Upper South Creek Advanced Water Recycling Centre – Response to Request for Information 44447594 - Flooding

11 July 2022

Issue

The Request for Information (RFI) notes advice received from the Department of Planning and Environment's Environment and Heritage Group (EHG) requesting Sydney Water to provide further information to clearly explain how the base case (flooding) scenario presented in the project's Flood Impact Assessment (FIA) is compatible with the NSW Government's flood model.

Response

The FIA in the project's Environmental Impact Statement (EIS) addressed the Secretary's Environmental Assessment Requirements for flooding, incorporated advice received during consultation with EHG, INSW and Penrith City Council, and addressed further comments on the EIS and Submissions Report to demonstrate how the project's FIA aligns with the base case scenario shown in the NSW Government's Study (Advisian, 2020).

With the Reference Design for the project adopting Penrith Council's adopted 1% AEP flood levels and ensuring all development be above that level, the FIA demonstrated that impacts during flood events up the PMF would be minor. Sydney Water confirms that the flood modelling provided in all project assessments including the EIS, Submissions Report and Attachment A of this document demonstrates the project does not impact the existing flood environment in South and Kemps Creek, including when NSW Government hydrology is used as a flow input.

Attachment A consolidates key information from the EIS and Submissions Report demonstrating how the project's Flood Impact Assessment produces results that are compatible with the NSW Government's base case flood scenario. It seeks to respond to the general intent of EHG's latest advice and includes additional modelling for the 0.5%, 0.2% 5% and 20% AEP flood scenarios using Advisian data.

Hydrology data used throughout the FIA and subsequent responses

Data from the Advisian study was not available to Sydney Water during EIS preparation, despite requests to Infrastructure NSW (INSW) across 2021. Sydney Water obtained hydrology data for the 1% AEP flow after the EIS was prepared and provided further analysis of this in the project's Submissions Report. Sydney Water did not obtain the additional hydrology data (0.5%, 0.2%, 5% and 20% AEP) from INSW until late June 2022. This data has now been in incorporated into our response in Attachment A.

In its latest comments, EHG has requested new information including preparation and validation of a new hydrology model to match the NSW Government's study (Advisian, 2020). Sydney Water maintains the additional modelling described in Appendix C of the Submissions Report that uses actual flow data (1% AEP) from the NSW Government's study (Advisian, 2020) is an appropriate approach to demonstrate that the models used are compatible with the NSW Government's models and that no new hydrology model is required when NSW Government hydrology is available.

Final results produced for this RFI response

Sydney Water considers that by incorporating actual flow data from the Advisian study, we have demonstrated that the project's flood model produces outputs that are compatible with NSW Government studies. Modelling described in Appendix C of the Submissions Report showed that the project's hydraulic model produces a 1% AEP flood extent which is a very close match with the

NSW Government's 1% AEP flood extent. This validates the project's flood model given it produces similar results.

Sydney Water considers we have diligently and reasonably addressed EHG's comments to date, have provided detailed explanation of the work done in the EIS and have demonstrated alignment with the NSW Government flood study (Advisian, 2020) in Appendix C of the Submissions Report. Sydney Water trusts that the additional information provided in Attachment A now closes out this matter.

Attachment A Alignment with NSW Government flood modelling

To	**Nat Swannack**	**From**	**Peter Gillam**
Copy	**Elissa Howie, Stephanie Clarke**	**Reference**	
Date	**8/07/2022**	**Pages (including this page)**	**17**
Subject	**Upper South Creek AWRC EIS –alignment with NSW Government flood modelling**		

1 Introduction

The following consolidates Sydney Water's Advanced Water Recycling Centre (AWRC) Flood Impact Assessment (FIA) to demonstrate that modelling has incorporated EHG's advice to date and aligns with the NSW Government flood model. This includes work done on defining base case and post development flooding using ARR1987 hydrology that is compatible with the Government's models as follows:

- 10% Annual Exceedance Probability (AEP) and Probable Maximum Flood (PMF) events taken from the AWRC EIS
- 1% AEP events as reported in Appendix C of the Submissions Report
- 20%, 0.2% and 0.5% AEP events mapped through subsequent modelling undertaken to ensure flows are consistent with the Government's flood model (INSW).

Much of the data provided within this summary document has been reproduced to provide a concise reference. The data is set out in a similar structure to the *Attachment A- Upper South Creek Advanced Water Recycling Centre (SSI 8609189) Flood Impact Assessment (FIA) Way Forward* provided by DPE.

Hydrology Base Case - The FIA data compiled below adequately demonstrates alignment with the Government's adopted base case flood modelling that uses ARR1987 hydrology calibrated to local gauges. The adoption of hydrographs provided by INSW for the 20%, 1%, 0.2% and 0.5% AEP events ensures that hydrograph shapes and peak flows are consistent with those used by the Government modelling. Other flows adopted for the 10% AEP and PMF event provide similar peak flows to the Government's model. This provides a basis for defining base case flooding and demonstrating flood impacts.

Hydraulic Base Case - Modelling of the 1% AEP event, has previously been validated against the Government adopted 1% AEP base case flood modelling. The adopted base case flooding, using ARR1987 flows, is presented and demonstrates compatibility with the Government's model. Base case flood mapping is presented to show how the AWRC facility is set back from flood constraints and that proposed land use is compatible with flood risk and hazard under existing and possible climate change flooding scenarios.

Post Development Flood Impact Mapping – Mapping is compiled to show how the AWRC facility impacts the adopted base case flooding for a range of events including the 20%, 1%, 0,2%, 0.5% AEP and PMF events. For completeness, new 20%, 0.5% and 0.2% AEP flood impact assessment mapping is included using ARR1987 hydrology provided by INSW and compatible with the Government model. 10% AEP hydrology is not available from the INSW modelling.

2 Hydrology Base Case

As stated, the purpose of this chapter is to confirm that hydrology has been adopted that is consistent with the Government model.

The submitted AWRC EIS has used rainfall data provided by Australian Rainfall and Runoff 2016 and the methods adopted have resulted in design flow hydrographs that are lower than those predicted by Australian Rainfall and Runoff 1987 and adopted by the Government model for the 1%, 0.5% and 0.2% AEP events. Flows adopted in the AWRC for the PMF event and the 1% flood frequency assessment matched the Government model and showed no flood impact for a range of events up to and including the PMF.

2.1 1% AEP

Subsequent modelling is presented below using ARR1987 hydrology provided by INSW to ensure consistency with the Governments model and remove any further risk of delays caused by discrepancy in defining base case hydrology.1% AEP Hydrology.

ARR1987 1% AEP flood hydrographs have been provided by Infrastructure NSW (INSW) (*ref: 210617_Base+Case+1%+AEP+Flows+(Rev+H)+-+Elizabeth+Drive+(Advisian).xlsx*). These hydrographs were taken directly from the Government Model.

2.2 Other Events

INSW provided XP-RAFTS hydrologic models to allow the extraction of 20% AEP, 0.5% AEP, 0.2% AEP and PMF event flows.

It was intended that the hydrograph shape and peaks would be used to validate Sydney Water's hydrologic models, however it is preferable to simply adopt the INSW model flows in this subsequent modelling for consistency. ARR1987 hydrographs for Wianamatta-South Creek at Elizabeth Drive are presented in Figure 1.

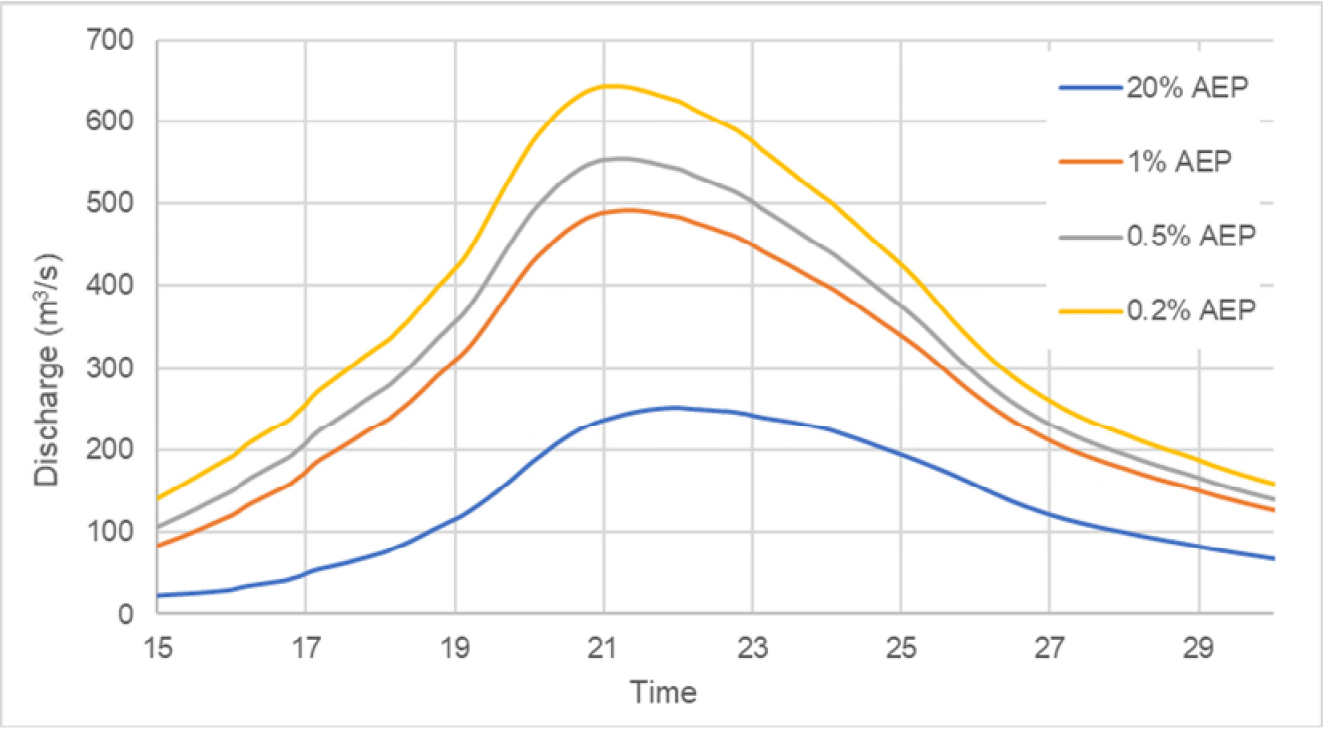

Figure 1 Base case hydrology adopted for Wianamatta-South Creek at Elizabeth Drive provided by INSW models and incorporated into base case hydraulic mapping. Hydrographs for Kemps, Badgerys and Cosgroves are not shown here.

2.3 Verification of Flow Rates

A summary of flow rates adopted in this study and their corresponding reference are provided below in Table 1.

The comparison of peak flows demonstrates consistency with Penrith Council's adopted flood data for all events.

Table 1 Modelled South Creek flood flowrates upstream of Elizabeth Drive

Event Flow (m^3/s)	PCC 2015 Adopted Flow Rate	Adopted AWRC Study Flow Rate	Source of data for AWRC flow	Commentary
20% AEP	-	252	INSW model 220520_South Creek_20% AEP_36h.XP	Hydrograph extracted from INSW models
1% AEP	450	491	INSW email 210617_Base+Case+1%+AEP+Flows+(Rev+H)+-+Elizabeth+Drive+(Advisian).xlsx	The same hydrograph (peak flow and shape) as adopted in the Government's flood model (i.e. the Wianamatta (South) Creek Flood Study – Existing conditions prepared by Advisian for Infrastructure NSW in November 2020 or subsequent versions of this report).

Event Flow (m^3/s)	PCC 2015 Adopted Flow Rate	Adopted AWRC Study Flow Rate	Source of data for AWRC flow	Commentary
0.5% AEP	520	555	INSW model 220520_South Creek_0.5% AEP_36h.XP	Hydrograph extracted from INSW models
0.2% AEP	600	642	INSW model 220520_South Creek_0.2% AEP_36h.XP	Hydrograph extracted from INSW models
PMF	1680	1651	AWRC XP RAFTS model	Peak flow matches flow adopted by Government

3 Hydraulic Base Case

The following section compiles hydraulic modelling undertaken using the AWRC TUFLOW model that demonstrates the base case scenario presented in the EIS is compatible with Government's flood model.

The full range of flows listed in Table 1 were used as inputs into the AWRC TUFLOW hydraulic model.

3.1 Model set up, parameters, inputs

The hydraulic model extends from the upstream hydraulic control (upstream of Elizabeth Drive) to downstream of the Warragamba pipeline. An overview of the data and information used in the hydraulic model are presented in Table 2.

Table 2 USC AWRC hydraulic model setup overview

Parameter	Information
Hydraulic Modelling Approach	TUFLOW software version Build 2018-03-AC – GPU - HPC
Aerial Imagery	Nearmap captured April 2020
Coordinate System	GDA94/MGA zone 56
Model Extent	Elizabeth Drive to downstream of Water NSW pipelines as shown in Figure 2.
Scenarios	The existing case and design case scenarios
Design Events	20% AEP, 1% AEP, 0.5% AEP, 0.2% AEP and PMP
Topography	LiDAR 2019
Grid Size	3m
Land Use	Grassed floodplain n = 0.05 Rural residential n = 0.06 Floodplain with moderate tree coverage n = 0.08
Upstream Boundary	Flow-Time (QT) boundary obtained from XP-RAFTS model
Downstream Boundary	HQ boundary conditions
Internal Boundaries	SA polygons based on the XP-RAFTS model
Bridges and Culverts	2 culverts at the Elizabeth Drive and one downstream of Tadpole Lake

Parameter	Information
	2 bridges along the Badgerys Creek at the intersection with Pitt Street and Elizabeth Drive, 2 bridges along the South Creek at the intersection with Elizabeth Drive and Orchard Hills, 1 bridge along the Kemps Creek at the intersection with Elizabeth Drive 1 modelled flow constriction at the WaterNSW pipeline to represent pipe footings

3.2 Validation of AWRC TUFLOW model

The AWRC TUFLOW model has been validated using 1% AEP ARR1987 hydrology to demonstrate that the model is compatible with the Government model.

Hydrographs for the 1% AEP, ARR1987 event provided by INSW were applied to the AWRC TUFLOW model and the results were compared to the data sets summarised in Table 3 and presented in Figure 2 which have been previously provided in Appendix C of the Submissions Report.

Table 3 USC AWRC hydraulic model setup overview

Data set	1% AEP ARR1987 AWRC TUFLOW model comparison
Historical flood markers reproduced in the 2015 Updated South Creek Flood Study (WorleyParsons, 2015) for an event in 1988 and 1986	The AWRC TUFLOW model generally compares well to the 1986 and 1988 flood markers providing confidence that the model predicts similar flood levels to historical flood events which the Government models have been calibrated to.
Penrith City Council's 2015 Updated South Creek Flood Study flood level results	The AWRC TUFLOW model predicts flood to levels within 10mm immediately adjacent to the AWRC site and downstream of the site in the Wianamatta-South Creek floodplain. Where the AWRC EIS hydraulic model flood results vary can be explained by differences in the terrain models adopted in both hydraulic models. Section 4.4.7 of the EIS finds that the 2015 flood model uses significantly older topography which does not reflect the current floodplain condition. Notwithstanding this difference, the AWRC TUFLOW model generally agrees with PCC adopted flood levels adjacent to the AWRC site.
1% AEP flood extent mapping provided by INSW (Flood extent mapping titled South Ck Sector - 1% AEP Flood Extent [Peak of Peaks]_Rev G (Oct 2020)	A comparison between the 1% AEP flood extents shows a good level of agreement with the flood extent predicted by the latest available INSW hydraulic model (blue outline). On this basis, the AWRC EIS hydraulic model results closely match the Government flood model INSW South Creek Sector Review flood extent mapping undertaken in 2020.

On the basis of the three comparisons to the Government's flood data sets provided in Appendix C of the project's Submissions Report, the AWRC TUFLOW model is compatible with Government's flood data including the Government's flood model of existing condition 1%AEP flooding documented in the *Wianamatta (South) Creek Flood Study* prepared for Infrastructure NSW in November 2020.

3.3 Existing Flood Behaviour

The validated AWRC TUFLOW model has been used to model and map existing flood conditions within the floodplain under 5%AEP, 1%AEP, 0.5%AEP and 0.2%AEP events using ARR1987 hydrology outlined above. This modelling is used as the basis for the flood impact assessment. The flood behavior for the 0.5% AEP and 0.2% AEP events will be utilised as proxies for assessing sensitivity to rainfall intensity due to climate change.

1% AEP floodway and flood storage constraints have been mapped using PCC2015 GIS data for consistency with the Government's available flood data. This mapping has been used to define setbacks for critical infrastructure. It is also noted that 1% AEP flood planning levels provided by PCC have been used to establish building floor levels. This has been done to remain consistent with current flood planning under the NSW Floodplain Development Manual. As shown in Figure 4, the proposed AWRC development sits outside of the existing 1% AEP flood extent.

Given that AWRC EIS hydraulic model outputs closely match recent flood extent mapping by INSW which adopts recent LiDAR and the same hydrology it is reasonable to expect that the hydraulic characteristics of the AWRC TUFLOW model predicts similar flood characteristics (velocity and depth) within the existing floodplain. Given that only minor works associated with drainage swales and WSUD are proposed in the floodplain, additional mapping of the flood velocities and flood depths has not been produced beyond that done already in the EIS.

3.4 Conclusion

The AWRC EIS hydraulic model results also provide a very similar 1% AEP flood extent to recent flood modelling undertaken by INSW (Advisian, 2020). Given that AWRC EIS hydraulic model closely matches recent flood extent mapping by INSW, which adopts recent LiDAR and the same 1% AEP hydrology for Kemps and South Creeks, the AWRC EIS hydraulic model therefore reasonably predicts the depth, conveyance and flood extent of the existing floodplain during 1% AEP event and is therefore fit for purpose in testing the flood impacts of the AWRC reference design.

While the hydraulic model will not be used to define flood planning levels (which is the role of Penrith City Council's 2015 Updated South Creek flood model), the AWRC EIS hydraulic model is appropriate (fit for purpose) for demonstrating changes in floodplain hydraulic conditions and or increases in flood level (afflux) resulting from the reference USC AWRC design.

4 Flood Impact Assessment

4.1 AWRC TUFLOW developed case model

The validated existing case AWRC TUFLOW model was converted to the proposed development AWRC TUFLOW model through the following steps:

- Topographic changes: Terrain models were developed to define the finished ground surface levels of roads, lots, WSUD, basins, swales, pipelines and pump stations.
- Manning's modifications: The roughness coefficients were adjusted to reflect the changes in land use within the proposed landscaping and WSUD elements in the floodplain.
- Impervious areas: The impervious fraction of the AWRC catchment was increased by 10% as a result of the proposed development.

4.2 AWRC TUFLOW flood impact mapping

Flood impact mapping has been undertaken using ARR1987 hydrology events for 20%, 1%, 0.5% and 0.2% AEP flood hydrographs. Hydrograph peaks and shapes are taken from and are consistent with Government models.

10% AEP and PMF flood impacts have also been tested using the AWRC RAFTS model which predicts similar peak flows to the respective PCC2015 flood hydrographs.

Flood impact mapping on flood levels and flood depths is provided in Appendix A as follows:

- Figure 5 Afflux mapping using 20% AEP Event hydrographs provided by INSW

- Figure 6 Afflux mapping using 1% AEP Event hydrographs provided by INSW
- Figure 7 Afflux mapping using 0.5% AEP Event hydrographs provided by INSW
- Figure 8 Afflux mapping using 0.2% AEP Event hydrographs provided by INSW
- Figure 9 Afflux mapping using PMF event hydrographs provided by the AWRC XP RAFTs model

4.3 Flood impacts

This finding of the flood impact assessment mapping presented in Appendix A re-affirms the findings of the AWRC EIS that the reference design has an acceptable impact on flooding outside of the AWRC site for a range of flows in that:

- Land which contains the AWRC operational facilities, roads and buildings, which is subject to earthworks is out of the 1% AEP floodplain, as defined by Penrith Council's flood data.
- The proposed earthworks and site works will prevent the AWRC facilities from becoming flooded up to the PMF event when shallow flooding is expected along roads.
- The AWRC facilities will remain flood free under climate change scenarios represented as the 0.2% and 0.5% AEP events.
- Flood impact mapping using the validated AWRC TUFLOW model shows no detectable flood impact for minor events.
- Flood impact mapping using the validated AWRC TUFLOW model shows minor localised flood impacts for the 1% AEP event that remain within the AWRC site boundary and will not extend off the site, thus preserving flooding conditions to the existing and future community.
- Flood impact mapping under the 0.2 and 0.5% AEP shows minor localised flood impacts that remain within the AWRC site boundary. The impact show that the site design is resilient to flooding under possible climate change scenarios.
- Flood impact mapping under the PMF event shows that the elevated site works associated with the AWRC facilities will encroach into the PMF floodplain resulting in an increase in flood levels within Kemps Creek in the order of 100 mm. These flood level increases are localised and do not impact on any significant infrastructure or emergency evacuation routes.

5 Concluding remarks

Additional hydraulic modelling using the AWRC EIS hydraulic model provides validation that the AWRC EIS hydraulic model results agree with existing data sets provided by Penrith City Council (WorleyParsons 2015) and INSW (Advisian, 2020) (described above). The AWRC EIS hydraulic model is therefore compatible with the Government model and is suitable for defining flood hydraulics of the existing floodplain and predicting changes in flood behavior associated with the AWRC. The AWRC EIS hydraulic model is fit for the purpose of flood impact assessment to meet the EIS objectives to demonstrate flood impacts for a range of flood events.

In adopting the above Council and INSW data sets to validate the model and test flood impacts of the AWRC reference design, this memo incorporates data produced by Council and the State Government in applying the Floodplain Development Manual. This means that the AWRC EIS hydraulic model, as demonstrated by this memo, compares favorably with other models and flood data when the consistent hydrograph inputs are applied.

The results from the flood model can be used confidently to assess the merits of the AWRC reference design with confidence that the AWRC reference design will not impact on flood events associated with the Government's adopted 20%, 1% , 0.5%, 0.2% AEP flows. This further validates the findings of the

main EIS Flood Impact Assessment report that the AWRC reference design will have an acceptable impact on a range of flood events greater and smaller than the 1% AEP event.

5.1 References

South Creek Flood Study Report (Department of Water Resources, 1990) (reproduced in the Updated South Creek Flood Study, 2015)

Updated South Creek Flood Study (WorleyParsons, 2015) (on behalf of Penrith City Council)

Western Sydney Aerotropolis South Creek Flood Study (AAJV, 2019)

Wianamatta (South) Creek Flood Study – Existing Conditions Report (Advisian, 2020) (on behalf of INSW)

Upper South Creek AWRC Flood Impact Assessment Draft for Comment (Aurecon Arup, 2021)

The following datasets have been obtained from INSW:

- 1% AEP flood hydrographs (File name reference: 210617_Base+Case+1%+AEP+Flows+(Rev+H)+-+Elizabeth+Drive+(Advisian).xlsx) received from INSW December 2021 (Advisian, 2020)
- 1% AEP flood extents (File name reference: South Ck Sector - 1% AEP Flood Extent [Peak of Peaks]_Rev G (Oct 2020). zip)) received from INSW December 2021 (Advisian, 2020)
- XP-RAFTS hydrologic models provided and adopted in this study
    - *220520_South Creek_0.2% AEP_36hr (Rev I).XP*
    - *220520_South Creek_0.5% AEP_36hr (Rev I).XP*
    - *220520_South Creek_5% AEP_36hr (Rev I).XP*

Appendix A – Flood Impact Assessment Mapping

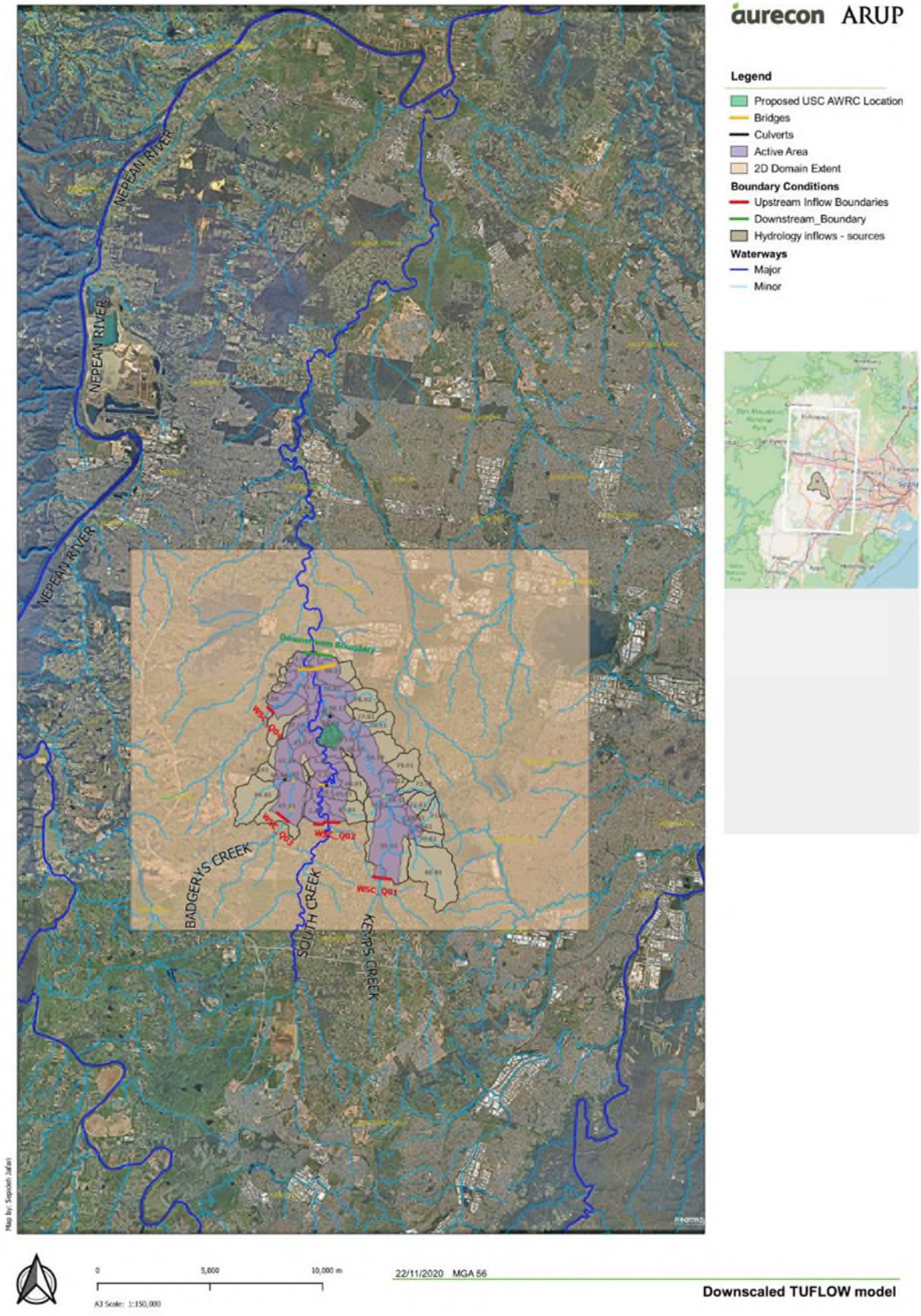

Figure 2 AWRC TUFLOW Model extent

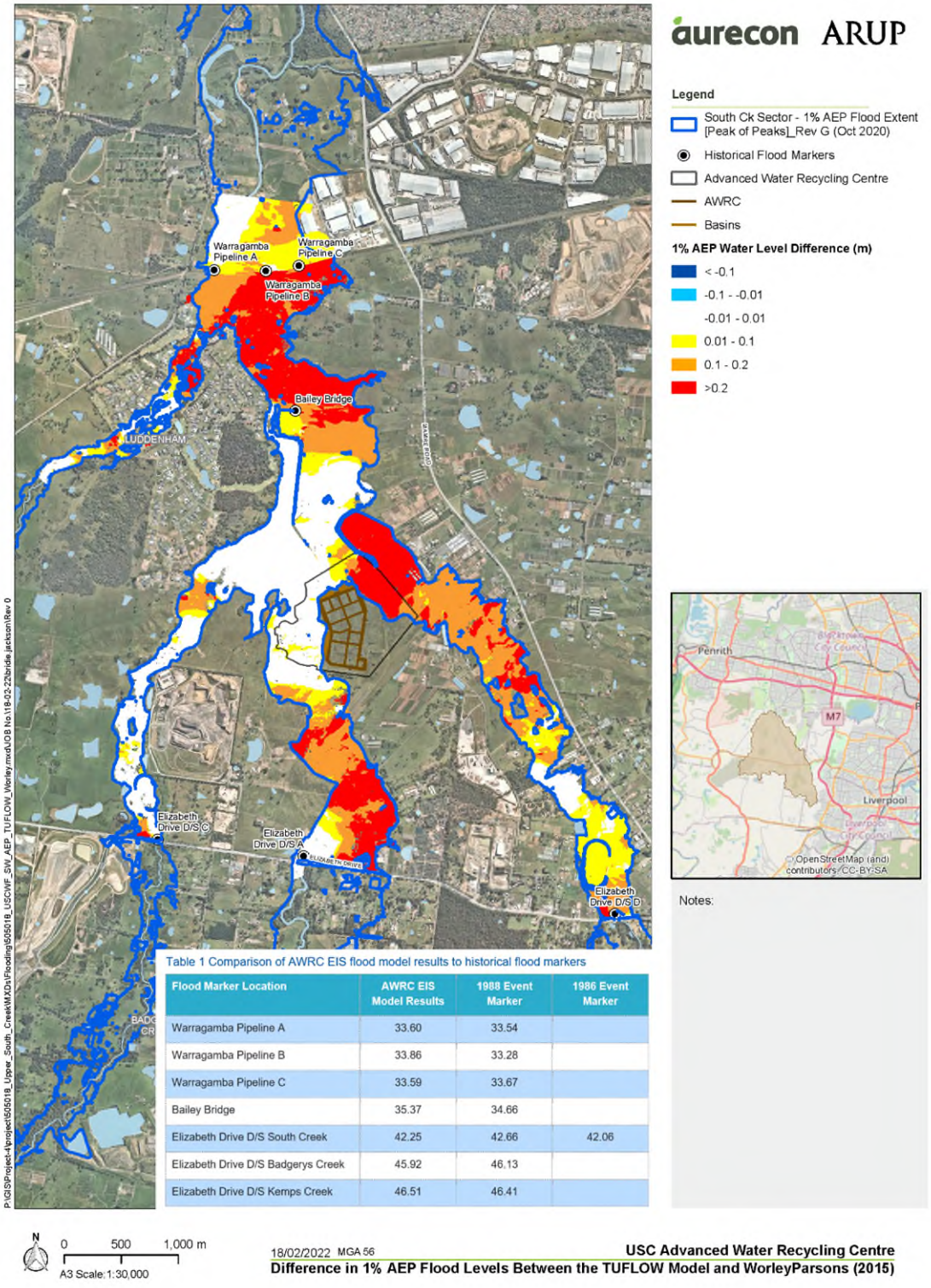

Table 1 Comparison of AWRC EIS flood model results to historical flood markers

Flood Marker Location	AWRC EIS Model Results	1988 Event Marker	1986 Event Marker
Warragamba Pipeline A	33.60	33.54	
Warragamba Pipeline B	33.86	33.28	
Warragamba Pipeline C	33.59	33.67	
Bailey Bridge	35.37	34.66	
Elizabeth Drive D/S South Creek	42.25	42.66	42.06
Elizabeth Drive D/S Badgerys Creek	45.92	46.13	
Elizabeth Drive D/S Kemps Creek	46.51	46.41	

Figure 3 Comparison between existing case 1% AEP ARR1987 flooding. AWRC TUFLOW results shown with the Government's flood model, Penrith City Council's flood model (WorleyParsons, 2015) and historical markers

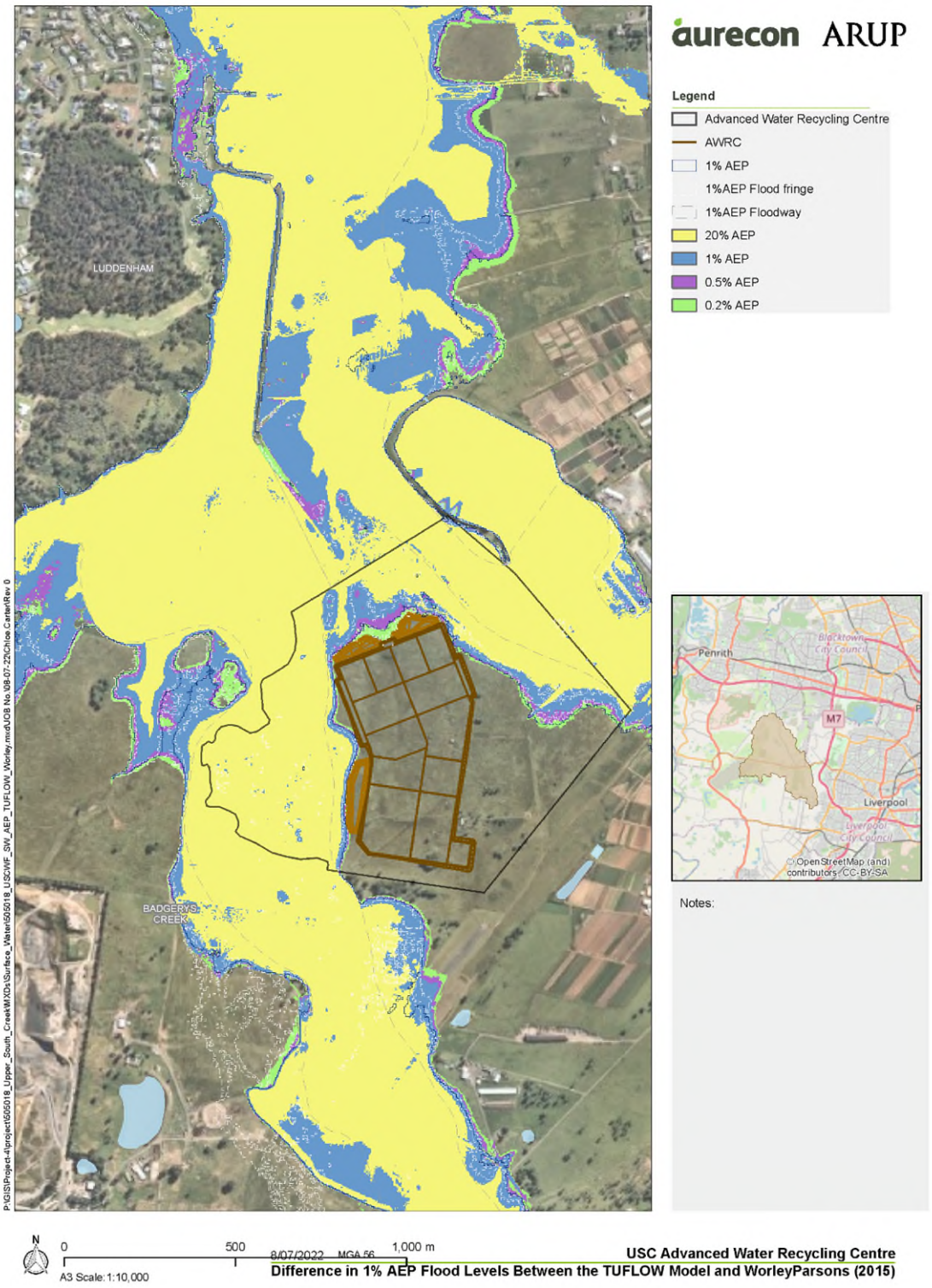

Figure 4 Existing flood behaviour mapping showing flood constraints and set backs to AWRC

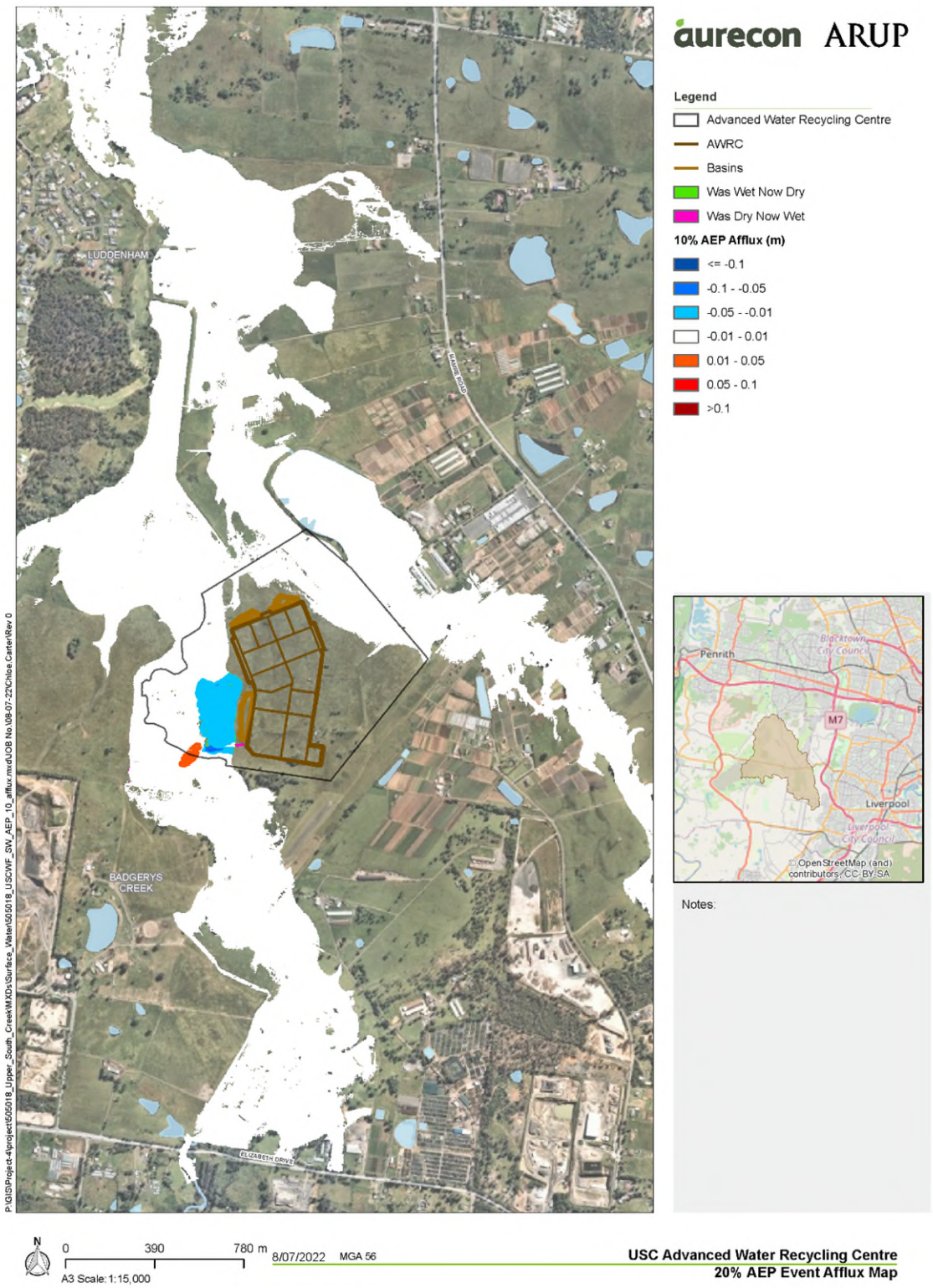

Figure 5 Afflux mapping using 20% AEP Event hydrographs provided by INSW

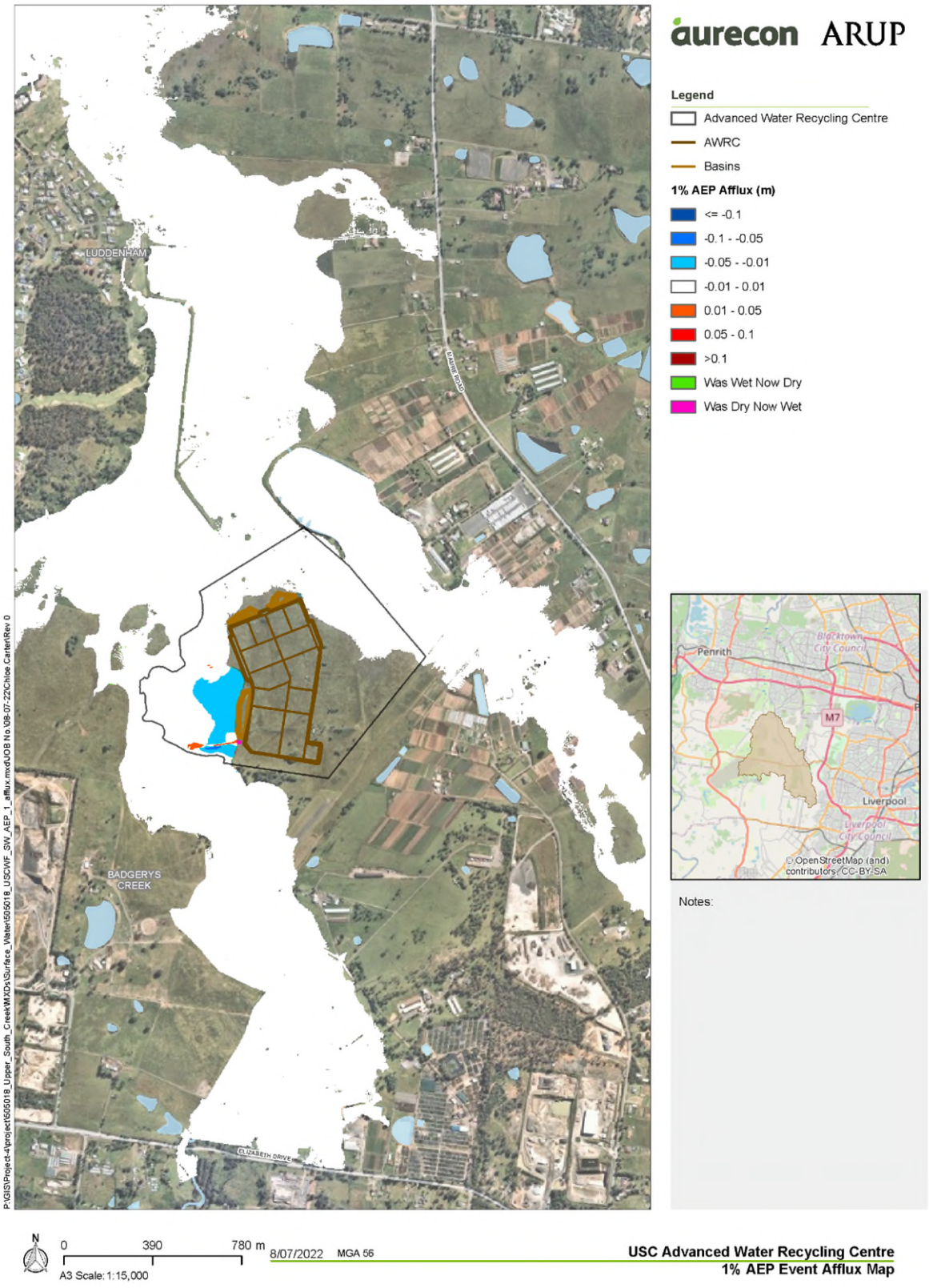

Figure 6 Afflux mapping using 1% AEP Event hydrographs provided by INSW

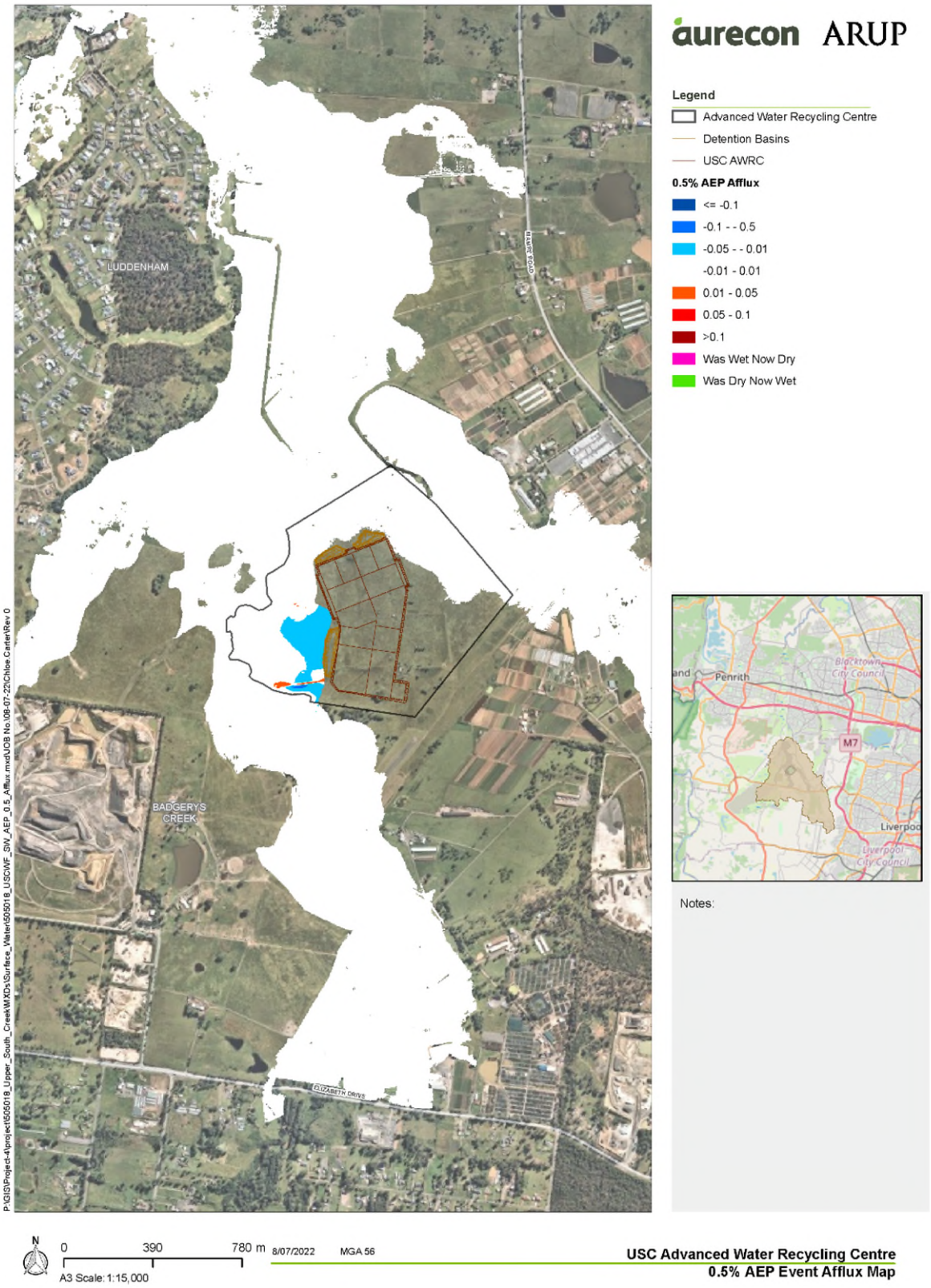

Figure 7 Afflux mapping using 0.5% AEP Event hydrographs provided by INSW

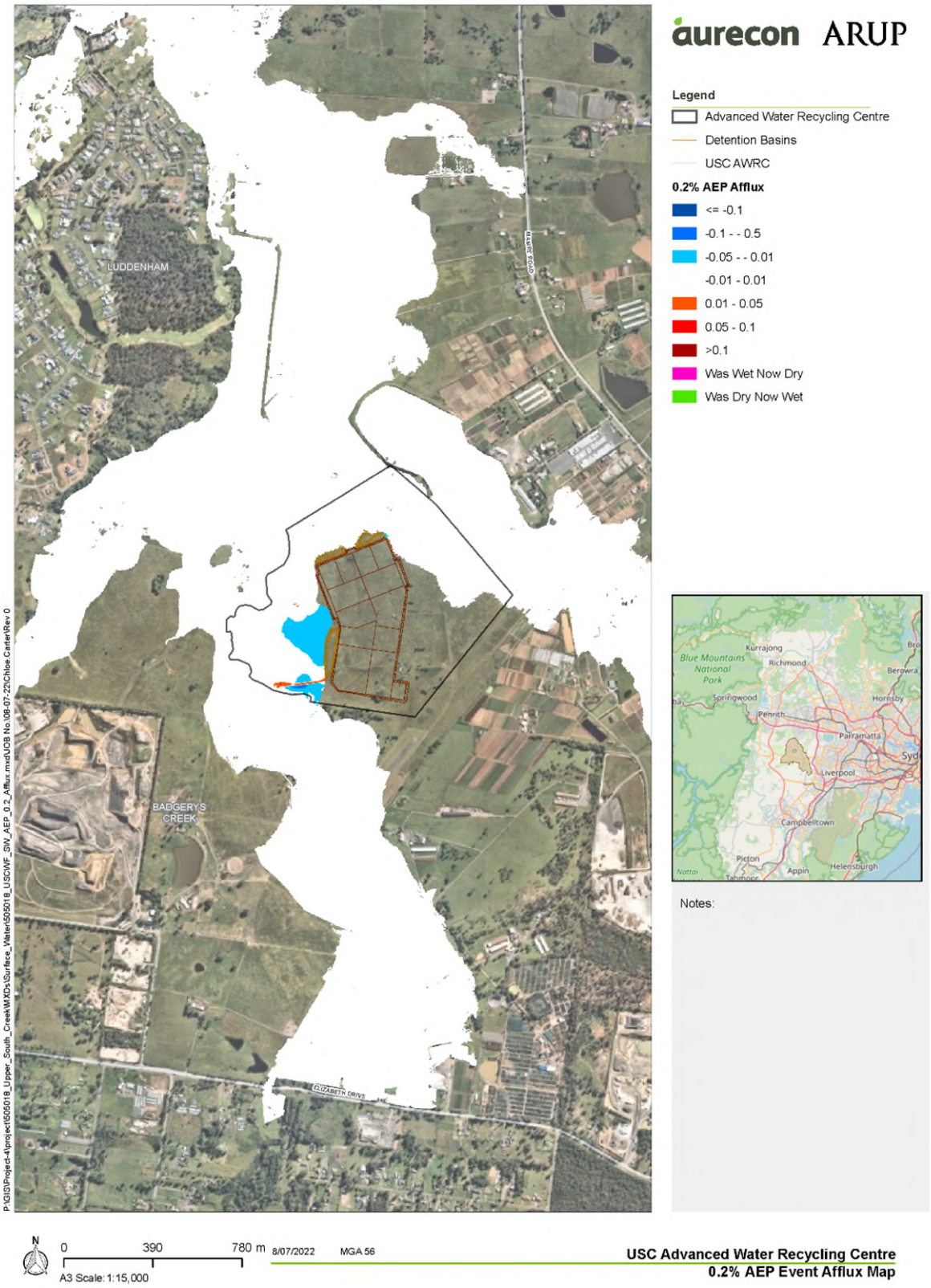

Figure 8 Afflux mapping using 0.2% AEP Event hydrographs provided by INSW

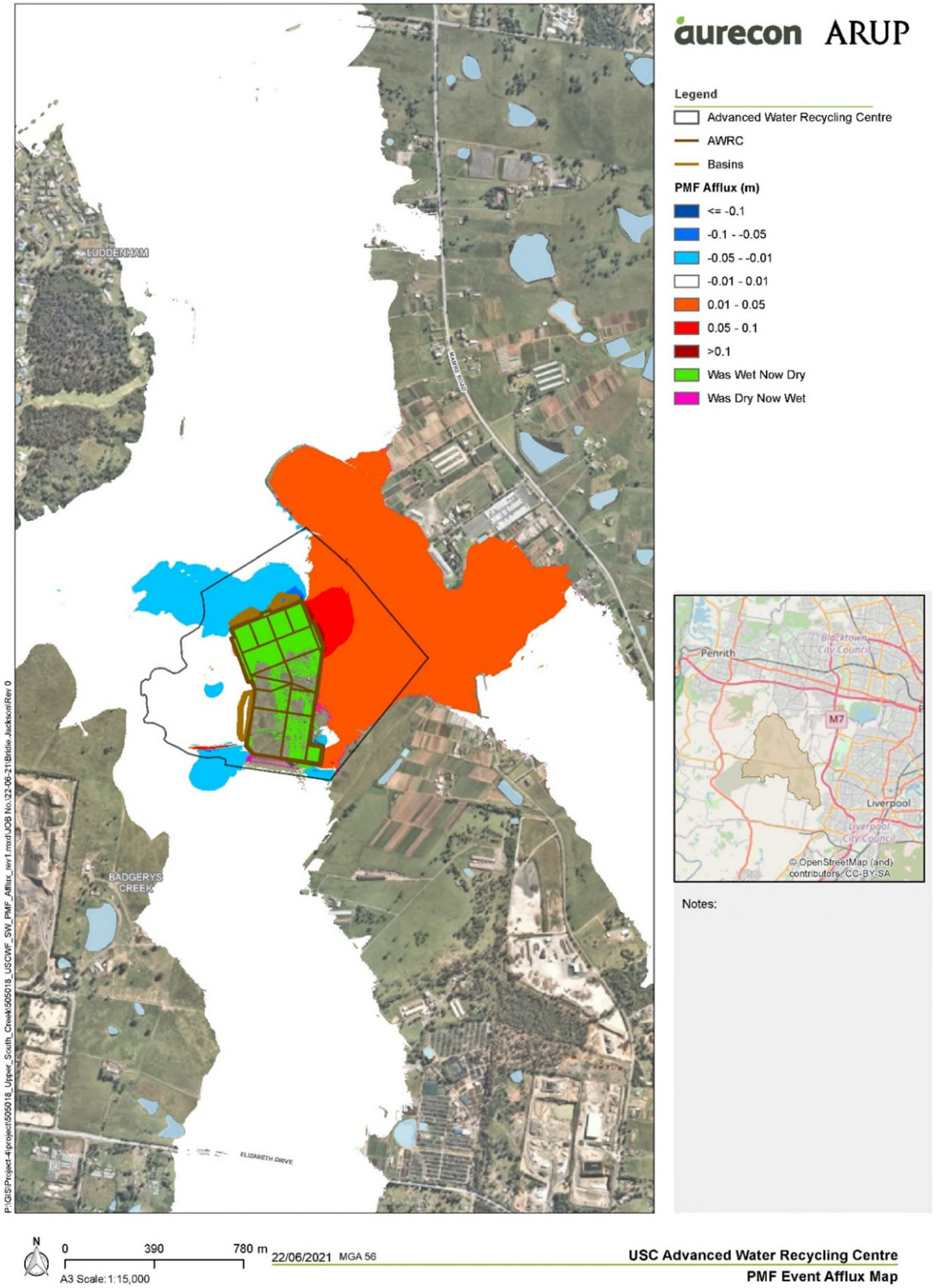

Figure 9 Afflux mapping using PMF event hydrographs provided by the AWRC XP RAFTs model