Blacktown City Council

St Bartholomew's Cemetery Expansion

Planning Proposal Flooding Stormwater Management Report

Final 2 | 28 June 2018

Job number 259202-00

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1 Background

The existing St Bartholomew's Church and Cemetery is located on a 3.17-hectares lot off Ponds Road, Prospect. The cemetery comprises approximately 3,600 occupied graves. In January 2016, Blacktown City Council (Council) received approximately 6 hectares of land east of St Bartholomew's Church from the New South Wales (NSW) State Government under a Land Transfer Agreement. In addition, Council intends to acquire approximately 2 hectares of land east of the existing cemetery. Further to this, Council is seeking to close St Bartholomew's Place (approximately 0.39 hectares), with the intention of including it in the expansion of the cemetery. This equates to a total of 11.56 hectares of land proposed to be used for the expanded cemetery.

A planning proposal (PP) is being prepared, which seeks to reactivate the existing church and cemetery on the 3.17-hectare land and to reclassify the Council-owned expansion lands from "community land" to "operational land" and to rezone the cemetery expansion lands from RE1 Public Recreation, RU4 Primary Production Small Lots and SP2 Classified Road, under BLEP2015 to SP1 Cemetery. In addition to the existing church and cemetery, the expanded cemetery is likely to include ancillary facilities such as an office, café, flower shop and potentially a chapel. They will most likely be in the vicinity of Tarlington Place. Details will be determined at the Development Application (DA) stage.

2 Existing Conditions

2.1 Land Use

The site is located on land between the Great Western Highway (GWH) to the north and M4 Western Motorway (M4) to the south and is bounded by the Prospect Highway to the west. The existing cemetery has an area of approximately 3.17 hectares, with the newly acquired land adding a further 6 hectares. A further 2.39 hectares of land is also intended to be acquired, including 2 hectares from other land owners and 0.39 hectares from the closure of St Bartholomew's Place, bringing the total area for the proposed cemetery site to 11.56 hectares. This is an increase of 8.39 hectares to the existing cemetery.

The existing cemetery is zoned SP1 Cemetery under Blacktown LEP 2015. The cemetery expansion land:

- Is predominantly zoned RE1 Public Recreation
- Includes land zoned RU4 Primary Production Small Lots (the site of the old Prospect Post Office)
- Includes land zoned SP2 Classified Road to the south of the existing cemetery.

The existing cemetery contains approximately 3,600 utilised graves. As the last church service was held on the site in 1967 and no new interment rights have been

sold at the cemetery since 1972, the existing cemetery site does not regularly attract many visitors.

The cemetery expansion land has been largely vacant and unused since the former Prospect Village (along Tarlington Place) was disrupted and eventually vacated/demolished following the realignment of the Great Western Highway in 1968 and the construction of the M4 Western Motorway in 1990.

The location of the site and its surrounding environs is shown in Figure 1.

Figure 1 Subject Site and its Environs

2.2 Access to the Site

Access to and from Tarlington Place can be achieved through the Great Western Highway in the eastbound and westbound directions. Eastbound access is gained via a right turn bay. Access points to the existing cemetery are from Ponds Road, Prospect.

2.3 Road Network

2.3.1 Adjoining Roads

Great Western Highway

The GWH is classified as a Roads and Maritime State Road and is aligned in an east-west direction to the site's north. It is a two-way road with 3 westbound lanes and 4 eastbound lanes near the site, set within a 32 metre carriageway with an approximately 9 metre central median. Being an arterial road, no parking is permitted. The GWH has a posted speed limit of 80 km/h.

Prospect Highway

The Prospect Highway is classified as a Roads and Maritime State Road and is aligned in a north-south direction to the site's west. It is a two-way road with generally one lane in each direction, set within an approximately seven-metre carriageway. Kerbside parking is not permitted, and the road has a posted speed limit of 60 km/h.

Ponds Road

Ponds Road is classified as a Roads and Maritime State Road and is aligned in an east-west direction along with the site's north-western boundary. It is a two-way road with 1 lane in each direction, set within an approximately 7 metre carriageway. Ponds Road functions as an exit-ramp to the GWH and connects with the Prospect Highway to the west. It also provides access to the existing cemetery and St Bartholomew's Church. Ponds Road has a posted speed limit of 60 km/h.

M4 Western Motorway

The M4 is classified as a Roads and Maritime State Road and is aligned in an east-west direction to the site's south. It is a two-way road with generally 3 lanes in each direction, set over an approximately 22-metre-wide carriageway including a central separation barrier. The Western Motorway has a posted speed limit of 100km/h in the vicinity of the site, with off and on ramps provided to/from the Prospect Highway.

Tarlington Place and St Bartholomew's Place

Tarlington Place and St Bartholomew's Place are classified as Local Roads and are internal roads located within the subject site. St Bartholomew's Place is an unsealed road which runs along the eastern boundary of the existing cemetery while Tarlington Place is a sealed road and primarily functions as the access road to 23 Tarlington Place (the old Prospect Post Office).

Council is looking to close St Bartholomew's Place (0.39 hectares) and absorb it into the cemetery expansion lands. It could, however, still function as an access point and internal cemetery road.

Vehicle access to the site is proposed via the existing 2 driveways along Ponds Road (access 1 and access 2) and Tarlington Place (access 3 St Bartholomew's

Place, whilst proposed to be closed, may also be used as an access point, depending on how the development is staged.

The internal road network will be determined at the Development Application stage. It is recommended that an internal link between the existing and expanded cemetery areas to be provided.

3 Future Conditions

3.1 Land Use

The proposal seeks to rezone 8.39 hectares of land to allow for the expansion of the existing St Bartholomew's Cemetery. The cemetery expansion will be developed in stages. New burial space is expected to become available in stages, approximately 5 years after development consent is granted for the cemetery. The site plan is outlined above in Figure 1.

The expanded cemetery is expected to ultimately include:

- Over 10,000 burial plots
- Above ground crypts
- Columbarium walls for ashes interment
- Ancillary facilities (such as an office, café, flower shop and potentially a chapel) with associated car parking, in the vicinity of Tarlington Place.

Table 1 Area Schedule

Use		Size
Existing Cemetery	Reactivation of existing church and cemetery [1]	3.17 hectares
Future Cemetery Expansion	Cemetery expansion and ancillary facilities [2]	8.39 hectares
Total		11.56 hectares

4 Executive Summary

Blacktown City Council is looking at the expansion of the existing St Bartholomew's Cemetery at Prospect, NSW. Arup has prepared this report, for Blacktown City Council, to support a planning proposal which seeks to rezone and expand the existing St Bartholomew's Cemetery. This will be done by consolidation of existing lots to the east including the existing St Bartholomew's Place (which is a paper road only.) This report applies to the proposed stormwater and flooding requirements associated with the proposed development.

A flood assessment was carried out to determine design flood behaviour at St Bartholomew's Cemetery. A review of previous flood studies was undertaken as part of the flood assessment, however, no publicly available reports were found to exist for this site. As such, a flood model was established for the site following current Australian Rainfall and Runoff (2016) guidelines.

Most of the flood affectation to the site in a 1% AEP flood event is seen at a sag point near the centre of the site, adjacent to the Great Western Highway. Peak flood depth is predicted above 1 m depth which results in an area of high hazard (unsafe for people and vehicles). The rest of the site is largely unaffected by flooding, except localised areas along the southern boundary.

On-Site Stormwater Detention will be required at a rate of 455 m^3/ha, and is likely to include the existing cemetery lands. Water quality devices will also need to be included across the site to mitigate the effects of development on the stormwater network. A variety of WSUD practices will be incorporated throughout the development to meet the applicable targets within the DCP.

5 Report Scope

The scope of the work addressed in this report covers stormwater drainage and flooding affected by the proposed works.

6 Existing Topography and Stormwater Infrastructure

The existing topography of the site grades naturally in an easterly direction, with a natural high point down the middle and gradual falls to the north and south of the ridgeline. This can be shown below in Figure 2.

According to the site survey, no in-ground stormwater infrastructure is located on the site. Some minor swales are located around the site periphery, but largely related to the adjacent roadways.

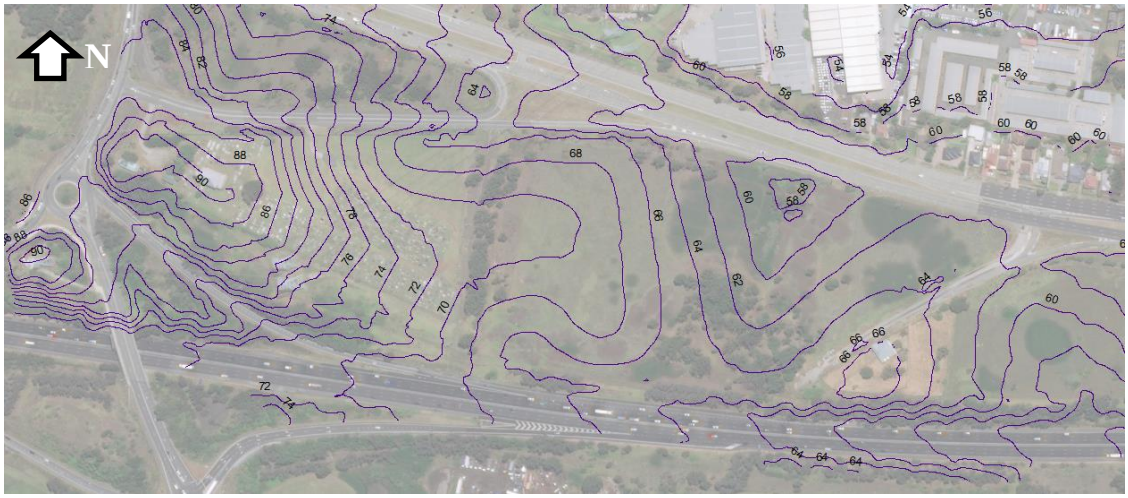


Figure 2: Existing site contours

6.1 Previous Flood Studies

A review of previous studies relevant to the site has been undertaken to gain an understanding of existing stormwater drainage and flooding behaviour at the site. No publicly available flood studies were found to exist for the site.

7 Relevant Stormwater Management Legislation

Legislation that is relevant to the planning of development at the site includes the Blacktown Local Environment Plan 2015 (LEP), Development Control Plan 2015 (DCP) and the Upper Parramatta Catchment River Trust (UPCRT) On-Site Stormwater Detention Handbook (2005). The key controls set out in these documents are summarised in the following sections.

7.1 Blacktown City Council Local Environment Plan 2015

As the site is within the Blacktown City Council Local Government Area the Blacktown LEP applies to the site. The relevant extracts in relation to stormwater management for this development type (mixed use residential and commercial) are detailed below:

7.1 Flood planning

(1) The objectives of this clause are as follows:
- *(a) to minimise the flood risk to life and property associated with the use of land,*
- *(b) to allow development on land that is compatible with the land's flood hazard, taking into account projected changes as a result of climate change,*
- *(c) to avoid significant adverse impacts on flood behaviour and the environment.*

(2) This clause applies to land at or below the flood planning level or the highest historical flood level.

(3) Development consent must not be granted to development on land to which this clause applies unless the consent authority is satisfied that the development:
- *(a) is compatible with the flood hazard of the land, and*
- *(b) will not significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties, and*
- *(c) incorporates appropriate measures to manage risk to life from flood, and*
- *(d) will not significantly adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses, and*
- *(e) is not likely to result in unsustainable social and economic costs to the community as a consequence of flooding.*

(4) A word or expression used in this clause has the same meaning as it has in the Floodplain Development Manual (ISBN 0 7347 5476 0) published by the NSW Government in April 2005, unless it is otherwise defined in this clause.

(5) In this clause:

***highest historical flood event** means the highest recorded flood in the Blacktown local government area, which occurred in 1867.*

***land at or below the flood planning level** means the level of a 1:100 ARI (average recurrent interval) flood event plus 0.5 metres freeboard.*

7.2 Blacktown City Council Development Control Plan 2015

The Blacktown City Council DCP also applies to the development of the site and includes controls related to flooding, Water Sensitive Urban Design (WSUD), and On-Site Stormwater Detention (OSD).

7.2.1 Flooding

The DCP sets out controls related to flooding in Part A, Section 9: Development on flood prone land & Section 10: Local overland flooding: major drainage and local runoff.

The objectives of Section 9: Development on flood prone land, are described below. Specific requirements for these objectives will be described further as necessary within Section 5: Flood Impact Assessment.

Council's primary aim in relation to the development of flood prone land is to reduce the impact of flooding and flood liability on individual owners and occupiers and to reduce private and public losses resulting from flooding by:

a) Carrying out flood mitigation works subject to the availability of necessary flood data and funding

b) Adopting a merit-based approach to all Development Applications

c) Encouraging development and construction which is compatible with the identified flood hazard to ensure the safety of the development itself.

The following are the development controls provided within Section 10: Local overland flooding – major drainage and local runoff:

The development controls contained in this section apply to all land shown affected by local overland flooding - major drainage and local runoff under Council's DCP. These controls may be used for other areas that are subsequently identified as subject to local overland flooding which has not yet been investigated and/or listed at that time.

Each proposed development would have site-specific development constraints and each Development Application will be treated on its individual merits. However, typical development controls may include, but are not limited to, consideration of any or all of the following:

a) Minimum finished habitable floor levels based on specific site conditions and flood risk

b) Restricting cut or fill and limiting concrete 'slab on ground' floors

c) Flood compatible building footing design and/or materials

d) Extent and/or location of the building footprint to ensure adequate provision for movement of overland flow and site drainage

e) Limiting the type and location of fencing to ensure unobstructed overland flows

f) Restricting filling / regrading within the defined overland flowpath

g) *Restricting future landscaping in medium density and non-residential developments which might raise flood levels and/or adversely redirect overland flows*

h) *Restrictions as to user and/or positive covenants on the property title under Section 88B of the Conveyancing Act 1919.*

Additionally, specific requirements are placed upon sites for landfilling activities. Council defines Landfill as: *any work or activity which involves the placement of soil or other material on land, excluding the top dressing of lawns, whether undertaken as a principal activity or associated with another development, which in the opinion of Council significantly alters the shape or drainage of land and includes any earthworks or excavation which would have similar impact, whether or not such works would involve the importation of fill.*

These specific considerations for flooding relating to landfill activities are addressed within Part H: Landfill Guidelines of the DCP:

In general, landfilling within a floodplain will not be supported. However, Floodplain Landfill Applications will be treated on their merits based on the following:

i. *No net loss of flood storage and/or conveyance within the floodway extents*

ii. *No net loss of flood storage within the 1% annual exceedance probability (AEP) critical duration flood. This requirement must address the cumulative impacts on flood levels from like development on other areas of the floodplain*

iii. *The alteration of local drainage or overland flow contours and/or natural watercourses must not adversely affect adjacent property.*

Council may require the undertaking of detailed hydrologic / hydraulic modelling and survey contour plans in support of such applications.

Where landfilling is proposed within 40m of a watercourse, under the Water Management Act 2000 a Controlled Activity Approval must be obtained from the NSW Office of Water.

Where work involves the reconstruction of creek lines, reclamation or dredging works, a separate permit will be required from the Department of Primary Industries under the Fisheries Management Act 1994.

Additionally, for filling works, the Development Application shall be accompanied by a *Hydraulic / Hydrological Report by a chartered professional Civil Engineer or equivalent which addresses cumulative impacts (eg the displacement of flood storage and effect on flood levels in flood liable areas)*

7.2.2 Water Sensitive Urban Design (WSUD) & Water Conservation

The DCP also provides requirements for WSUD in Part J, Section 4.2. For this development, it shall achieve a minimum percentage reduction of the post development average annual load of pollutants:

Pollutant	% post development average annual load reduction
Gross pollutants	90
Total suspended solids	85
Total phosphorous	65
Total nitrogen	45
Total hydrocarbons	90

In addition, Blacktown sets additional requirements for water conservation in Part J, Section 4.3 of the DCP. For industrial and business developments, these requirements state that 80% of non-potable water demand should come from non-potable sources, with rainwater as the primary source. For water used within public open space, the following applies:

Water use within public open space (for uses such as irrigation, pools, water features) must be supplied from non-potable sources such as recycled water, roof water, harvested stormwater or other non-licensed water sources and treated to NSW Government and Commonwealth Government standards.

7.2.3 On-Site Stormwater Detention (OSD) Requirements

The development site is located within the Upper Parramatta River Catchment, as shown below in Figure 3:

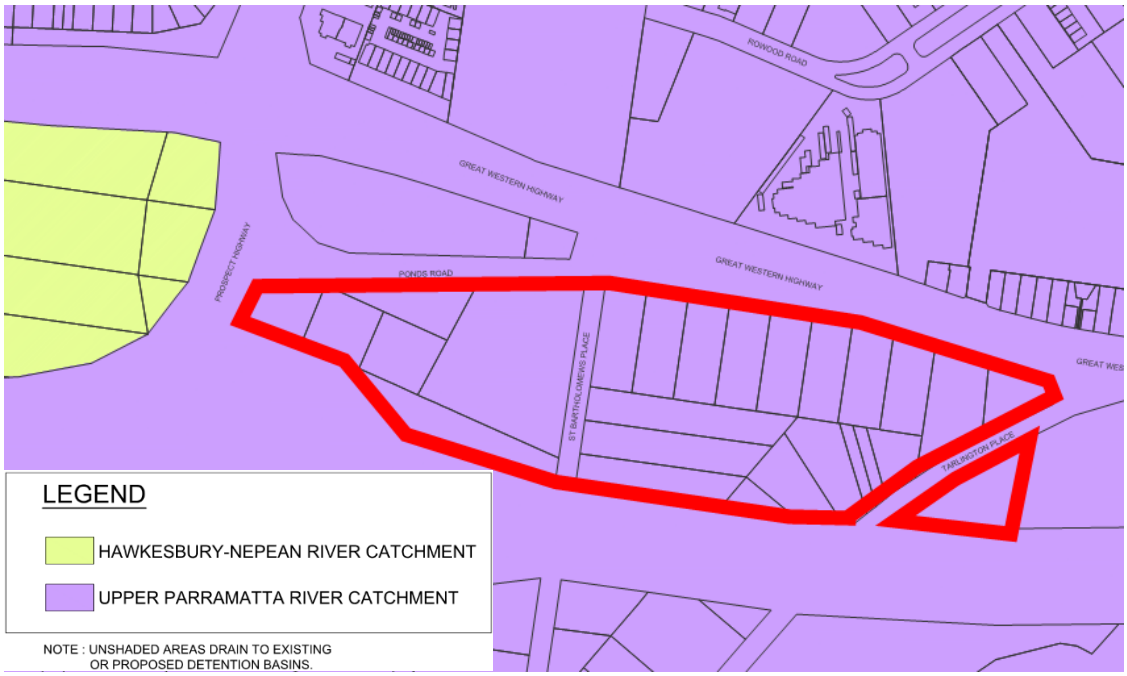


Figure 3: Catchment Areas Subject to OSD

According to Part J of the DCP, Section 2.1, this site is subject to On-Site Stormwater Detention (OSD) in accordance with the requirements set out within the Upper Parramatta River Catchment Trust On-Site Stormwater Detention Handbook (version 4, December 2005). The UPRCT Handbook sets out a standard for OSD Storage volume of 455 m^3/ha (with 300 m^3/ha of that volume for extended detention) and a total permissible site discharge (PSD) of 190L/s/ha (40L/s/ha for the primary outlet and 150 L/s/ha for the secondary outlet).

8 Preliminary Stormwater Management Concepts

The following section outlines a preliminary stormwater management concept plan based on the current concept plan for the site and Council requirements for stormwater management. Information provided in this section includes site grading, flood management, stormwater detention, and water sensitive urban design.

8.1 Site Grading & Bulk Earthworks

Site grading and bulk earthworks will be prepared so that there is a no net loss of flood storage. Existing drainage points will be maintained where possible, or re-provided elsewhere without having negative impacts on surrounding properties. Steep slopes with adverse erosion consequences will be avoided.

8.2 On-Site Stormwater Detention (OSD)

The on-site stormwater detention requirement for the site is 455m^3/ha based on the Upper Parramatta River Catchment Trust (UPRCT) Handbook. OSD will likely be required on the existing cemetery lands as part of these expansion works; it is not currently provided across the existing cemetery. Based on an approximate site area of 12.2ha, this equates to a total detention volume of 5,551 m^3. This number is contingent on which lands are ultimately developed for these stages of work (noting some are currently owned by BCC and others are contingent on acquisition). The UPRCT requires a standard development storage rate that is indifferent of land condition, thus this value is much more conservative than a pre- to post-development runoff comparison.

This estimated volume of stormwater detention does not account for the following, as they are currently not expected to be design constraints:

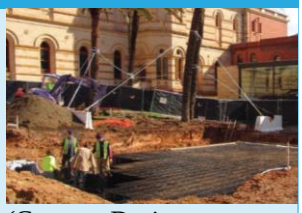
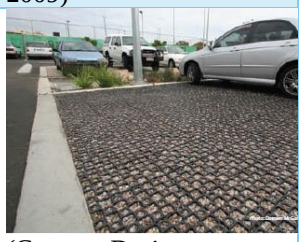
- Detention of flows from the upstream sub-catchment that may enter the site.
- Any allowance for backwater effects from floodwaters which may restrict the effective detention volume in the tanks.

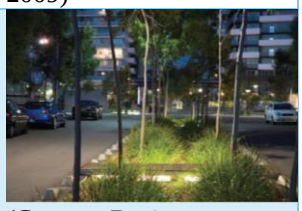
8.3 Water Sensitive Urban Design (WSUD)

Filtration for the site is expected to be met using sediment basins, bio-filtration basins and rain gardens. The total area of required filtration will need to be determined after a site layout is proposed, and the sites final uses have been determined. The final proposed WSUD treatment train will need to be assessed by MUSIC water quality modelling at a later design stage.

The following are sample treatment devices that could be incorporated throughout the site:

Table 1: Summary of best practice WSUD devices

WSUD Technology	Description	Contribution to WSUD Strategies	Typical Images
Rainwater Harvesting	Roof water can be collected in above-ground or below-ground rainwater tanks for re-use.	Water conservation by reducing the demand for potable water. Reduction in stormwater runoff	 (Concept Design Guidelines for WSUD pp 63, Water by Design, 2009)
Gross Pollutant Traps	Many types of devices which can be located at point of entry to subsurface network or on-line in a pit or at a discharge point	Removal of visually obtrusive litter and depending on the device, some coarse sediment Most suitable at locations that generate high levels of litter (e.g. commercial areas)	 (Rocla, http://www.rocla.com.au/CleansAll.php)
Sedimentation Basins	Basins at start of stormwater treatment train. Work by settling runoff, thereby removing course suspended solids and gross pollutants from runoff	Able to achieve approximately 80% reduction in coarse sediment loads and remove gross pollutants	 (Concept Design Guidelines for WSUD pp 70, Water by Design, 2009)
Porous Pavements	Alternative to impermeable parking allowing infiltration	Reduced runoff volume, increased infiltration	 (Concept Design Guidelines for WSUD pp 82, Water by Design, 2009)

WSUD Technology	Description	Contribution to WSUD Strategies	Typical Images
Green Roofs	Multi-layered systems that cover the roof of a building with vegetation cover/landscaping over a drainage layer. Designed to intercept and retain precipitation, reducing the volume of runoff and attenuating peak flows.	Mimics greenfield state of building footprint for high density developments, good removal of pollutants	 (Chicago City Hall, New York Times via Domain, http://www.domain.com.au/news/diy-rooftop-gardens-20120829-250aa/)
Tree Pits	Small vegetated filters that receive stormwater runoff prior to discharge to subsurface network	Able to capture and filter suspended solids, nutrients and heavy metals	 (Concept Design Guidelines for WSUD pp 55, Water by Design, 2009)
Bio-retention Swales	A combination of grassed swales and bio-retention basins. Typically comprise densely vegetated swales with filter media able to convey small flows.	As stormwater is conveyed it is filtered through vegetation and allowed to percolate through filter media where nutrients are removed.	 (Concept Design Guidelines for WSUD pp 45, Water by Design, 2009)
Bio-retention Basins/Rain Gardens	Densely planted basin with appropriate vegetation and filtration media	Stormwater filtered through densely planted vegetation then percolates through filter media where nutrients are retained through fine filtration, adsorption and some biological uptake. High nutrient removal performance.	 (Concept Design Guidelines for WSUD pp 45, Water by Design, 2009)

9 Flood Impact Assessment

As noted previously, no publicly available flood study covers the site area. In order to understand flooding behaviour across the site, a flood assessment has been undertaken for existing conditions. A two-dimensional hydrodynamic

TUFLOW model has been developed to derive design flood behaviour. Once a proposed design for the site has been determined, the existing flood conditions will be compared against the proposed flooding condition to ensure there are no negative effects on downstream properties or a loss flood storage of as a result of development. This assessment is summarised in this section of the report.

9.1 Flood Assessment Criteria

Preliminary flood modelling work has been carried out to derive design flood behaviour at the site for current conditions. The assessment has been based on determining two elements for the 1% AEP storm event:

- Flood depth
- Provisional hydraulic hazard.

9.1.1 Flood Depth

Flood Depth is defined as the peak water level, relative to ground level, that will result as a product of flooding.

As a result of adopting rainfall-on-grid to derive flood behaviour, results have been reported where flood depth is equal or in excess of 100mm as some areas may show unrepresentative extent and ponding of water due to the rainfall-on-grid approach.

9.1.2 Provisional Flood Hazard

The consideration of potential impacts on risk to life, structural stability and other damages has been assessed based on provisional flood hazard categorisation. The NSW Floodplain Development Manual 2005 (FDM 2005) defines best practice guidelines to assess and manage the impact of flooding and flood risk on flood prone land. Its objective is to reduce the impact of flooding and flood liability on owners and occupiers of flood prone property and reduce private and public infrastructure losses as a consequence of flooding. Further, the Australian Institute for Disaster Resilience (AIDR, 2017) provides a detailed classification of flood hazard based on thresholds that relate to the vulnerability of people, vehicles and buildings when interacting with floodwaters. These thresholds are presented in Figure 4 and use depth, velocity and depth-velocity product of flow.

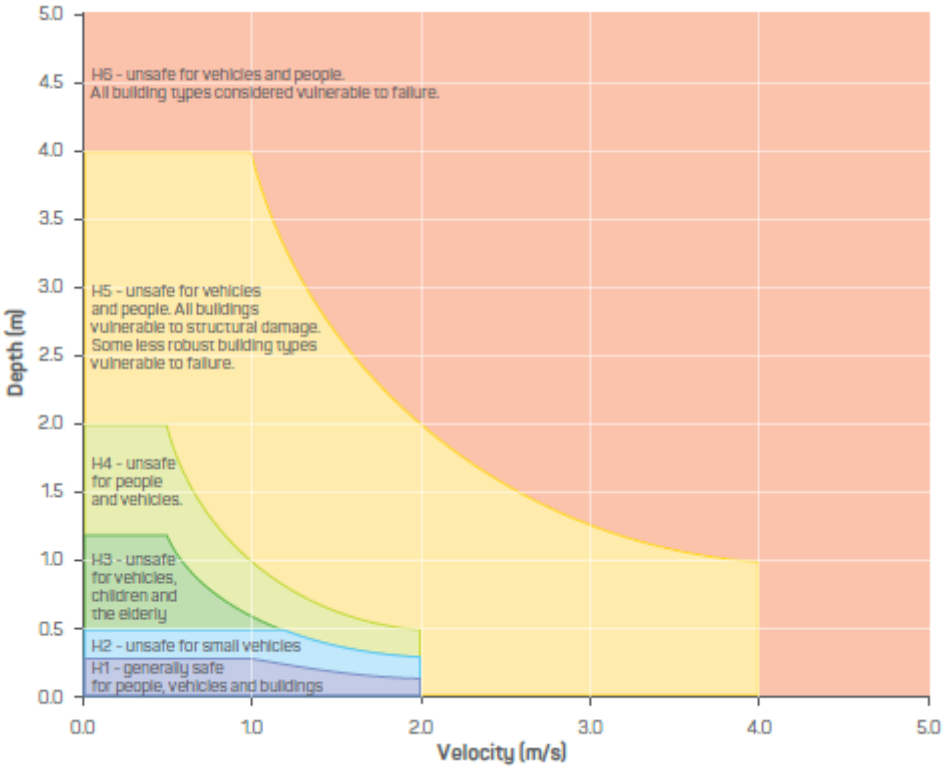


Figure 4 Provisional hydraulic flood hazard categories (source: AIDR 2017)

9.1.3 Modelling Approach

Design flood behaviour has been estimated adopting the rainfall-on-grid approach into a TUFLOW 2D hydrodynamic model based on the current national guidelines for design flood estimation presented in Australian Rainfall and Runoff 2016 (ARR2016).

9.1.3.1 Areal Reduction Factors

Design rainfall information utilised for design flood estimation is usually provided at specific location rather than catchment wide format. The information is normally provided in IFD tables (Intensity-Frequency-Duration). Depending on the size of the catchment the ratio of the design rainfall value at a given point will differ from the areal average rainfall. This is due to the fact that larger catchments will not experience the same intensity of rainfall than small catchments. As such, the Areal Reduction Factor (ARF) allows the use of point rainfall data into catchment wide calculations.

Book 2 – Chapter 4 of ARR2016 outlines the estimation of ARF values based on catchment area and duration of storm. In the current study, due to the small catchment size of the site (1 km^2) a value of 1 was adopted.

9.1.3.2 Temporal Patterns

Book 2 – Chapter 5 of ARR2016 provides guidance on the selection of temporal patterns for design rainfall estimation. The current guidelines recommend the use of an ensemble approach rather than a single-event approach as was previously carried out using ARR1987. The new approach was devised to account for the natural variability of rainfall in time and space and apply it to current design.

Rainfall temporal pattern information was sourced from the ARR Data Hub (Appendix B). Temporal pattern "bins" define the variability of rainfall across Australia. The corresponding temporal pattern region for the subject site is the East Coast South.

9.1.3.3 Design Rainfall Information and Losses

Design rainfall information was sourced from the Bureau of Meteorology (BoM). Table 2 shows the IFD information corresponding to the site.

Table 2: IFD data

Duration	63.20% AEP	50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP
1 min	2.11	2.36	3.17	3.73	4.28	5.02	5.59
2 min	3.44	3.78	4.93	5.75	6.59	7.71	8.59
3 min	4.78	5.29	6.94	8.12	9.3	10.9	12.1
4 min	6.03	6.7	8.86	10.4	11.9	14	15.6
5 min	7.15	7.98	10.6	12.5	14.3	16.8	18.7
10 min	11.4	12.8	17.3	20.4	23.4	27.4	30.5
15 min	14.2	16	21.6	25.5	29.2	34.3	38.1
20 min	16.2	18.3	24.7	29.1	33.4	39.1	43.5
25 min	17.8	20	27	31.8	36.5	42.7	47.5
30 min	19.2	21.5	28.9	34	39	45.6	50.8
45 min	22.2	24.8	33.1	38.8	44.5	52.1	58
1 hour	24.5	27.3	36.1	42.3	48.5	56.9	63.5
1.5 hours	28.1	31.1	40.9	47.8	54.8	64.5	72.1
2 hours	30.9	34.2	44.8	52.4	60.2	70.9	79.5
3 hours	35.6	39.4	51.6	60.5	69.6	82.3	92.7
4.5 hours	41.4	45.9	60.5	71.2	82.2	97.7	110
6 hours	46.4	51.5	68.5	80.9	93.7	112	127
12 hours	61.8	69.4	94.9	114	133	160	182
24 hours	82	93.4	132	162	193	232	264

9.1.3.4 Model Built

A TUFLOW 2D hydrodynamic model was developed for the site and used to determine the 1% AEP flood event. The TUFLOW model adopts a two-metre grid size and utilises detailed ground survey of the existing site provided by LandPartners (02/05/2018). Where topographic survey data was unavailable, (such as areas beyond the project boundary), LiDAR data was utilised to complete the hydraulic model extent (sourced from Foundation Spatial Data Framework Elevation and Depth Dataset, ELVIS).

As no pits and pipes are located on the existing site, the TUFLOW model has not included this level of detail within the flood model.

The extent of the TUFLOW model boundary, shown in Figure 5, was chosen based on the topography of the surrounding area. This boundary incorporates the entire upstream catchment area that drains to the site.

A normal depth-flow relationship was adopted as downstream boundary located sufficiently downstream of the subject site such that hydraulic backwater effects would not impact results at the study site. Sensitivity testing was undertaken to confirm the appropriateness of these boundary conditions (refer to Section 9.1.4).

9.1.4 Sensitivity Testing

Sensitivity tests were undertaken as part of the TUFLOW model development process in order to confirm the appropriateness of the boundary conditions chosen. Specifically, the impact of changes to tailwater conditions on flood behaviour at the site were tested in the existing case model. These results provide a basis for determining the relative sensitivity of the flood model results at the site to the adopted values.

It was found that changes to the tailwater levels did not result in any significant change to the 1% AEP peak flood levels and therefore the boundary location chosen is considered appropriate for the assessment of flooding at the development site.

9.2 Existing Terrain

The existing topography of the site grades naturally in a easterly direction, with a natural high point down the middle and gradual falls to the north and south of the ridgeline. The site falls approximately 40m from west to east. Existing site topography, including indicative locations of overland flow paths and site falls through the site, are shown in Figure 5.

Figure 5 Topography of the existing site with indicative site slopes

9.3 Flood Behaviour

Flood modelling simulations was undertaken for the existing site development scenario for the 1% AEP storm events. Flood maps showing flood depths, levels, and provisional hazards were compiled to summarise the results of these storm events and are contained in Appendix A. A list of flood maps prepared as part of this report is also included in Table 3.

Table 3: List of flood maps in prepared as part of the flood assessment

Figure	Title
A-01	1% AEP Peak Flood, Existing Scenario, Level and Depth, Sheet 1 of 2
A-02	1% AEP Peak Flood, Existing Scenario, Level and Depth, Sheet 2 of 2
A-03	1% AEP Provisional Flood Hazard, Existing Scenario, Sheet 1 of 2
A-04	1% AEP Provisional Flood Hazard, Existing Scenario, Sheet 1 of 2

9.3.1 Existing Conditions Flood Behaviour

The existing conditions flood model results indicate that a majority of the site drains to an isolated low point near the centre of the site (directly to the south of the Great Western Hwy). An overland flow route from this low point is not immediately clear from the modelling. This low point is shown in Figure 6, below. Additionally, water collects to the southern boundary edge along the M4 Western Motorway edge, in existing swales and low points nearby the site boundary.

The critical duration storm event for the 1% AEP event was found to be 6 hours.

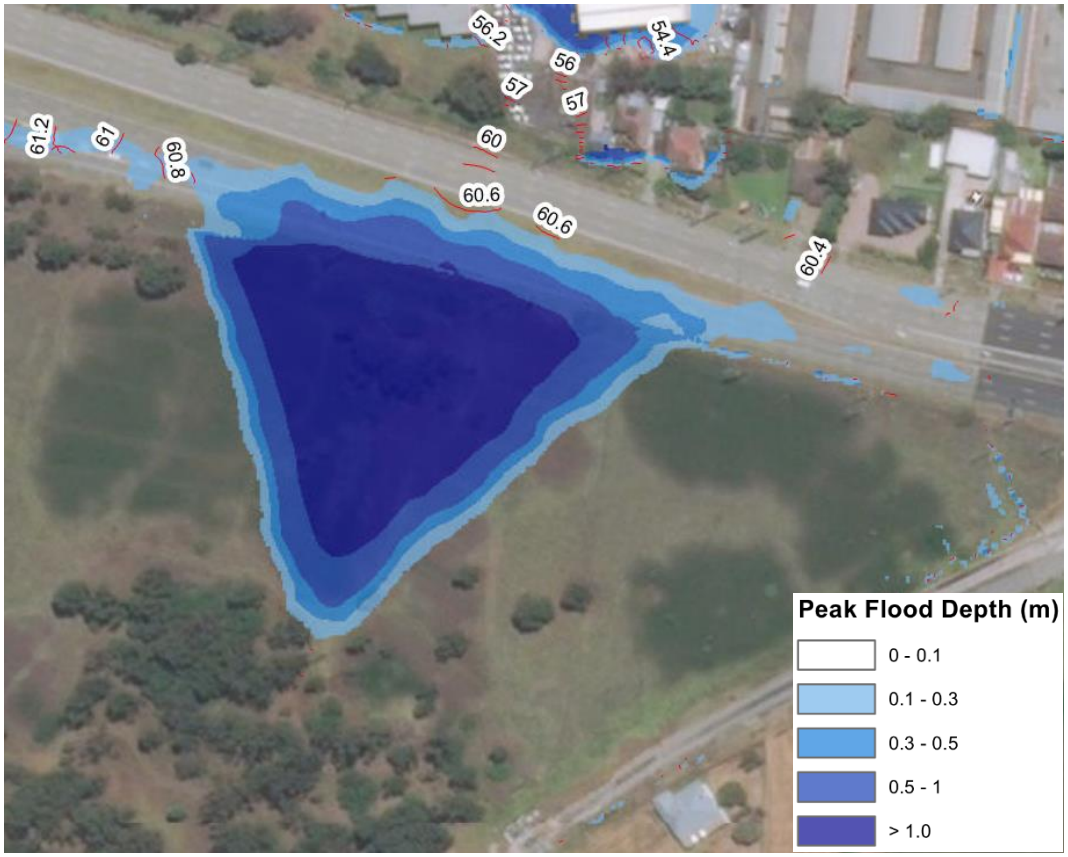


Figure 6 Existing Site Low Point for the 1% AEP event

9.3.2 Proposed Flood Behaviour

The proposed site design will be designed to make sure any building footprints provide adequate provision for movement of overland flow and site drainage. Additionally, to have no net loss of flood storage and/or conveyance within the floodway extents for storms within the 1% annual exceedance probability (AEP) critical duration flood. The alteration of local drainage or overland flow contours will ensure no adverse effects on adjacent property.

9.3.3 Provisional Flood Hazard

Provisional flood hazard maps (refer Appendix A) were prepared for the 1% AEP flood event for the existing site condition. The maps generally present the site as low hazard for the existing development scenarios for the 1% AEP event. The ultimate site design will need to ensure any changes to provisional flood hazards shall be mitigated appropriately. The significant area of hazard is the low point along the northern boundary of the site; future buildings should be avoided within this area (unless site grading provides flood storage elsewhere). This is shown within the figure below:

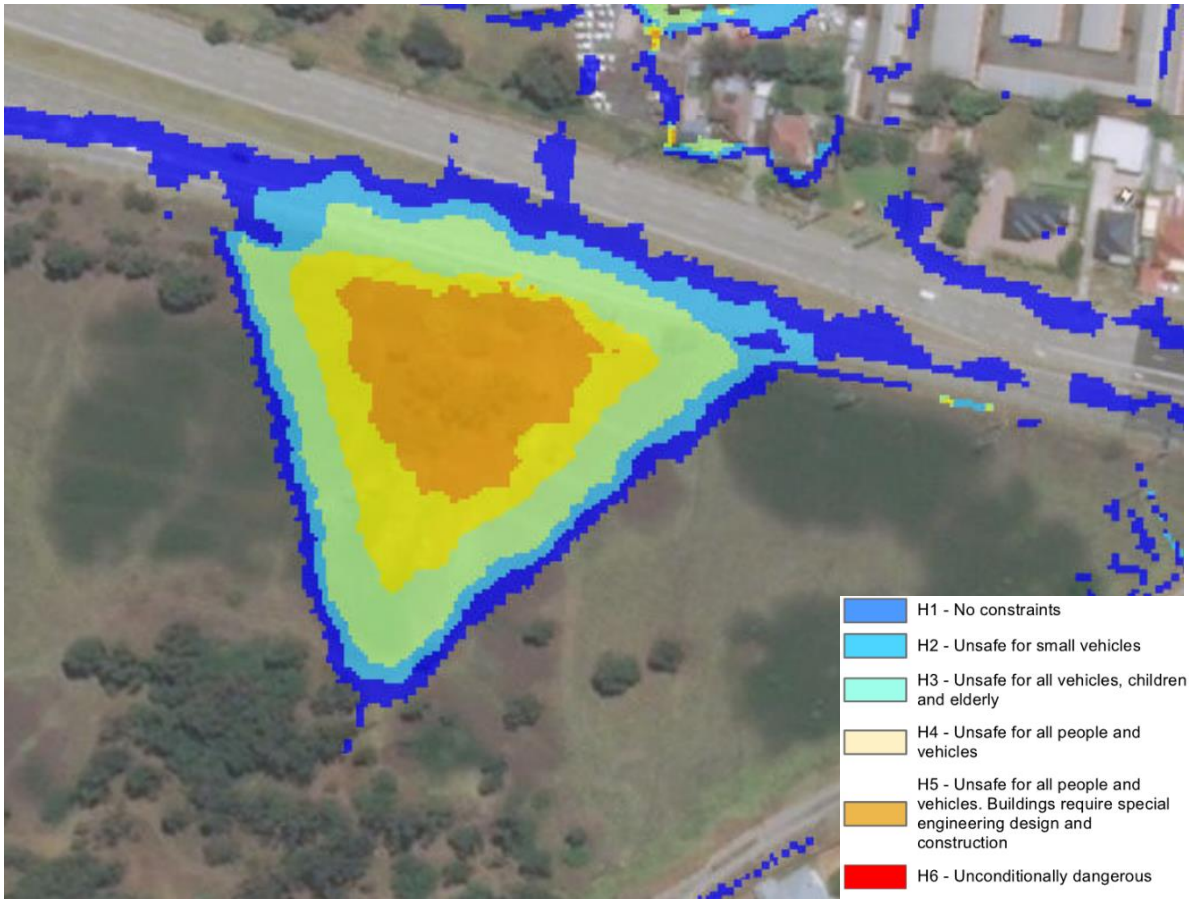


Figure 7: Existing Provisional Flood Hazard (1% AEP event)

10 Summary

The existing St Bartholomew's Cemetery is seeking rezoning and expansion. The expansion will be onto lots that are largely undeveloped lots.

Cemetery expansion will be in accordance with the requirements set out within the Blacktown City Council LEP 2015, Blacktown City Council DCP 2015, and the UPCRT Stormwater Detention Handbook. This will ensure that there will be no net loss of existing flood storage as a result of the development, and development will not adversely affect the adjacent properties.

On-Site Stormwater Detention will be required at a rate of 455 m^3/ha, and is likely to include the existing cemetery lands. Water quality devices will also need to be included across the site to mitigate the effects of development on the stormwater network. A variety of WSUD practices will be incorporated throughout the development to meet the applicable targets within the DCP.

The existing flood conditions for the 1% AEP peak flood event were analysed as part of this report, using the ARR 2016 methodology. The site topography slopes to a low point in the centre of the site, adjacent to Great Western Highway. As such, most of the site flood affection is located within this area. In the 1% AEP peak flood event, water ponds in this area to depths greater than 1.0m, creating an area of high hazard. Development will need to account for this existing flooding, either by retaining this as the low point or providing sufficient flood storage space elsewhere. The rest of the site is largely unaffected by flooding, with the exception of small pockets of flooding along the southern boundary.

Appendix A

Flood Impact Assessment Maps

A3

Legend

- Model Boundary
- Peak Flood Level Contours 0.2m

Peak Flood Depth (m)

- 0 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- > 1.0

Issue	Date	By	Chkd	Appd
1	30/05/2018	MB	IS	SL

Metres
0 25 50 100

ARUP

201 Kent Street
Sydney 2000
Tel +61 2 9320 9320 Fax +61 2 9320 9321
www.arup.com

Client

Blacktown City Council

Job Title

St Bartholomew's Cemetery Expansion

1% AEP Peak Flood Existing Scenario Level and Depth Sheet 1 of 2

Scale at A3

1:2000

Job No	Drawing Status	Issue
259202	**Preliminary**	**1**

Map No

A-01

A3

Legend

- Model Boundary
- Peak Flood Level Contours 0.2m

Peak Flood Depth (m)

- 0 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- > 1.0

Issue	Date	By	Chkd	Appd
1	30/05/2018	MB	IS	SL

Metres
0 25 50 100

ARUP

201 Kent Street
Sydney 2000
Tel +61 2 9320 9320 Fax +61 2 9320 9321
www.arup.com

Client
Blacktown City Council

Job Title
St Bartholomew's Cemetery Expansion

1% AEP Peak Flood Existing Scenario Level and Depth Sheet 2 of 2

Scale at A3
1:2000

Job No
259202

Drawing Status
Preliminary

Map No
A-02

Issue
1

A3

Legend

Model Boundary

Provisional Flood Hazard

- H1 - No constraints
- H2 - Unsafe for small vehicles
- H3 - Unsafe for all vehicles, children and elderly
- H4 - Unsafe for all people and vehicles
- H5 - Unsafe for all people and vehicles. Buildings may require special engineering design
- H6 - Unconditionally dangerous

Issue	Date	By	Chkd	Appd
1	30/05/2018	MB	IS	SL

Metres
0 25 50 100

ARUP

201 Kent Street
Sydney 2000
Tel +61 2 9320 9320 Fax +61 2 9320 9321
www.arup.com

Client

Blacktown City Council

Job Title

St Bartholomew's Cemetery Expansion

1% AEP Peak Flood Existing Scenario Level and Depth Sheet 1 of 2

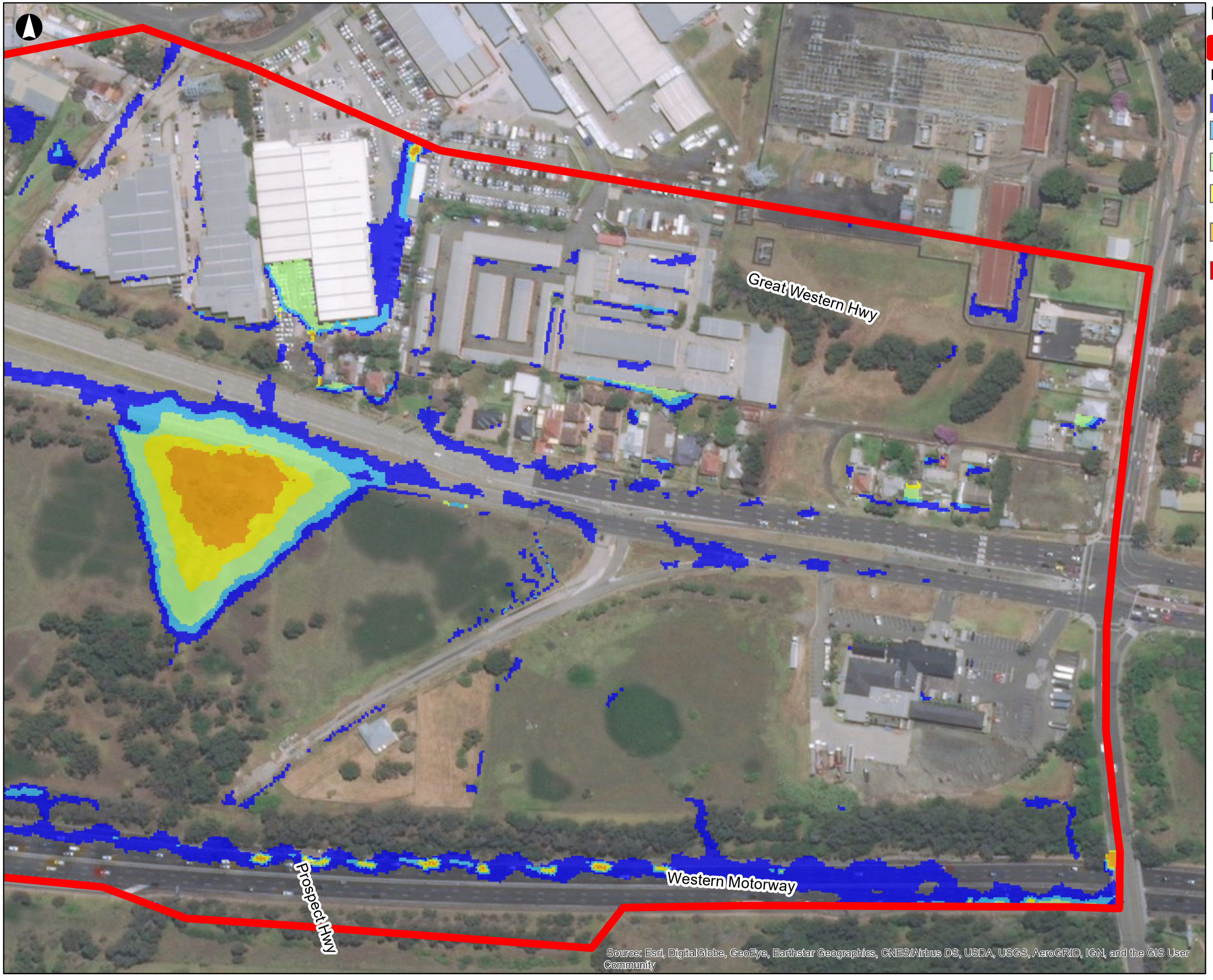
Scale at A3

1:2000

Job No	Drawing Status
259202	**Preliminary**

Map No	Issue
A-01	**1**

A3



Legend

Model Boundary

Provisional Flood Hazard

- H1 - No constraints
- H2 - Unsafe for small vehicles
- H3 - Unsafe for all vehicles, children and elderly
- H4 - Unsafe for all people and vehicles
- H5 - Unsafe for all people and vehicles. Buildings may require special engineering design
- H6 - Unconditionally dangerous

Issue	Date	By	Chkd	Appd
1	30/05/2018	MB	IS	SL

Metres
0 25 50 100

ARUP

201 Kent Street
Sydney 2000
Tel +61 2 9320 9320 Fax +61 2 9320 9321
www.arup.com

Client

Blacktown City Council

Job Title

St Bartholomew's Cemetery Expansion

1% AEP Peak Flood Existing Scenario Level and Depth Sheet 2 of 2

Scale at A3

1:2000

Job No	Drawing Status
259202	Preliminary

Map No	Issue
A-02	1

Appendix B

Site AR&R 2016 Rainfall Data

Results - ARR Data Hub

[STARTTXT]

Input Data Information

[INPUTDATA]

Latitude,-33.804808

Longitude,150.92108

[END_INPUTDATA]

River Region

[RIVREG]

division,South East Coast (NSW)

rivregnum,13

River Region,Sydney Coast-Georges River

[RIVREG_META]

Time Accessed,15 June 2018 02:30PM

Version,2016_v1

[END_RIVREG]

ARF Parameters

[LONGARF]

Zone,SE Coast

a,0.06

b,0.361

c,0.0

d,0.317

e,8.11e-05

f,0.651

g,0.0

h,0.0

i,0.0

[LONGARF_META]

Time Accessed,15 June 2018 02:30PM

Version,2016_v1

[END_LONGARF]

Storm Losses

[LOSSES]

id,26336.0

Storm Initial Losses (mm),28.0

Storm Continuing Losses (mm/h),1.9

[LOSSES_META]

Time Accessed,15 June 2018 02:30PM

Version,2016_v1

[END_LOSSES]

Temporal Patterns

[TP]

code,ECsouth

Label,East Coast South

[TP_META]

Time Accessed,15 June 2018 02:30PM

Version,2016_v2

[END_TP]

Areal Temporal Patterns

[ATP]

code,ECsouth

arealabel,East Coast South

[ATP_META]

Time Accessed,15 June 2018 02:30PM

Version,2016_v2

[END_ATP]

BOM IFD Depths

[BOMIFD]

No data,No data found at this location!

[BOMIFD_META]

Time Accessed,15 June 2018 02:30PM

[END_BOMIFD]

Median Preburst Depths and Ratios

[PREBURST]

min (h)\AEP(%),50,20,10,5,2,1,

60 (1.0),0.8 (0.028),1.2 (0.033),1.5 (0.035),1.7 (0.036),1.7 (0.030),1.6 (0.026),

90 (1.5),0.5 (0.016),0.9 (0.023),1.2 (0.025),1.5 (0.027),1.5 (0.024),1.6 (0.022),

120 (2.0),1.0 (0.029),1.3 (0.029),1.5 (0.028),1.6 (0.027),1.5 (0.021),1.4 (0.018),

180 (3.0),1.5 (0.038),2.0 (0.040),2.4 (0.040),2.8 (0.040),2.7 (0.032),2.6 (0.028),

360 (6.0),4.7 (0.092),12.4 (0.180),17.4 (0.215),22.2 (0.237),17.3 (0.154),13.5 (0.107),

720 (12.0),9.2 (0.132),10.3 (0.109),11.1 (0.098),11.9 (0.089),15.5 (0.097),18.3 (0.100),

1080 (18.0),0.6 (0.007),6.4 (0.056),10.3 (0.074),14.0 (0.085),15.6 (0.078),16.8 (0.074),

1440 (24.0),0.0 (0.000),4.1 (0.031),6.8 (0.042),9.4 (0.049),12.6 (0.054),15.0 (0.057),

2160 (36.0),0.0 (0.000),1.5 (0.009),2.5 (0.013),3.4 (0.015),4.8 (0.017),5.8 (0.018),

2880 (48.0),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),1.3 (0.004),2.3 (0.006),

4320 (72.0),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),

[PREBURST_META]

Time Accessed,15 June 2018 02:30PM

Version,2018_v1

Note,Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

[END_PREBURST]

10% Preburst Depths

[PREBURST10]

min (h)\AEP(%),50,20,10,5,2,1,

60 (1.0),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),

90 (1.5),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),

120 (2.0),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),

180 (3.0),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),

360 (6.0),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),

720 (12.0),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),

1080 (18.0),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),

1440 (24.0),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),

2160 (36.0),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),

2880 (48.0),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),

4320 (72.0),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),

[PREBURST10_META]

Time Accessed,15 June 2018 02:30PM

Version,2018_v1

Note,Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

[END_PREBURST10]

25% Preburst Depths

[PREBURST25]

min (h)\AEP(%),50,20,10,5,2,1,

60 (1.0),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),

90 (1.5),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),

120 (2.0),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),

180 (3.0),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),

360 (6.0),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),

720 (12.0),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),

1080 (18.0),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),

1440 (24.0),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),

2160 (36.0),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),

2880 (48.0),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),

4320 (72.0),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),

[PREBURST25_META]

Time Accessed,15 June 2018 02:30PM

Version,2018_v1

Note,Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

[END_PREBURST25]

75% Preburst Depths

[PREBURST75]

min (h)\AEP(%),50,20,10,5,2,1,

60 (1.0),13.7 (0.501),14.7 (0.407),15.4 (0.364),16.1 (0.332),18.2 (0.320),19.7 (0.311),

90 (1.5),13.8 (0.443),14.3 (0.349),14.6 (0.306),14.9 (0.272),21.0 (0.325),25.5 (0.353),

120 (2.0),13.8 (0.404),19.8 (0.442),23.8 (0.454),27.6 (0.459),29.8 (0.421),31.5 (0.396),

180 (3.0),21.8 (0.553),38.9 (0.753),50.2 (0.829),61.0 (0.877),49.1 (0.596),40.1 (0.433),

360 (6.0),27.7 (0.538),44.2 (0.646),55.1 (0.682),65.6 (0.700),77.1 (0.689),85.7 (0.676),

720 (12.0),35.6 (0.513),45.3 (0.478),51.8 (0.456),58.0 (0.435),62.0 (0.386),64.9 (0.356),

1080 (18.0),16.0 (0.194),28.9 (0.250),37.3 (0.267),45.5 (0.274),51.1 (0.255),55.2 (0.243),

1440 (24.0),13.2 (0.141),26.2 (0.198),34.8 (0.215),43.0 (0.223),46.6 (0.201),49.3 (0.187),

2160 (36.0),12.9 (0.118),17.7 (0.112),20.9 (0.107),24.0 (0.102),36.3 (0.129),45.5 (0.142),

2880 (48.0),0.8 (0.007),6.0 (0.034),9.5 (0.043),12.8 (0.048),22.5 (0.071),29.8 (0.083),

4320 (72.0),0.0 (0.000),0.2 (0.001),0.4 (0.002),0.5 (0.002),11.7 (0.032),20.0 (0.049),

[PREBURST75_META]

Time Accessed,15 June 2018 02:30PM

Version,2018_v1

Note,Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

[END_PREBURST75]

90% Preburst Depths

[PREBURST90]

min (h)\AEP(%),50,20,10,5,2,1,

60 (1.0),56.4 (2.066),56.0 (1.551),55.8 (1.319),55.6 (1.146),61.3 (1.078),65.6 (1.034),

90 (1.5),53.8 (1.730),78.1 (1.911),94.3 (1.971),109.7 (2.000),90.8 (1.409),76.7 (1.064),

120 (2.0),48.0 (1.406),69.9 (1.560),84.4 (1.610),98.3 (1.633),104.1 (1.469),108.5 (1.365),

180 (3.0),46.4 (1.178),75.5 (1.463),94.8 (1.568),113.4 (1.630),124.7 (1.514),133.1 (1.437),

360 (6.0),69.7 (1.353),95.5 (1.395),112.6 (1.393),129.0 (1.377),137.5 (1.229),143.9 (1.136),

720 (12.0),59.8 (0.862),82.7 (0.871),97.8 (0.860),112.3 (0.842),111.9 (0.697),111.6 (0.612),

1080 (18.0),49.5 (0.598),63.9 (0.553),73.4 (0.524),82.5 (0.498),103.0 (0.516),118.4 (0.521),

1440 (24.0),46.3 (0.496),68.6 (0.518),83.3 (0.515),97.4 (0.505),104.1 (0.448),109.1 (0.413),

2160 (36.0),43.5 (0.398),48.5 (0.307),51.8 (0.266),55.0 (0.234),77.5 (0.274),94.3 (0.295),

2880 (48.0),24.9 (0.206),38.1 (0.216),46.9 (0.214),55.3 (0.209),77.2 (0.243),93.7 (0.261),

4320 (72.0),7.8 (0.057),14.2 (0.071),18.4 (0.074),22.5 (0.074),39.4 (0.109),52.0 (0.128),

[PREBURST90_META]

Time Accessed,15 June 2018 02:30PM

Version,2018_v1

Note,Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

[END_PREBURST90]

Interim Climate Change Factors

[CCF]

2030,0.892 (4.5%),0.775 (3.9%),0.979 (4.9%),

2040,1.121 (5.6%),1.002 (5.0%),1.351 (6.8%),

2050,1.334 (6.7%),1.28 (6.4%),1.765 (8.8%),

2060,1.522 (7.6%),1.527 (7.6%),2.23 (11.2%),

2070,1.659 (8.3%),1.745 (8.7%),2.741 (13.7%),

2080,1.78 (8.9%),1.999 (10.0%),3.249 (16.2%),

2090,1.825 (9.1%),2.271 (11.4%),3.727 (18.6%),

[CCF_META]

Time Accessed,15 June 2018 02:30PM

Version,2016_v1

Note,ARR recommends the use of RCP4.5 and RCP 8.5 values

[END_CCF]

[ENDTXT]