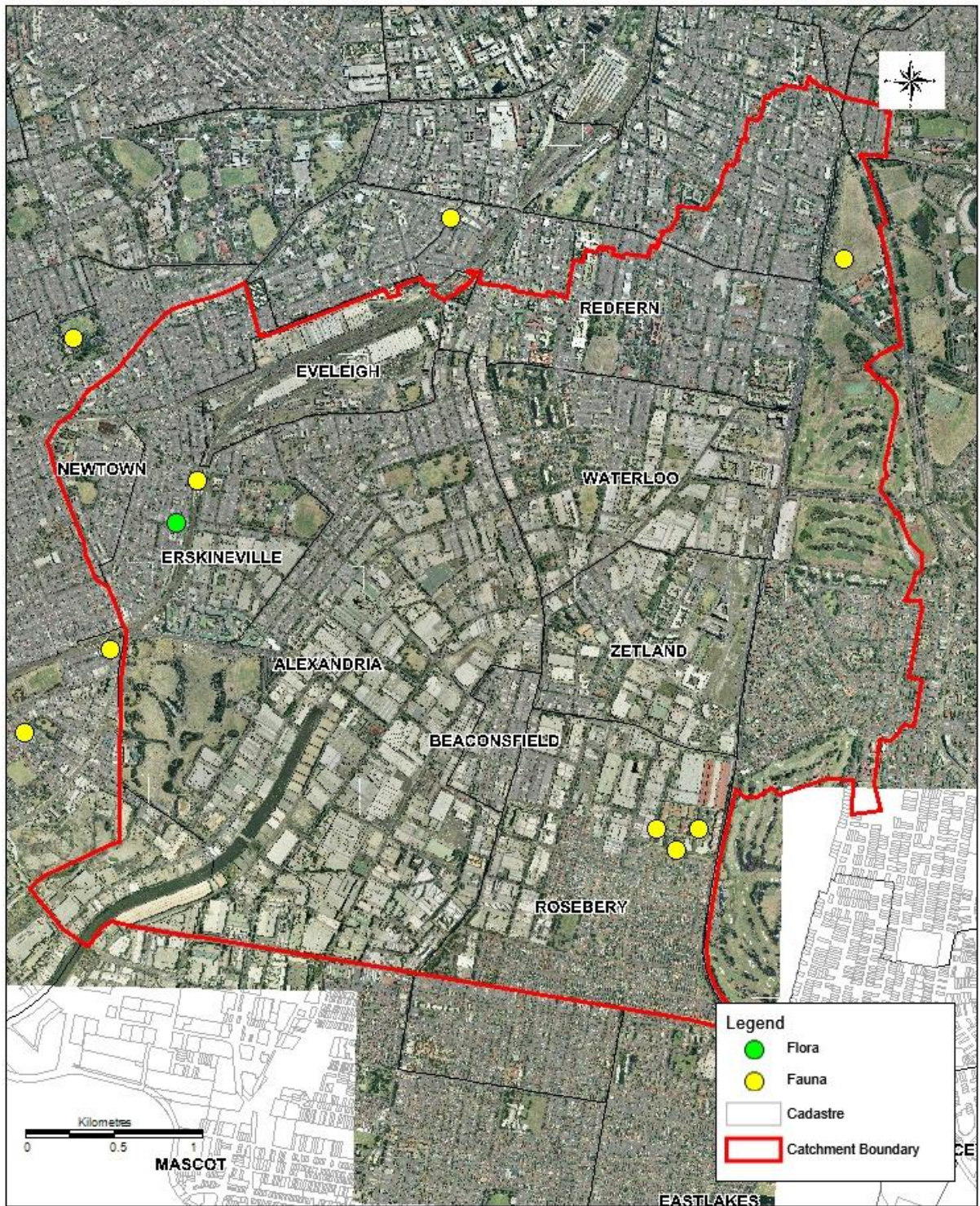


Figure C6 Threatened Species

## C1.3 Aboriginal and Non-Aboriginal Cultural Heritage

### C1.3.1 Aboriginal Cultural Heritage

The original inhabitants of the Sydney city region are the Gadigal people. As the town of Sydney developed into a city, the Gadigal were joined by other Aboriginal people from elsewhere in NSW, to live, work and forge relationships within the urban Aboriginal community. To this day, Redfern, Alexandria and Waterloo are seen as the heart of the contemporary Aboriginal community.

The earliest recorded excavation of an Aboriginal archaeological site in Sydney was uncovered on the banks of Sheas Creek in 1896 during construction of the Alexandra Canal. Artefacts included incised skeletal remains of a dugong and stone tool fragments.

A preliminary investigation of indigenous heritage was undertaken by searching the Aboriginal Heritage Information Management System (AHIMS) (2012b) in November 2012 for known or potential indigenous archaeological or cultural heritage sites within or surrounding the Alexandra Canal Catchment. Only one site (the Wynyard Station Midden) was identified within the vicinity of the study area. A more detailed heritage assessment should be undertaken prior to implementation of any management actions to ensure that any proposed flood modification works will not impact upon this site.

The following qualifications apply to an AHIMS search:

- AHIMS only includes information on Aboriginal objects and Aboriginal places that have been provided to OEH;
- Large areas of New South Wales have not been the subject of systematic survey or recording of Aboriginal history. These areas may contain Aboriginal objects and other heritage values which are not recorded on AHIMS;
- Recordings are provided from a variety of sources and may be variable in their accuracy. When an AHIMS search identifies Aboriginal objects in or near the area it is recommended that the exact location of the Aboriginal object be determined by re-location on the ground; and
- The criteria used to search AHIMS are derived from the information provided by the client and OEH assumes that this information is accurate.

All Aboriginal sites are protected under the *National Parks and Wildlife Act 1974* (NPW Act) and therefore any management considerations that impact upon Aboriginal sites must include this in their design. Known Aboriginal sites should be left undisturbed if possible, however if a management measure requires their destruction, an Aboriginal Heritage Impact Permit (AHIP) must be sought from OEH. Under the National Parks and Wildlife Act 1974 it is a requirement that any developments show “due diligence” with regard to Aboriginal heritage in the area.

#### C1.3.1.1 *Land Rights and Native Title Claims*

Land rights and Native Title are two different forms in which traditional land owners can gain access to land or claim compensation for previous dispossession of their land.

Under the *Aboriginal Land Rights Act 1983* (ORALRA), local Aboriginal land councils can claim Crown land areas, on condition that the lands are vacant and not otherwise required for an essential public purpose. A search on the Land Claims Register maintained by the Office of the Registrar, ORALRA on 23 November 2012 found no Native Title claims in the catchment.

### C1.3.2 Non-Aboriginal Heritage

There are three different types of statutory heritage listings of non-Aboriginal origin; local, state or national heritage items. A property is a heritage item if it falls into a listings category. The category of an item depends on whether it is considered to be significant to the nation, state or a local area. The significance of an item is a status determined by assessing its historical, scientific, cultural, social, archaeological, architectural, natural or aesthetic value.

A desktop review of non-Aboriginal heritage was undertaken for the catchment. Searches were undertaken on a number of databases to determine the cultural heritage within this area. Databases searched include:

- Australian Heritage Database (incorporates World Heritage List; National Heritage List; Commonwealth Heritage List); and
- NSW Heritage Office – State Heritage Register.

The Sydney Local Environment Plan (LEP) 2011 also lists 559 natural heritage items of significance that are found within or around the catchment under Schedule 5 of the LEP.

**Table C9** contains 31 items that are found within or surrounding the catchment area which have been listed by the Heritage Council under the *NSW Heritage Act 1977* (**Figure C7**). This includes listing on the state heritage register, an interim heritage order or protected under Section 136 of the *NSW Heritage Act 1977*. This information has been provided by the Heritage Council. A further 825 items were found within or surrounding the catchment area which have been listed by local council and state government agencies. No items were found to be included on the World Heritage List, National Heritage List or Commonwealth Heritage List.

Table C9 Items listed under the NSW Heritage Act 1977 (OEH, 2012c)

Item Name	Address	Suburb	LGA
Alexandra Canal	Adjacent to Burrows Road	Alexandria	Botany Bay
Enginemans Resthouse	39 Brandling Street	Alexandria	Sydney
Yiu Ming Temple	16-22 Retreat Street	Alexandria	Sydney
AAH 19 - Old Commissioners Car	Large Erecting Shed Locomotive Street	Eveleigh	Sydney
AAH 7 - Commissioners Train - Attendants Carriage	Large Erecting Shed Locomotive Street	Eveleigh	Sydney
AAH 8 - Commissioners Train - Officers Inspection Carriage	Large Erecting Shed Locomotive Street	Eveleigh	Sydney
AAH 9 - Commissioners Car (new)	Large Erecting Shed Locomotive Street	Eveleigh	Sydney
PAM 11 - Premier's Car	Large Erecting Shed Locomotive Street	Eveleigh	Sydney
Premiers and Railway Commissioners Rail Car Collection	Large Erecting Shed Locomotive Street	Eveleigh	Sydney
Sydney Cricket Ground - Members Stand and Lady Members Stand	Driver Avenue	Moore Park	Sydney
Newtown Railway Station group and Former Newtown Tramway Depot	Great Southern and Western Railway	Newtown	Sydney

Item Name	Address	Suburb	LGA
Trocadero	69-77 King Street	Newtown	Sydney
Uniting Church and Pipe Organ	280a King Street	Newtown	Sydney
Women's College, University of Sydney	15 Carillon Avenue	Newtown	Sydney
Cathedral of the Annunciation of Our Lady	242 Cleveland Street	Redfern	Sydney
Eveleigh Chief Mechanical Engineers Office	Great Southern and Western Railway	Redfern	Sydney
Eveleigh Chief Mechanical Engineer's office movable relics	Great Southern and Western Railway	Redfern	Sydney
Eveleigh Railway Workshops	Great Southern and Western Railway	Redfern	Sydney
Eveleigh Railway Workshops machinery	Great Southern and Western Railway	Redfern	Sydney
Fitzroy Terrace	6-18 Pitt Street	Redfern	Sydney
Redfern Post Office	113 Redfern Street	Redfern	Sydney
Redfern Railway Station group	Great Southern and Western Railway	Redfern	Sydney
Busby's Bore	Centennial Park to College Street	Surry Hills	Sydney
Cleveland House	146-164 Chalmers Street	Surry Hills	Sydney
Cottage	203-205 Albion Street	Surry Hills	Sydney
Crown Street Public School	Crown Street	Surry Hills	Sydney
Crown Street Reservoir & Site	285 Crown Street	Surry Hills	Sydney
Durham Hall	207 Albion Street	Surry Hills	Sydney
Holy Trinity Greek Orthodox Church	626-630 Bourke Street	Surry Hills	Sydney
Railway Institute Building	Chalmers Street	Surry Hills	Sydney
Terrace Cottages	197, 199, 201 Albion Street	Surry Hills	Sydney

Under Part 5, Clause 5.10 of the Sydney LEP 2011, an outline of the provisions that must be followed in relation to heritage items is provided. Due to the extensive list of heritage items and places found within and around the catchment area, it is recommended that a detailed heritage assessment is undertaken prior to the implementation of any management options, as there are development restrictions and procedures that may need to be followed.

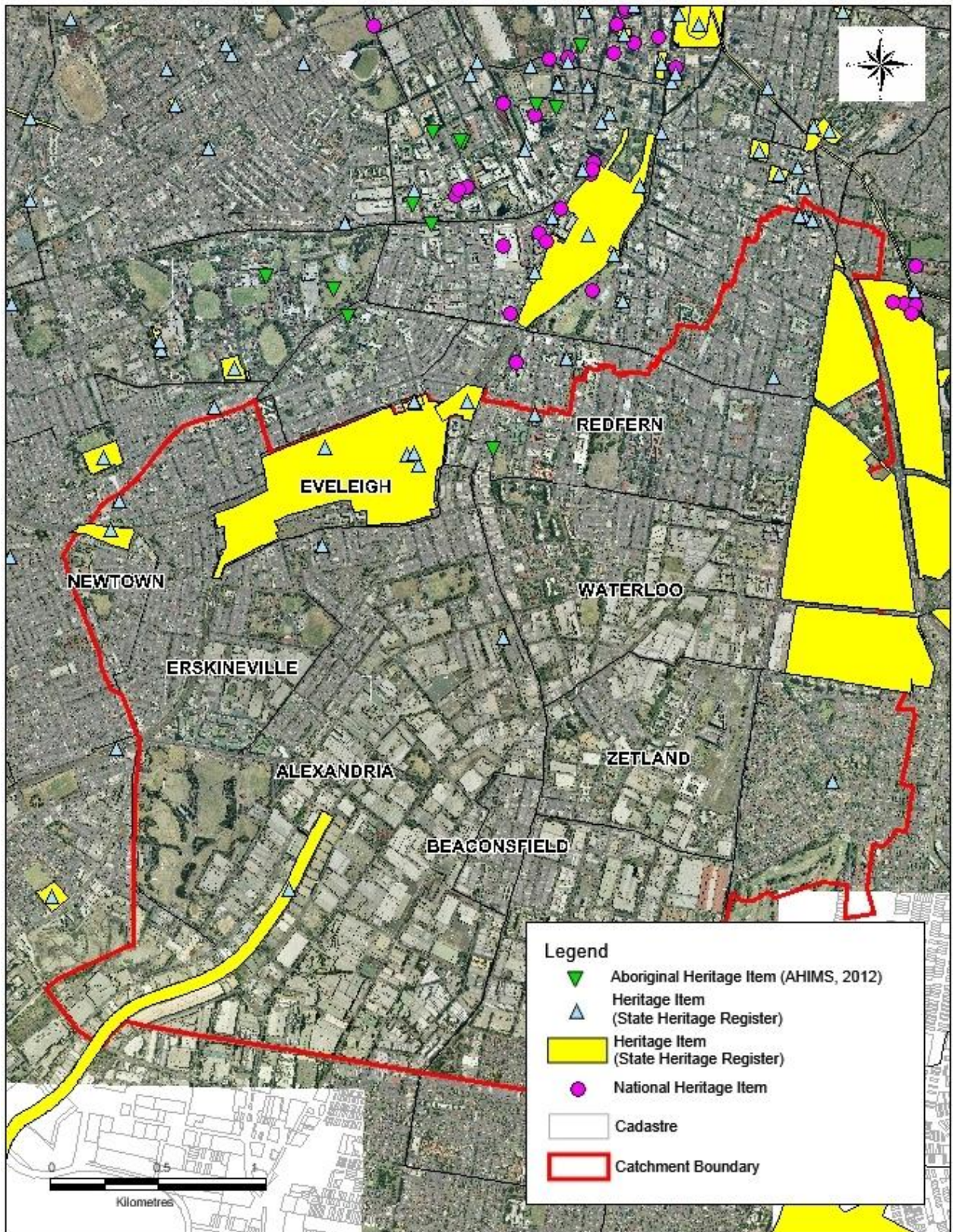


Figure C7 Heritage

## C1.4 Summary of Environmental and Social Issues

Environmental and social issues to be considered in the development of floodplain management strategies for the Alexandra Canal Catchment include:

- The soil types that are present may potentially pose issues related to earth movement and construction due to erosion risk, low soil fertility, poor soil drainage and high permeability.
- The area adjacent to Alexandra Canal has a high probability of Acid Sulfate Soils, within 1m of the ground surface (severe environmental risk if ASS materials are disturbed by activities such as shallow drainage, excavation or clearing).
- There are 28 contaminated sites and three Protection of the Environment and Operations Act 1997 licenced premises within the catchment.
- The Alexandra Canal Catchment is located on the Botany Sand Beds Aquifer. The aquifer is highly vulnerable to contamination due to the permeability of the sands and the generally shallow water table. The Botany Sands Beds Aquifer plays an important role in the Decentralised Water Master Plan 2012 – 2030.
- Almost a third of people living in the Alexandra Canal catchment are within the 25-34 year age bracket. In fact, 72% of the population are aged below 55 years. This indicates a community which may be primarily able-bodied, able to evacuate effectively and/or assist with evacuation procedures.
- English was the only language spoken in approximately 62% of homes in the Alexandra Canal catchment. The most common languages spoken at home other than English are Greek, Chinese languages, Indo-Aryan languages, South-east Asian languages, Russian and Spanish.
- Most of the plant species found within the catchment are introduced species or species that are not indigenous to the Sydney Area. Only the *Syzygium paniculatum* (Magenta Lilly Pilly) is known to occur within the immediate catchment area.
- Only a small number of threatened or endangered fauna species have been recorded within the immediate catchment area. This included the endangered Green and Golden Bell Frog.
- Only one Aboriginal heritage site (the Wynyard Station Midden) was identified within the vicinity of the study area.
- 31 non-Aboriginal heritage items are found within or surrounding the catchment area which have been listed by the Heritage Council under the NSW Heritage Act 1977. A further 825 items were found within or surrounding the catchment area which have been listed by local council and state government agencies.