VOLUME 4

Appendix L1
Surface water hydrology and geomorphology

Department of Infrastructure and Regional Development

Western Sydney Airport EIS

Surface Water Hydrology and Geomorphology

October 2015

Limitations

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Executive summary

This report presents an assessment of the impacts of the proposed Western Sydney Airport (proposed airport) on surface hydrology and geomorphology during construction, operation of the Stage 1 Development, and operation of the longer term development. The assessment includes definition of the existing environment both on and off the site with respect to watercourse type, quantities of estimated surface water and potential flooding. The assessment was carried out through desktop analysis, site inspections and hydrologic and hydraulic modelling of the site and related catchments. An assessment was also made of the sensitivity of the watercourses downstream of the site to changes in flow hydraulics. Nearby flood-affected residences were also identified in the review of flood impacts.

The indicative Stage 1 and longer term airport layouts and specifications were reviewed and an assessment was made of the potential for impacts on surface water sources. The impact analysis includes consideration of the sensitivity of the existing creeks and surrounding environment to change, together with the results of predictive modelling of surface water hydrology and hydraulics for Stage 1 and for the longer term airport.

Specific indicators of impact include changes in discharge from the site, changes in watercourse bed shear stress and changes in downstream water level. Consideration was also given to biodiversity that could be affected by changes to surface water flows, based on the findings of the biodiversity assessment carried out for this environmental impact statement (EIS). Potential groundwater changes are also considered for their impact on surface water sources.

The study finds that construction of the proposed airport would result in a major modification of the site in terms of land use characteristics and surface water runoff generated. It would also result in removal of a large number of watercourses and farm dams. The effects of these changes is mitigated by the inclusion in the design of a number of detention basins, though the strategy does not eliminate impacts altogether.

During construction, a detailed surface water management plan would be developed and would need to consider the impacts of flooding on-site over the course of the construction period.

Downstream of the site, the assessment finds that the detention basin strategy would be effective at limiting the downstream impact such that any increases in flood level would not worsen flooding to surrounding roads and dwellings. The risk to changes in creek geomorphology would be low, other than for a short reach of Oaky Creek and a tributary of Badgerys Creek.

Some localised increases and decreases in water level are predicted downstream of the site.

The assessment considers the potential for the cumulative impacts of climate change to exacerbate the environmental impacts of the proposed airport and also to increase susceptibility of the airport infrastructure to flooding. Aspects of climate change science, particularly as they relate to flooding, are still developing and the effect of climate change on the proposed airport cannot be determined with certainty. It is concluded that current and emerging advice should be considered as the airport design is finalised.

The cumulative impact of potential future development surrounding the airport was also considered.

The assessment finds that there is a need to further develop the detention basin strategy during design development, such that the basins would be effective at mimicking natural flows as closely as possible across a range of storm durations and magnitudes, including low and high flows. Consideration would need to be given to providing a basin or other form of water quantity detention on a tributary of Duncans Creek prior to discharge from the site.

Another mitigation requirement would be to ensure that any future development in the vicinity of Badgerys Creek where it passes through the site would be appropriate for a third order creek. This would involve protecting and preserving the habitat and riparian corridor and ensuring no worsening of flooding downstream.

During construction, demands on potable water would be high and there would be a need to develop a strategy for water supply to the airport site to meet the construction requirements as well as the ongoing operational water requirements. During operation, use of potable water on site would be supplemented with recycled water to reduce demand on potable water.

The effects of the proposed airport on surface water quality and groundwater are discussed in separate reports.

Glossary and abbreviations

Term	Definition
Annual exceedance probability (AEP)	The annual exceedance probability is a measure of the frequency of a rainfall event. It is the probability that a given rainfall total accumulated over a given duration will be exceeded in any one year. A one per cent event is a rainfall event with a one per cent chance of being exceeded in magnitude in any year. The current Australian Rainfall and Runoff recommendations (Institute of Engineers, Australia, 1987) are for use of AEP terminology rather than Average Recurrence Interval (ARI) terminology (refer below). However, for consistency with the hydrological modelling undertaken, Average Recurrence Interval terminology is used in this report.
Afflux	With reference to flooding, afflux refers to the predicted change, usually in flood levels, between two scenarios. It is frequently used as a measure of the change in flood levels between an existing scenario and a proposed scenario.
Airport	Western Sydney Airport
Airport site	The airport site is the total of all properties that may become part of Western Sydney Airport. The airport site includes existing Commonwealth land and land to be acquired by the Commonwealth, such as The Northern Road.
Airport features	Specific features of the proposed airport, such as runways, taxiways, terminal buildings or hangars.
Alluvium	Unconsolidated deposit of gravel, sand or mud formed by water flowing in identifiable channels. Commonly well sorted and stratified.
Australian Height Datum (AHD)	A common reference level used in Australia which is approximately equivalent to the height above sea level.
Average recurrence interval (ARI)	The average recurrence interval, like the annual exceedance probability, is a measure of the frequency of a rainfall event. The average, or expected, value of the periods between exceedances of a given rainfall total accumulated over a given duration. For example, a 100-year average recurrence interval event occurs or is exceeded on average once every 100 years. It is important to note that the ARI is an average period and it is implicit in the definition of the ARI that the periods between exceedances are generally random. Average recurrence intervals of greater than ten years are closely approximate to the reciprocal of the annual exceedance probability. A 100-year average recurrence interval is therefore approximately equivalent to a 1 per cent annual exceedance probability event. See also annual exceedance probability.

Term	Definition
Badgerys Creek	Badgerys Creek is a suburb in western Sydney and the general locality of the proposed airport, which is about 50 kilometres west of the Sydney central business district. Badgerys Creek is also the name of a watercourse which is referred to in this report.
Catchment	The area drained by a stream or body of water or the area of land from which water is collected.
Consent	Approval to undertake a development received from the consent authority.
Datum	A level surface used as a reference in measuring elevations.
DEM	Digital elevation model
Discharge	Quantity of water per unit of time flowing in a stream, for example cubic meters per second or megalitres per day.
DRAINS modelling	DRAINS is a multi-purpose software program for designing and analysing urban stormwater drainage systems and catchments.
Ephemeral	A stream that is usually dry, but may contain water for rare or irregular periods, usually after significant rainfall.
Erosion	A natural process where wind or water detaches a soil particle and provides energy to move the particle.
Flood	For the purposes of this report, a flood is defined as the inundation of normally dry land by water which escapes from, is released from, is unable to enter, or overflows from the normal confines of a natural body of water or watercourse such as rivers, creeks or lakes, or any altered or modified body of water, including dams, canals, reservoirs and stormwater channels.
Flood liable land	Land which is within the extent of the probable maximum flood and therefore prone to flooding.
Floodplain	The area of land subject to inundation by floods up to and including the probable maximum flood.
Floodway	The area of the floodplain where a significant portion of flow is conveyed during floods. Usually aligned with naturally defined channels.
Formation	A fundamental unit used in the classification of rock or soil sequences, generally comprising a body with distinctive physical and chemical features.
Geomorphology	Scientific study of landforms, their evolution and the processes that shape them. In this report, geomorphology relates to the form and structure of watercourses.
Groundwater	Subsurface water stored in pores of soil or rocks.
Hazard	The potential or capacity of a known or potential risk to cause adverse effects.
Headward erosion	The upstream lengthening and/or cutting of a valley or gully at its head, as the stream erodes away the rock and soil at its headwaters in the opposite direction that it flows.

Term	Definition
Hydraulic conductivity	The rate at which water at the prevailing kinematic viscosity will move under a unit hydraulic gradient through a unit area measured perpendicular to the direction of flow, usually expressed in metres per day (this assumes a medium in which the pores are completely filled with water).
Hydraulics	The physics of channel and floodplain flow relating to depth, velocity and turbulence.
Hydrograph	A graph which shows how a water level at any particular location changes with time.
Hydrology	The study of rainfall and surface water runoff processes.
Impervious	In the context of this report, impervious surfaces are surfaces non-permeable to water. These include hardstanding areas such as paved surfaces.
Infiltration	The downward movement of water into soil and rock, which is largely governed by the structural condition of the soil, the nature of the soil surface (including presence of vegetation) and the antecedent moisture content of the soil.
Landform	A specific feature of the landscape or the general shape of the land.
Light Detection and Ranging (LiDAR)	LiDAR is a remote sensing method used to examine the surface of the Earth. LiDAR has been used in this study to define the topography of the airport site and surroundings.
Longer term development	A future stage in the development of the proposed airport, where the airport is assumed to comprise parallel runways and handling approximately 82 million passengers annually. The EIS assumes this occurs in 2063 for assessment purposes.
LPI	NSW Land and Property Information
Meteorology	The science concerned with the processes and phenomena of the atmosphere, especially as a means of forecasting the weather.
MIKE21 modelling	MIKE21 is a two dimensional hydraulic modelling software program used to simulate surface flow and estimate flood levels and flow velocities.
Monitoring well/bore	A hole sunk into the ground and completed for the abstraction or injection of water or for water observation purposes. Generally synonymous with bore.
MUSIC modelling	MUSIC is a software program used to estimate the performance of stormwater quality management systems.
Newtons per square metre (N/m^2)	A measure of force per unit area, in this case, per square metre. In this report it is used to measure stream bed shear stress i.e. the force of water acting parallel to the stream bed. The level of shear stress is used as an parameter for prediction of the movement of stream bed sediments.
Overbank	The portion of the flow that extends over the top of watercourse banks.

Term	Definition
Overland flow path	The path that water can follow if it leaves the confines of the main flow channel. Overland flow paths can occur through private property or along roads. Water travelling along overland flow paths, often referred to as 'overland flows', may either re-enter the main channel or may be diverted to another watercourse.
Permeability	The capacity of a porous medium to transmit water.
Pluviograph	A rain gauge with the capability to record data in real time to observe rainfall over a short period of time.
Probable maximum flood (PMF)	The probable maximum flood is the maximum flood which can theoretically occur based on the worst combination of the probable maximum precipitation and flood-producing catchment conditions that are reasonably possible at a given location.
Probable maximum precipitation (PMP)	The probable maximum precipitation is the greatest amount of rainfall which can theoretically occur over a given duration (period of time) for a particular geographical location.
RAFTS modelling	XP-RAFTS is a hydrology modelling software program used to simulate urban and rural runoff and routing through a watershed based on catchment characteristics and rainfall events.
Reach	Defined section of a stream with uniform character and behaviour.
Recharge	Addition of water to the zone of saturation; also the amount of water added. An area in which there are downward components of hydraulic head in the aquifer. Infiltration moves downward into the deeper parts of an aquifer in a recharge area.
Riparian	Pertaining to, or situated on, the bank of a river or other water body.
Risk	The chance of something happening that will have an impact measured in terms of likelihood and consequence.
Risk assessment	Systematic process of evaluating potential risks of harmful effects on the environment from exposure to hazards associated with a particular product or activity.
River Styles® framework	A geomorphic approach for examining river character, behaviour, condition and recovery potential which provides a template for river management.
Runoff	The amount of rainfall which actually ends up as streamflow, also known as rainfall excess.
Salinity	The total soluble mineral content of water or soil (dissolved solids); concentrations of total salts are expressed as milligrams per litre (equivalent to parts per million).
Sediment	Material of varying sizes that has been or is being moved from its site of origin by the action of wind, water or gravity.

Term	Definition
Sinuosity	Extent of curvature or meandering of a stream. Highly sinuous streams meander over a low gradient and short distance. Low sinuosity streams are straighter and have a steeper gradient.
Stream order	Stream classification system, where order 1 is for headwater (new) streams at the top of a catchment. Order number increases downstream using a defined methodology relating to the branching of streams.
Stage 1 (or initial) development	The initial stage in the development of the airport, including a single runway and handling approximately 10 million passengers annually. The EIS assumes 10 million passengers is reached in 2030 for assessment purposes.
Study area	The subject site and any additional areas which are likely to be affected by the proposal, either directly or indirectly. The study area extends as far as is necessary to take all potential impacts into account.
Surface water	Water that is derived from precipitation or pumped from underground and may be stored in dams, rivers, creeks and drainage lines.
Topography	Representation of the features and configuration of land surfaces.
Watercourse	Generic term used to refer to rivers, streams and creeks.
Water quality	Chemical, physical and biological characteristics of water. Also the degree (or lack) of contamination.
Water sharing plan	A legal document prepared under the *Water Management Act 2000* (NSW) that establishes rules for sharing water between the environmental needs of the river or aquifer and water users and also different types of water use.
Water table	The surface of saturation in an unconfined aquifer, or the level at which pressure of the water is equal to atmosphere pressure.
Western Sydney Airport	The airport proposed on the Commonwealth owned land at Badgerys Creek and assessed in accordance with the Western Sydney Airport environment impact statement.

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Appendices

1. Introduction

1.1 Background

Planning investigations to identify a site for a second Sydney airport first commenced in 1946 with a number of comprehensive studies—including two previous environmental impact statements for a site at Badgerys Creek—having been completed over the last 30 years.

More recently, the Joint Study on Aviation Capacity in the Sydney Region (Department of Infrastructure and Transport, 2012) and A Study of Wilton and RAAF Base Richmond for civil aviation operations (Department of Infrastructure and Transport, 2013) led to the Australian Government announcement on 15 April 2014 that Badgerys Creek will be the site of a new airport for Western Sydney. The airport is proposed to be developed on approximately 1,700 hectares of land acquired by the Commonwealth in the 1980s and 1990s. Construction could commence as early as 2016, with airport operations commencing in the mid-2020s.

The proposed airport would provide both domestic and international services, with development staged in response to demand. The initial development of the proposed airport would include a single, 3,700 metre runway coupled with landside and airside facilities such as passenger terminals, cargo and maintenance areas, car parks and navigational instrumentation capable of facilitating the safe and efficient movement of up to 10 million passengers per year. While the proposed Stage 1 development does not currently include a rail service, planning for the proposed airport preserves flexibility for several possible rail alignments including a potential express service. A final alignment will be determined in consultation with the New South Wales Government, with any enabling work required during Stage 1 subject to a separate approval and environmental assessment process.

In the longer term, approximately 40 years after operations commence and in accordance with relevant planning processes, the airport development could include parallel runways and additional passenger and transport facilities for around 82 million passenger movements per year. To maximise the potential of the site, the airport is proposed to operate on a 24 hour basis. Consistent with the practice at all federally leased airports, non-aeronautical commercial uses could be permitted on the airport site.

On 23 December 2014, the Australian Government Minister for the Environment determined that the construction and operation of the airport would require assessment in accordance with the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act). Guidelines for the content of an environmental impact statement (EIS) were issued in January 2015. Approval for the construction and operation of the proposed airport will be controlled by the Airports Act 1996 (Cth) (Airports Act). The Airports Act provides for the preparation of an Airport Plan which will serve as the authorisation for the development of the proposed airport.

The Australian Government Department of Infrastructure and Regional Development is undertaking detailed planning and investigations for the proposed airport, including the development of an Airport Plan. The draft Airport Plan is the primary source of reference for, and companion document to, the EIS. The draft Airport Plan identifies a staged development of the proposed airport. It provides details of the initial development being authorised, referred to as Stage 1, as well as a long-term vision of the airport's development. This enables preliminary consideration of the implications of longer term airport operations. Any stages of airport development beyond Stage 1 would be managed in accordance with the existing process in the Airports Act. This includes a requirement that for major developments (as defined in the Airports Act), a major development plan be approved by the Australian Government Minister for Infrastructure and Regional Development following a referral under the EPBC Act.

The Airport Plan will be required to include any conditions notified by the Environment Minister following this EIS. Any subsequent approvals for future stages of the development will form part of the airport lessee company's responsibilities in accordance with the relevant legislation.

1.2 Scope of the assessment

The study assesses the impacts of the airport on:

- surface water hydrology and flooding; and
- geomorphology.

Groundwater impacts, impacts on aquatic ecology and impacts on surface water quality are discussed in separate reports. The key findings relevant to the scope of this report are included.

The key aspects of the study are to:

- describe the existing environment with respect to surface water hydrology, flooding and geomorphology;
- assess the likely impact of the airport on these features in the context of Commonwealth legislation, EIS guidelines and national, regional and local industry practice and guidelines; and
- identify measures to mitigate or manage the expected impacts.

1.3 Study area

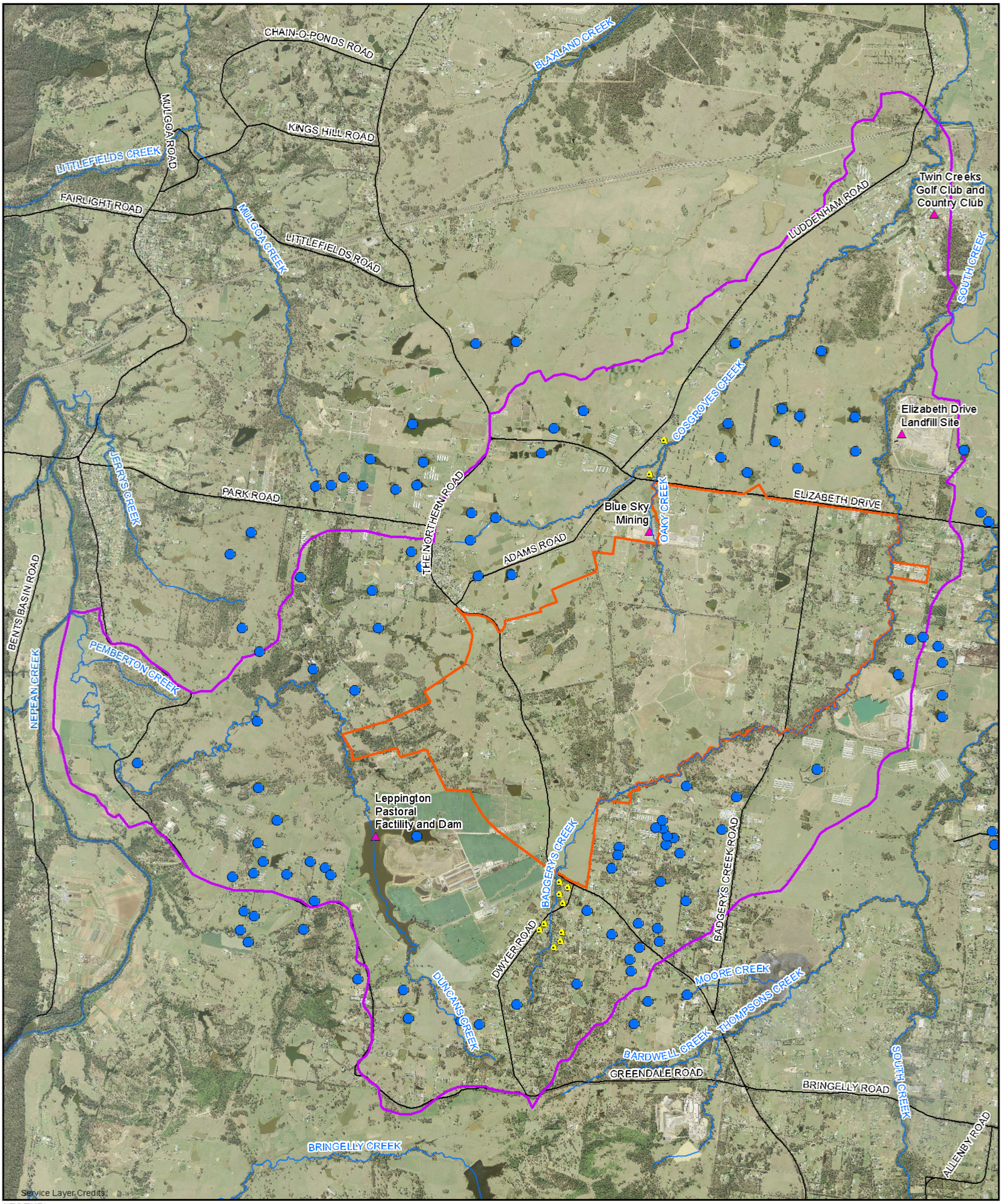
The study area for both the Stage 1 and longer term development consists of the airport site as well as the hydrological catchments of Duncans Creek to its confluence with the Nepean River, and Oaky, Cosgroves and Badgerys Creeks to their confluences with South Creek.

The airport site and the primary surface water study area are shown in Figure 1-1, together with a number of points of interest referred to in this report.

1.4 Structure of this report

The remainder of this report is structured as follows.

- **Section 2**: Provides the legislative context for the assessment including relevant policies and guidelines.
- **Section 3**: Describes in detail the methodology used in the surface water assessment, including details of the surface water modelling methodology.
- **Section 4**: Describes the existing environment, based on the findings of the desktop assessment, site visits and modelling analyses.
- **Section 5**: Describes the potential impact of the airport on surface water features during construction.
- **Section 6**: Describes the potential impact of the airport on surface water features during operation.
- **Section 7**: Assesses the likely cumulative impact of the airport together with other factors such as climate change and surrounding development.
- **Section 8**: Outlines management and mitigation measures to address the impacts.



LEGEND

- Airport site
- Watercourses
- Farm dam
- Surface water study area
- Surface water key features
- Dwellings located within or near to 1 in 100-year ARI flood extent, Badgerys/Cogroves

Paper Size A3

0 380 760 1,520

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Job Number	21-24265
Revision	A
Date	05 Aug 2015

Airport site and surface water study area

Figure 1-1

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Data source: Data source: General Topo - NSW LPI DTDB 2012, Imagery - ESRI 2015 Created by: afoddy

2. Legislation and guidelines

The legislative requirements and guidelines relevant to this assessment are described in this section. The methodology outlined in the following sections has been developed to address the legislative and regulatory requirements

2.1 Environment Protection and Biodiversity Conservation Act 1999

The objects of the EPBC Act include to provide for the protection of the environment, especially those aspects of the environment that are matters of national environmental significance (MNES) and to promote the conservation of biodiversity.

MNES are relevant to surface water where either:

- surface water features form part of the natural environment associated with a MNES or
- a MNES is dependent on surface water features.

Surface water features are natural resources and are an integral part of the environment. They are relevant in the context of the EPBC Act wherever there is potential for impact upon them.

2.1.1 Environmental Impact Statement Guidelines

The Guidelines for the Content of a Draft Environmental Impact Statement, Western Sydney Airport (Australian Government, 2015), identify that impacts to the environment including hydrological changes must be assessed. Section 5 of the Guidelines (EPBC 2014/7391) require that:

(g) Impacts to the environment should include but not be limited to the following:

- *changes to siltation*
- *hydrological changes.*

This report has been prepared in accordance with the guidelines.

2.2 NSW Water Management Act

The *Water Management Act 2000* (NSW) *(WM Act)* is administered by the NSW Department of Primary Industries (DPI) Water (formerly NSW Office of Water) and is intended to ensure that water resources are conserved and properly managed for sustainable use benefitting both present and future generations. The WM Act is also intended to provide a formal means for the protection and enhancement of the environmental qualities of waterways and their in-stream uses as well as to provide for protection of catchment conditions. The intent and objectives of the WM Act have been considered as part of this assessment.

NSW Water Sharing Plans

Water sharing plans are implemented under the *Water Management Act 2000* (NSW) and specify the rules for the sharing of water between the environment and water users and between water users themselves. Water sharing plans also specify rules for the trade and management of water access licences.

The Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources (the water sharing plan), which commenced in 2011, covers 87 management zones that are grouped into six water sources. The airport is situated in the Hawkesbury and Lower Nepean Rivers catchment or source.

The Hawkesbury and Lower Nepean Rivers catchment is separated into management areas, which includes amongst others the Upper and Lower South Creek Management Zones and the Mid Nepean River Catchment Management Zone. Badgerys, Oaky and Cosgroves Creeks are interpreted to be within the Upper South Creek Management Zone, and Duncans Creek is interpreted to be within the Wallacia Weir Management Zone (one of the Mid Nepean River Catchment Management Zones).

Extraction from these zones currently occurs for irrigation and town and industrial water supply.

The water sharing rules listed in the water sharing plan for the Upper South Creek and Wallacia Weir Management Zones are summarised below.

Upper South Creek Management Zone

- Access rules stipulate at what flow rates users must cease to pump from the creek, based on A and B flow classes.
- Trading is permitted within the management zone (subject to assessment) but is not permitted into the management zone.

Wallacia Weir Management Zone

- Environmental flow protection rules apply when inflows to the dams are greater than the 80th percentile, depending on the ability of the weir to pass flows released upstream.
- Trading is permitted within the management zone and is permitted into the management zone from upstream management zones (but not from other management zones).
- Limited access to very low flows is allowed for during water shortages depending on conditions that trigger a water shortage.
- Lagoon rules prevent water trading onto a lagoon and application for new works on a lagoon.

Water Sharing Plans in relation to groundwater resources and groundwater recharge are discussed in the groundwater assessment report.

2.3 Other policies and guidelines

2.3.1 New South Wales Floodplain Development Manual

The New South Wales Floodplain Development Manual (former Department of Infrastructure, Planning and Natural Resources, 2005) concerns the management of flood-prone land within NSW. It provides guidelines in relation to the management of flood liable lands, including any development that has the potential to influence flooding, particularly in relation to increasing the flood risk to people and infrastructure.

2.3.2 Hawkesbury Nepean Catchment Action Plan

The Hawkesbury-Nepean and Sydney Metropolitan Catchment Management Authority (CMA) regions were amalgamated in late 2012. Following this, a Catchment Action Plan (CAP) for the Hawkesbury-Nepean catchment was developed and later superseded by a *Greater Sydney Local Land Service Transition Catchment Action Plan* (NSW Government, 2014).

Catchment Action Plans (CAPs) are ten year plans to guide the management of water, land and vegetation by state government and local communities.

The catchments of Badgerys Creek, Oaky Creek, Cosgroves Creek and Duncans Creek fall within the *Greater Sydney Local Land Service Transition Catchment Action Plan*. The action plan is relevant with respect to any influence the airport may have on the downstream catchments in relation to surface water and aquatic ecology.

Relevant strategies within the action plan include development of a more water sensitive catchment, promoting resilience through climate change adaptation and a number of strategies relating to protecting aquatic ecosystems.

2.3.3 Managing Urban Stormwater: Soils and Construction (Blue Book)

The NSW Government publishes the following documents about the management of erosion and sediment control during construction and other land disturbance activities.

Managing Urban Stormwater: Soils and Construction – Volume 1 (Blue Book)

The document provides guidance for local councils and practitioners on the design, construction and implementation of measures to improve stormwater management, primarily erosion and sediment control, during the construction phase of urban development.

Managing Urban Stormwater: Main road construction – Volume 2D

This document provides guidelines, principles and recommended minimum design standards for managing erosion and sediment control during the construction of main roads. The construction of main roads and highways commonly involves extensive earthworks, with significant potential for erosion and subsequent sedimentation of watercourses and the landscape, and the document therefore has been considered in the preparation of this report.

3. Methodology

3.1 Overview

The approach adopted to surface water assessment in this report includes the following steps:

- data collection and review;
- existing environment modelling and analysis;
- Stage 1 and longer term development modelling and analysis;
- impact assessment; and
- development of mitigation and management measures.

Each stage is explained in more detail below.

3.2 Data collection and review

3.2.1 Key project documents and data

Key data relevant to the project and surface water studies was collected and reviewed. Key reference documents and data are listed in Table 3-1.

Table 3-1 Key reference documents and data

Document / dataset	Data source	Description	Date
Aerial imagery	AusImage	Aerial imagery	2014
Airport Plan – Concept Plan – Longer Term Development	DIRD	Concept drawing of proposed longer term airport layout	May 2015
Airport Plan – Concept Plan – Stage 1 Development	DIRD	Concept drawing of proposed Stage 1 airport layout	May 2015
Airport Plan – Concept Plan – Stage 1 Land Use Zoning Plan	DIRD	Drawing of proposed land use zoning for Stage 1	May 2015
Airport Plan – Concept Plan – Longer Term Land Use Zoning Plan	DIRD	Drawing of proposed land use zoning for longer term development	May 2015
Stage 1 Surface Water Management Layout Plan	DIRD	Drawing of proposed surface water management strategy for Stage 1	2015
Ultimate Surface Water Management Layout Plan	DIRD	Drawing of proposed surface water management strategy for the longer term development	2015

Document / dataset	Data source	Description	Date
Draft Airport Plan – Western Sydney Airport	DIRD	Draft report as at the time of conducting the surface water assessment	May 2015
Environmental Field Survey of Commonwealth Land at Badgerys Creek	DIRD	Documentation of water quality sampling data collected by SMEC	2014
Hydrology models	DIRD	RAFTS model of the existing airport site and longer term development	2015
Hydraulic models	DIRD	MIKE 21 models of the existing airport site and longer term development	2015
LiDAR	NSW LPI	Topographical LiDAR outputs at 1 metre and 5 metre intervals	2014
Hydrolines layer	NSW LPI	Map layer defining watercourse centre lines	2012
Updated South Creek Flood Study	Worley Parsons	Flood study of South Creek and its contributing catchments	2015
Water quality models	DIRD	MIKE 21 models of the existing airport site and longer term development	2015
Western Sydney Airport – Feasibility Design Version 0.01	DIRD	Draft report as at time of conducting surface water assessment	March 2015
Western Sydney Airport Climatological Review v1	Bureau of Meteorology	Report containing analysis of climatic data from Badgerys Creek gauge	April 2015
Western Sydney Airport Usability Report v1	Bureau of Meteorology	Report documenting the meteorological parameters affecting the usability of the airport site	April 2015

A detailed list of references is provided in Section 10.

3.2.2 Review of related studies

A number of past studies investigated hydrology and flooding characteristics of the catchments of South Creek and the Nepean River. These are summarised below and relevant findings in relation to the existing environment are discussed in Section 4.

1997 – 1999 Environmental Impact Assessment

An Environmental Impact Statement for a second Sydney airport at Badgerys Creek was prepared in 1997 and updated following public consultation and review in 1999. The impacts for surface water hydrology and geomorphology documented in the *Draft Environmental Impact Statement – Second Sydney Airport Proposal* included removal of stream habitat and associated ecological impact. The focus of the water study was on surface water quality impacts.

An updated technical study associated with the 1999 EIS identified the following key impacts including associated ecological impacts:

- removal of wetland habitat;
- increases in downstream runoff; and
- changes in streamflow characteristics.

Updated South Creek Flood Study

This study was completed in January 2015 and is the most recent available flood study for the catchment of South Creek (Worley Parsons 2015). The study was prepared for Penrith Council, Liverpool City Council, Fairfield City Council and Blacktown City Council and will be used to inform floodplain management within the South Creek catchment. The study documents flooding under existing conditions and is relevant as a benchmark for definition of flood extents within the catchment.

A RAFTS hydrological model was developed for the study. The extent of the RAFTS model includes the airport site. The focus of the study was on South Creek and the available subcatchment mapping suggests that it is not of sufficient detail at the airport site for the purposes of this study.

Flood extents, levels and depths were generated using a hydraulic model. The model results cover a portion of Badgerys Creek at the airport site, but with regards to Cosgroves Creek the model does not extend as far upstream as the airport site.

Based on correspondence with the modellers who prepared the study, detailed information regarding hydraulic structures in the vicinity of the airport was not available during preparation of their study.

The study was validated against the findings of earlier studies of the South Creek catchment, including the *South Creek Flood Study* (NSW Department of Water Resources 1990) and the *South Creek Floodplain Risk Management Study and Plan* (Willing and Partners 1991).

The Updated South Creek Flood Study document was used in this assessment for the validation of findings where appropriate. The associated hydraulic models, hydrology models and input data used in the Updated South Creek Flood Study were not used in the current study. Consultation was undertaken with various parties to obtain the information but it could not be sourced in the available timeframes.

3.2.3 Field investigations

Field investigations at the airport site and surrounding areas were conducted on 6 May 2015 and 7 May 2015.

The field visits focused on the following:

- collection of details regarding key hydraulic structures (road bridge and culvert crossings);
- review of land use characteristics;
- visual inspection of watercourse condition at several locations; and
- inspection of debris marks from recent flooding, believed to be from the event which occurred between 21 April and 22 April 2015.

There were limitations on accessibility to private properties. This meant that conducting a walkover of the entire length of watercourses on the site and downstream was not possible. The available data was used in characterising existing watercourse types and condition as discussed in Section 4.

Geomorphological findings of the field investigations are described in Section 4. The field observations relating to hydrology were used mainly in the development and validation of the flood model.

Photographs of some of the key hydraulic structures used in the hydraulic modelling are provided in Appendix A.

The Twin Creeks Golf and Country Club Estate Manager provided rainfall record data from a daily rainfall gauge held on site which was used in the validation of the hydraulic model (refer Appendix A).

3.3 Existing environment modelling and analysis

Hydrologic and hydraulic modelling was undertaken to establish baseline conditions and assess the potential impact of the proposed airport. The methodology adopted for the modelling analysis is described in this section. Definition of the existing environment based on the results of the modelling is discussed in Section 4. Additional model development detail not contained in this Section is included in Appendix A.

3.3.1 Hydrology

Watercourse stream ordering

Stream ordering of watercourses was established using the Strahler stream classification system where watercourses are given an 'order' according to the number of additional tributaries associated with each watercourse (Strahler, 1952). This system provides a measure of system complexity and is used as an input into assessing hydrological significance and environmental attributes such as potential for fish habitat. Watercourse locations were determined from the NSW LPI hydrolines layer. The stream ordering was used as an input to various EIS studies.

Hydrological modelling

A RAFTS hydrology model prepared by the Department of Infrastructure and Regional Development's business advisor was available and was refined and updated for the purposes of the EIS.

Hydrological subcatchments and land use

Subcatchments were delineated using available elevation data and regional hydroline mapping. Aerial imagery was used to determine the existing landuse types within each catchment. Subcatchment boundaries are shown in Figure 3-1.

Impervious areas were calculated by adopting rates of imperviousness for typical landuse types within the modelled area. This is the approach adopted in Liverpool City Council's *Handbook for Drainage Design Criteria* (2003). Landuse types used in the hydrology modelling of the existing study area and the adopted percentage impervious for each are shown in Table 3-2. The dominant landuse in the study area is farmland (pasture), listed here as primary production.

The pervious and impervious areas for each catchment were input into the RAFTS model as subcatchments.

Table 3-2 Landuse types and adopted impervious percentages

Landuse type	% impervious
Low density residential	45%
Large lot residential	20%
Primary production	10%
Primary production (small lot)	15%
Dams	100%
Infrastructure	10%
Commonwealth land	10%

LEGEND

- Airport site
- Watercourses
- Existing subcatchment boundaries

Paper Size A3

0 380 760 1,520

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Hydrology assessment
existing subcatchment boundaries

Figure 3-1

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Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Data source: Data source: General Topo - NSW LPI DTDB 2012, Imagery - ESRI 2015 Created by: afoddy

A summary of the Badgerys Creek, Cosgroves Creek and Duncans Creek catchments within the airport site and their percentage impervious is provided in Table 3-3.

Table 3-3 Summary of existing catchment areas and impervious percentages

Catchment	Catchment area (ha)	% of catchment within airport site	% impervious in existing catchment
Badgerys Creek to South Creek	2,799	38.2	12.1
Cosgroves Creek to South Creek	2,163	23.1	13.7
Duncans Creek to Nepean River	2,379	8.7	13.9

Design storms

Design storms were generated in RAFTS using design rainfall intensity-frequency-duration (IFD) data for the airport site from *Australian Rainfall and Runoff* (Institute of Engineers Australia 1987). Design storms of various durations (1 to 24 hours) and average recurrence intervals (100, 20, 5, 2 and 1 year) were simulated in the RAFTS model to assess the existing hydrology of the study area.

Probable maximum flood (PMF) simulations were conducted in RAFTS using probable maximum precipitation estimates calculated using the generalised short duration method as described by the Bureau of Meteorology (BOM 2003).

Further details of the model development and validation are provided in Appendix A.

3.3.2 Hydraulics and flooding

A flood model prepared using MIKE 21 software was developed for the Department of Infrastructure and Regional Development.

The model was refined and extended for the purposes of the EIS and used to define existing flooding downstream of the site and adjacent to it.

No hydraulic models were available for the tributaries of Duncans Creek on the site or for Duncans Creek itself. The land use downstream of the site was largely primary industry, with few dwellings identified close to the creek. Following the hydrology assessment, the benefit of developing a detailed hydraulic model of Duncans Creek to inform the impact assessment was considered limited. An impact assessment was carried out but was based on the findings of the hydrology model at the points of discharge from the site for Duncans Creek.

Model terrain

The hydraulic model terrain was developed from Light Detection and Ranging data (LiDAR). The LiDAR data from which the model terrain was sourced was provided on a one metre by one metre square grid. It was adjusted to a five metre by five metre square grid size for use in the model.

Hydraulic roughness

Hydraulic roughness parameters were selected based on aerial imagery and on-site observations. The values adopted are included in Table 3-4.

Table 3-4 Hydraulic model adopted roughness values

Land use	Hydraulic roughness
Water	0.02
Roads	0.02
Floodplain – grass with light vegetation	0.08
Channel – trees	0.12
Channel – grass	0.05

The downstream boundary of the model was chosen to ensure that flood behaviour at the study area boundary could be identified. A normal depth open channel flow was selected at the extreme downstream section of the model.

Representation of key hydraulic structures

Bridges and other flow controlling structures were represented in the model as a MIKE 21 feature. Dimensions were based on observations made during the site visit. Adjustments to the MIKE 21 grid were made to represent the road level across the structure.

The hydraulic model extents and key structures are shown in Figure 3-2.

3.3.3 Watercourse geomorphology

The assessment of the physical form and geomorphic condition of watercourses was broadly based on the methods and principles of the River Styles® framework (Brierley and Fryirs 2005). Determination of watercourse geomorphic types is largely based on the following parameters:

- degree of valley confinement and bedrock influences;
- presence and continuity of a channel;
- channel planform (number of channels, sinuosity);
- channel and floodplain geomorphic features; and
- nature of channel and floodplain sediments.

The assessment of the geomorphic type and condition of watercourses in the study area was primarily based on a desktop review of aerial imagery and topographic data. This was supported by visual inspections of watercourses at several locations undertaken over the period 6–7 May 2015.

3.4 Stage 1 and longer term modelling and analysis

3.4.1 Description of proposals for surface water

Development of the Stage 1 airport would involve significant earthworks to level the central northern portion of the site for the runway and related Stage 1 infrastructure to be built.

All existing surface water features within the Stage 1 construction zone would be removed to make way for the development.

The Stage 1 development area would be drained via a number of pipes and swales in order to maintain the serviceability of the site from a stormwater perspective and to the required design standards.

A number of stormwater detention and treatment basins are incorporated in the design of the airport for the management of the quantity and quality of stormwater runoff expected from the airport. Key stormwater features of the proposed Stage 1 development are shown in Figure 3-3.

In the longer term, development of the proposed airport could include construction of an additional runway in the south of the site, as well as development of ancillary facilities. All surface water features on the remainder of the airport site would be removed to make way for the longer term development.

Although the longer term plan would involve further development on the site, surface water management features would remain largely unchanged. Substantial changes to the catchments in the southern portion of the site however would result from associated earthworks in this area.

The detention basins constructed during the Stage 1 development would be maintained in the longer term, with a number being extended and enlarged to accommodate the runoff from the additional development areas. An additional basin would also be constructed in the south west of the site. Key stormwater features of the longer term development are shown on Figure 3-4.

The adopted design standards for the stormwater management infrastructure on the site are outlined in Table 3-5.

Table 3-5 Typical Annual Recurrence Intervals for Aerodromes

Aerodrome Area	Criterion	Storm Frequency (ARI, years)
Pavements		
Runways	No Ponding	50
Taxiways	No Ponding	50
Apron	No Ponding	10
Other paved areas	No Ponding within 30 m of buildings	50
Grassed Areas		
Runway Strip	Ponding within 75 m of runway centreline not to exceed 12 hours	5
Taxiway Strip and Apron Flanks	Ponding within 15 m of pavement edge not to exceed 12 hours	5

Capture and reuse of stormwater runoff from the proposed airport (for example roof water recycling) has not been incorporated into the design at this stage. Hence, the design and sizing of stormwater capture systems and detention basins does not include reuse of stormwater. Reuse of a portion of treated wastewater for typical recycled water applications is proposed.

Further results of the modelling analysis not included in the main body of the report are included in Appendix B.

LEGEND

- Airport site
- Watercourses
- Hydraulic model key structures
- Hydraulic model extent - Badgerys Creek
- Hydraulic model extent - Cosgoves Creek

Paper Size A3

0 250 500 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Hydraulic model extent
and key structures

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Figure 3-2

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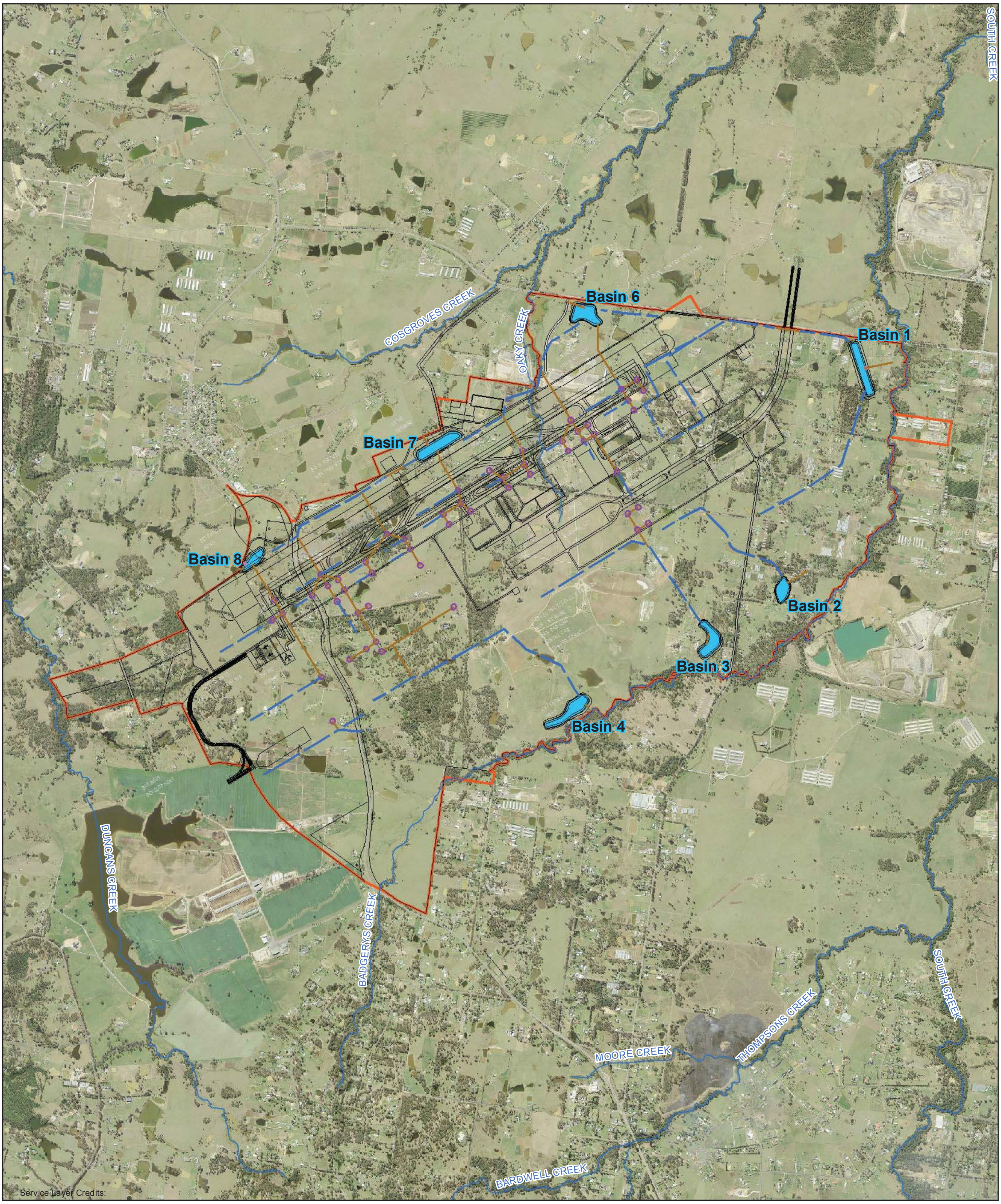
Data source: Data source: General Topo - NSW LPI DTDB 2012, Imagery - ESRI 2015 Created by: afoddy



LEGEND

- Airport site
- Watercourses
- Stage one footprint
- Channel
- Culvert
- Pipe
- Pit
- Detention ponds

Paper Size A3

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Job Number	21-24265
Revision	A
Date	06 Aug 2015

Key development features,
Stage 1

Figure 3-3

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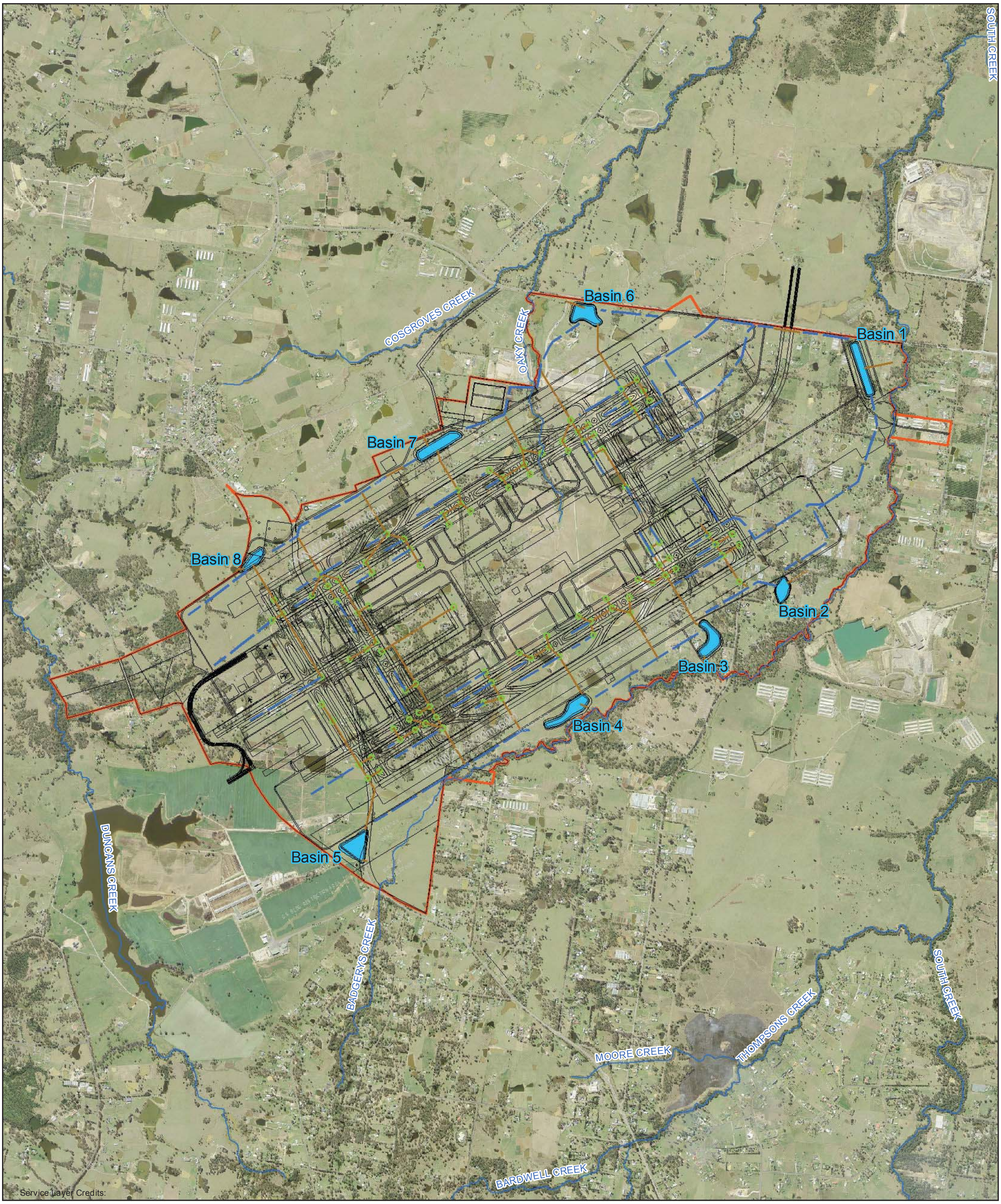
Data source: Data source: General Topo - NSW LPI DTDB 2012, Imagery - ESRI 2015 Created by: afoddy



LEGEND

Airport site	Channel
Watercourses	Culvert
Longer term footprint	Pipe
	Pit
	Detention ponds

Paper Size A3

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Job Number 21-24265
Revision A
Date 06 Aug 2015

Key development features,
Longer term

Figure 3-4

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Data source: Data source: General Topo - NSW LPI DTDB 2012, Imagery - ESRI 2015 Created by: afoddy

3.4.2 Hydrology and hydraulics

An analysis of the Stage 1 surface water system was carried out to inform the impact assessment. The analysis was based on the land use plan, surface water management plan and design basis report provided.

The hydrology model provided by the business advisor was updated based on the following:

- surface water management plans; and
- land use plans.

There was no hydrology model available from the business advisor for Stage 1 and a RAFTS model was therefore developed for the purposes of this assessment. There was a longer term hydrology model available which was extended further downstream and updated in accordance with the latest available drainage layouts and with the latest land use plans for the proposed airport. Subcatchment boundaries were delineated based on the available information and are shown in Figure 3-5 for Stage 1 and in Figure 3-6 for the longer term development.

Proposed detention basin volumes were available for Stage 1 from the design information provided. Outlet configurations for the basins were assumed based on the proposed outlet configurations provided for the longer term development. Assumptions regarding proposed stage-storage information for the Stage 1 basin were made in the model based on the configuration of the longer term basins.

A Stage 1 hydraulic model was created by:

- incorporating the available design landform within the model topography; and
- incorporating the Stage 1 surface water runoff estimated by the hydrology assessment.

In order to refine hydraulic estimates, hydraulic structures were incorporated into both the Stage 1 and the longer term models, and their description was based on site observations.

3.5 Impact assessment

The assessment considered the impacts of the development on:

- surface flows, including the effectiveness of the proposed basins in mitigating changes to hydrology;
- watercourse geomorphology;
- flooding and flood risk to surrounding developments and people; and
- cumulative aspects.

3.5.1 Hydrology and hydraulics

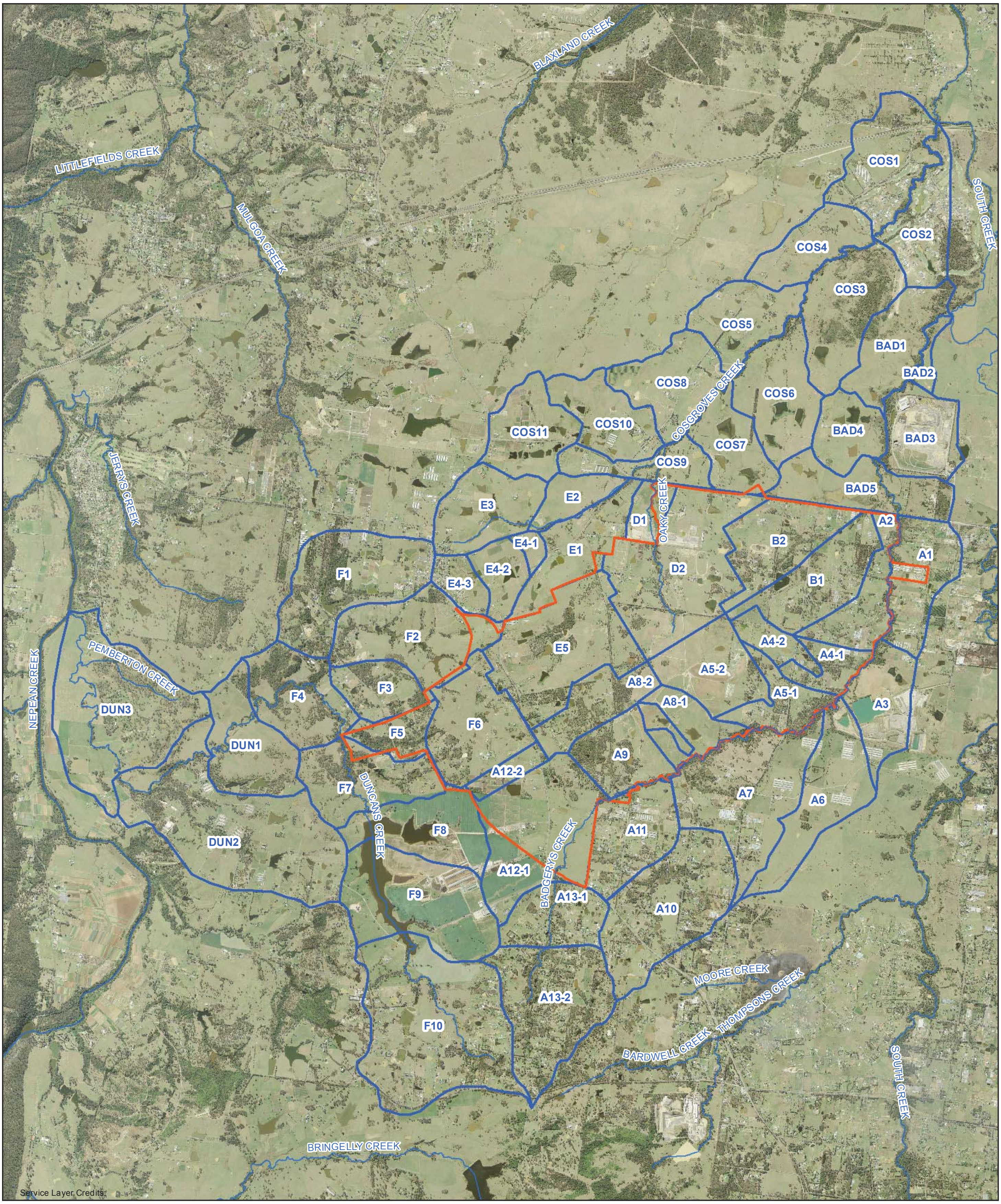
Findings are reported in section 6.1.1.

Outputs from the hydrology model were used:

- to inform the impact assessment of changes to flows as a result of the airport; and
- to confirm the effectiveness of the proposed basins in mitigating changes to hydrology.

The results of the hydraulic modelling were used to determine:

- the impact of the proposed airport on watercourse geomorphology; and
- the impact of the proposed airport on flooding and the flood risk to surrounding developments and people.



LEGEND

- Airport site
- Watercourses
- Stage 1 subcatchment boundaries

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Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Job Number	21-24265
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Date	05 Aug 2015

Hydrology assessment
Stage 1 subcatchment boundaries

Figure 3-5

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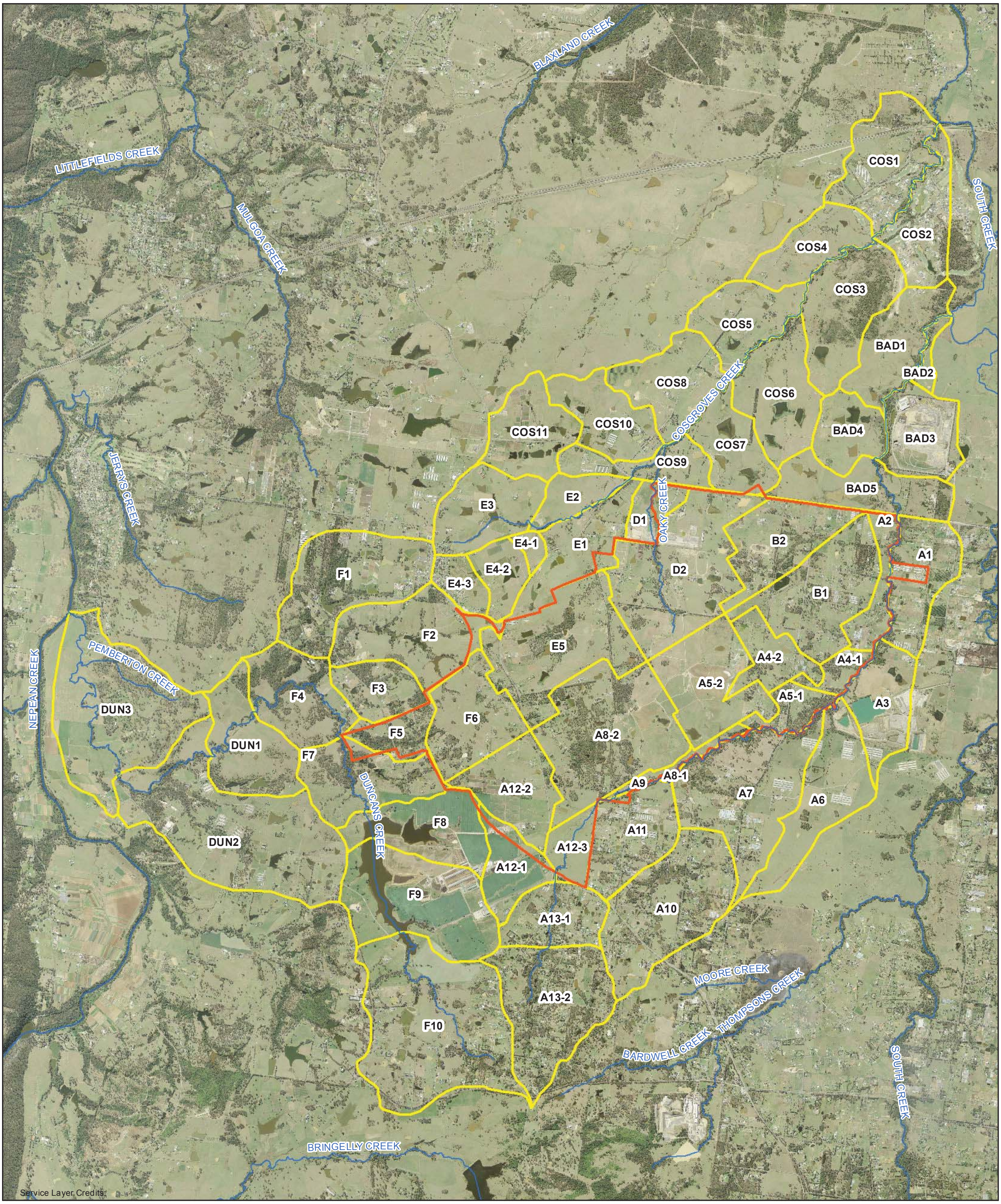

LEGEND

- Airport site
- Watercourses
- Ultimate subcatchment boundaries

Paper Size A3

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Job Number	21-24265
Revision	A
Date	05 Aug 2015

Hydrology assessment

Longer Term subcatchment boundaries

Figure 3-6

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Data source: Data source: General Topo - NSW LPI DTDB 2012, Imagery - ESRI 2015 Created by: afoddy

Changes in catchment area and land use were identified for their potential to change the flows discharging from the site during both Stage 1 and the longer term development.

The significance of the magnitude of change between the existing and the Stage 1 or longer term scenarios depends on factors such as watercourse stability (see below), the sensitivity of biodiversity to changes in surface water parameters and the sensitivity of surrounding infrastructure such as residences to flooding. These factors were considered when assessing changes to surface water between the existing condition and the Stage 1 and longer term airport.

As part of the flood analysis, differences in predicted flood depth of greater than or less than 100 mm were reviewed for the potential to influence flooding of surrounding residences and other infrastructure

3.5.2 Geomorphology

The footprints of the Stage 1 and longer term developments were reviewed to assess the length and stream order of mapped watercourses directly subsumed by the development footprints. Changes in baseline hydraulics at discharge points from the site were considered together with watercourse type to determine the likelihood of such changes affecting watercourse stability.

Changes in shear stress from the existing case of less than 5 N/m^2 were considered to be minor in influencing watercourse stability, provided that actual shear stress levels were expected to be low (less than 100 N/m^2).

3.5.3 Cumulative impacts

Cumulative impacts of the Stage 1 and longer term development were considered including the future effects of climate change, as well as surrounding development within the catchment.

Accounting for the future effects of climate change

Background to adopted climate change methodology

The NSW Office of Environment and Heritage (OEH) publishes information regarding the expected effects of future climate change on rainfall and sea levels. The document *Metropolitan Sydney Climate Change Snapshot* (OEH November 2014), which incorporates the airport site, is the most recent relevant New South Wales publication. It identifies predicted changes to rainfall seasonality and average rainfall in the near future (from 2020 – 2039) and in the far future (from 2060 – 2079).

In the Sydney region, the majority of the climate change models show that autumn rainfall will increase in the near future and in the far future. The majority of models show that spring rainfall will decrease in the near future, though far future predictions are less clear. It is important to note that there is a significant degree of uncertainty in the findings of the climate change modelling, and that the NSW Government is conducting ongoing research into climate change.

The publication does not provide details regarding changes to flood-producing rainfall events other than to confirm that changes to rainfall intensity are expected.

The *Practical Consideration of Climate Change* (NSW Department of Environment and Climate Change 2007) publication references climate change modelling carried out by the CSIRO in 2007 for the NSW Government to assess the impacts of climate change on rainfall intensities. The results showed a trend of increased rainfall intensities for the 40 year ARI one-day rainfall event across New South Wales. The projected increase in rainfall totals in the Sydney Metropolitan Area are indicated in Table 3-6.

Table 3-6 CSIRO indicative change in rainfall one-day totals (CSIRO, 2007)

Location	40 Year 1 day rainfall total projected change by 2030	40 Year 1 day rainfall total projected change by 2070
Sydney Metropolitan Area	-3% to +12%	-7% to +10%
New South Wales average	-2% to +15%	-1% to +15%

The values in the table are considered indicative. OEH is currently working with the University of New South Wales to analyse the effects of climate change on flooding and it is expected that new information will become available.

For catchments in NSW, the *Practical Consideration of Climate Change* publication suggests considering a 10 per cent, 20 per cent and 30 per cent increase in peak rainfall and volume to account for the future effects of climate change when considering flood events.

Adopted climate change methodology

Climate change predictions are not incorporated into the main impact assessment but are considered as a future cumulative impact. Consideration was given to the potential for both increases and decreases in rainfall as outlined in the *Metropolitan Sydney Climate Change Snapshot*.

For the flood assessment, the cumulative impact of the Stage 1 and longer term development together with the predicted impacts of climate change were assessed for the following modelling scenarios based on the upper and lower range recommendations of the *Practical Consideration of Climate Change* publication:

- Stage 1 Development and 100 year ARI flood event with 10 per cent increase in rainfall intensity; and
- longer term development and 100 year flood ARI event with 30 per cent increase in rainfall intensity.

Accounting for the effects of future development

The analysis also considered the cumulative impacts of future development surrounding the airport site. This is discussed further in Section 7.

4. Existing environment

4.1 Topography

The proposed airport site is located in the south-west portion of the Cumberland Plain (PPK, 1997) and includes rolling hills dissected by a number of drainage lines. The ridge system trends northwest to southeast in the vicinity of The Northern Road and reaches elevations of just over 120m AHD. There are some other isolated ridge lines in and around the Luddenham Dyke and The Northern Road with approximate elevations of slightly more than 100m AHD. The topography generally slopes away from these ridgelines to the south and east into Oaky, Cosgrove and Badgerys Creeks as part of the South Creek catchment and to the northwest into Duncans Creek as part of the Nepean River Catchment. The lowest points of the site are where Badgerys Creek exits the north eastern extent of the site (approximately 44m AHD).

4.2 Land use

The airport site is rural, with a mixture of vacant lots, large agricultural lots and smaller scale residential and rural use. A large number of small farm dams are present across the airport site.

Paved areas on the site are associated mainly with buildings and the arterial and local roads located on the site or passing through it.

4.3 Rainfall

An Automatic Weather Station (AWS) operated by the Bureau of Meteorology is located on the site.

This data from the station has been analysed by the Bureau of Meteorology in the *Western Sydney Airport Climatological Review* (Bureau of Meteorology 2015).

Results from the analysis of the gauge are summarised in Table 4-1.

Table 4-1 Badgerys Creek AWS rainfall gauge data

Gauge name	Badgerys Creek AWS
Gauge Number	067108
Location	33.90 S, 150.73 E
Period of data	Dec 1998 – Present
Data Set Completeness	93.9%
Data resolution	1 minute
Mean Annual Rainfall (mm)	676.4

Monthly statistics, taken from Table 4-1 of the *Western Sydney Airport Usability Report, Meteorological Impacts* (Bureau of Meteorology 2015) are provided in Figure 4-1.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean Monthly Rainfall (mm)	77.4	108.0	77.3	43.2	40.1	52.1	23.0	35.9	33.9	52.7	74.5	63.6
Highest Monthly Rainfall (mm)	192.2	342.4	198.0	129.4	155.6	220.0	71.6	231.0	82.2	182.2	173.2	131.2
Lowest Monthly Rainfall (mm)	13.6	13.4	21.4	1.8	1.8	2.0	2.8	1.0	6.4	0.4	8.4	14.2
Highest Daily Rainfall (mm)	138.0	106.8	67.8	82.4	54.0	63.8	28.4	70.0	50.8	63.0	63.0	65.0

Figure 4-1 Monthly rainfall statistics at Badgerys Creek AWS

The findings of the Bureau of Meteorology studies also indicate that heavy rainfall events of probability 1 Exceedance Year (EY) and rarer are more likely to occur between November and March, based on the available record. The likely timing of heavy rainfall events would be relevant for consideration during the scheduling of the airport construction (refer also to Section 5).

4.4 Surface water sources

4.4.1 Regional

The airport site is situated in the Hawkesbury-Nepean basin. The Hawkesbury-Nepean catchment is one of the largest coastal basins in NSW with an area of 21,400 square kilometres (NSW Office of Water). The airport site is located downstream of Warragamba Dam in a part of the catchment termed the lower Hawkesbury-Nepean.

The airport site drains partially to the Nepean River upstream of Warragamba Dam and partially to South Creek and then the Hawkesbury River downstream of Warragamba Dam via a system of tributaries.

South Creek drains a catchment of approximately 414 square kilometres and flows generally from south to north along its length (Worley Parsons 2015). It has its headwaters near Narellan and flows for a length of around 70 kilometres to its discharge point into the Hawkesbury River near Windsor. South Creek could be sensitive to impacts from the airport if they propagate downstream via the tributaries.

The catchment is shale-based and is characterised by meandering streams. The catchment is highly disturbed due to increasing urbanisation and associated land clearing.

Based on available flood maps for the Hawkesbury-Nepean River, as well as Penrith and Liverpool Council Local Environmental Plan Flood Maps, the airport site is not affected by flooding from the Hawkesbury-Nepean system. In particular, it is not within the available modelled flood extents of the PMF resulting from the overtopping of Warragamba Dam.

4.4.2 Local

The airport site is located in the upper reaches of the catchments of Badgerys Creek, Cosgroves Creek, Oaky Creek (a tributary of Cosgroves Creek) and Duncans Creek. Badgerys Creek and Cosgroves Creek are tributaries of South Creek which is itself a tributary of the Hawkesbury River.

Duncans Creek is a tributary of the Nepean River.

The catchments of Cosgroves and Oaky Creeks, Badgerys Creek and Duncans Creek are shown in Figure 4-2. The creeks and their associated ecosystems are environmental receptors for potential impacts from the airport development.

Further details of the hydrological and geomorphological features of key catchments are described in greater detail in later sections of this section.

Badgerys Creek

Badgerys Creek has its headwaters in the vicinity of Findley Road, Bringelly, approximately two kilometres upstream of the airport site. It flows generally in a north to north-east direction. It passes through the airport site starting at the site’s southern extent and continues for a distance of approximately 1.2 kilometres before its course returns to the airport site boundary. The creek then forms the south-eastern boundary of the airport site as far as Elizabeth Drive. Downstream of the airport site, Badgerys Creek continues for a further four kilometres until its confluence with South Creek.

Between the airport site and the confluence, the creek passes the Elizabeth Drive landfill site operated by SUEZ Environnement (previously operating as SITA).

Badgerys Creek has a catchment area of approximately 2,800 hectares (28.0 square kilometres) in total and an area of 2,360 hectares (23.6 square kilometres) at Elizabeth Drive, the downstream extent of the airport site.

In addition to being used for agricultural and landfill purposes, the catchment of Badgerys Creek contains a number of residential properties downstream of the site and adjacent to the site which would be sensitive to changes in flood behaviour.

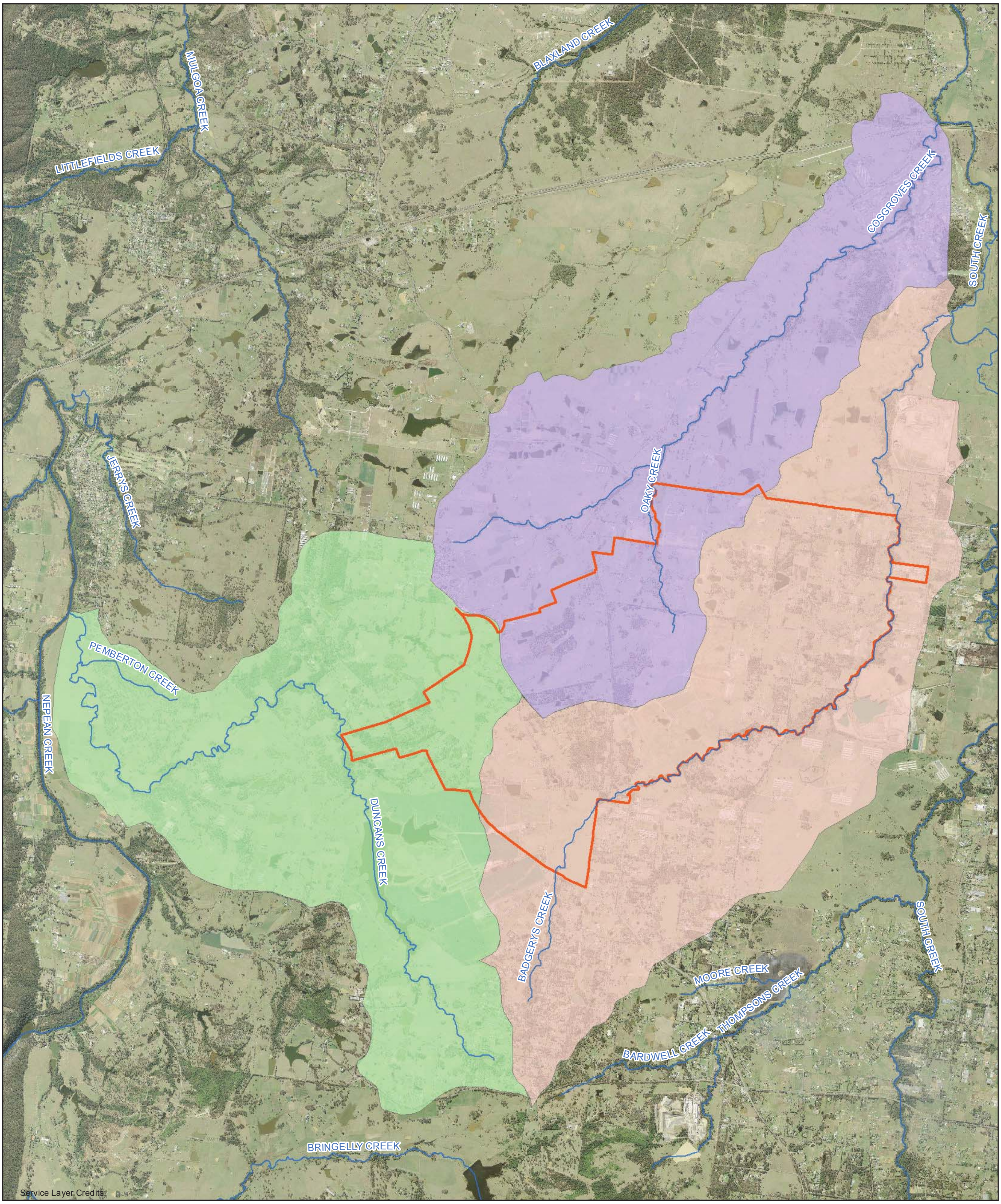
Oaky and Cosgroves Creeks

The headwaters of Oaky Creek are located on the airport site. The watercourse flows in a north-westerly direction for around two kilometres before it reaches the western boundary of the airport site. From this point, it meanders away from the airport site boundary, through the Blue Sky Mining site for several hundred metres, before rejoining the airport site boundary and continuing along it for 400 metres as far as the north-west corner of the site. Downstream of the airport site, the watercourse continues for a further half a kilometre before its confluence with Cosgroves Creek. Downstream of the confluence, the watercourse continues as Cosgroves Creek.

Downstream of the confluence with Oaky Creek, Cosgroves Creek continues for approximately seven kilometres before joining with South Creek. In the reach between Oaky Creek and South Creek, Cosgroves Creek passes through rural lots, the Twin Creeks Golf and Country Club and beneath an above-ground Sydney Water Corporation water pipeline.

Oaky Creek has a catchment area of 382 hectares (3.82 square kilometres) in total, and 361 hectares (3.61 square kilometres) at the downstream extent of the airport site. The total catchment area of Cosgroves Creek at the confluence with South Creek is approximately 2163 hectares (21.63 square kilometres).

The catchments are largely rural and without residential development downstream of the site, with the exception of the Twin Creeks Golf and Country Club residential estate downstream of the site towards Cosgroves Creek’s confluence with South Creek.



LEGEND

Airport site	**Catchment**
Watercourses	Badgerys creek
	Duncans creek
	Oaky and Cosgroves creeks

Paper Size A3

0 380 760 1,520

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Job Number	21-24265
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Local hydrological catchments

Figure 4-2

N:\AU\Sydney\Projects\21\24265\GIS\Maps\Deliverables\KBM.mxd [KBM: 36]

Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

Data source: Data source: General Topo - NSW LPI DTDB 2012, Imagery - ESRI 2015 Created by: afoddy

Duncans Creek

Duncans Creek has its headwaters in Bringelly and flows initially in a north-westerly direction. A number of unnamed tributaries of Duncans Creek are located on the airport site. A large water storage dam is located on the creek at the Leppington Pastoral Company site. Information regarding the dam was requested from the owners but available data was limited to the total dam size of 5,000 ML. Downstream of the dam the creek continues, passing close to the southern tip of the airport site before turning sharply towards the south west and later meandering north again before discharging into the Nepean River around nine kilometres downstream of the southern site extent. The Duncans Creek catchment downstream of the site is rural and zoned for primary production (plant or animal cultivation) according to the Liverpool City Council Local Environmental Plan.

A small portion of the site north west of The Northern Road drains to Duncans Creek via several tributaries.

4.5 Hydrology and flooding

4.5.1 Hydrological modelling findings

The RAFTS hydrology model was used to understand characteristics of flood flows on, and downstream of, the site.

The critical storm for each catchment is the storm producing the highest flood peak at a given location for a given ARI. The critical duration is influenced by factors such as overall catchment size as well as the properties of contributing sub-catchments.

Table 4-2 indicates the critical duration storm events which range from two hours to nine hours depending on design storm average recurrence interval and location.

Table 4-2 Critical storm durations modelled in RAFTS

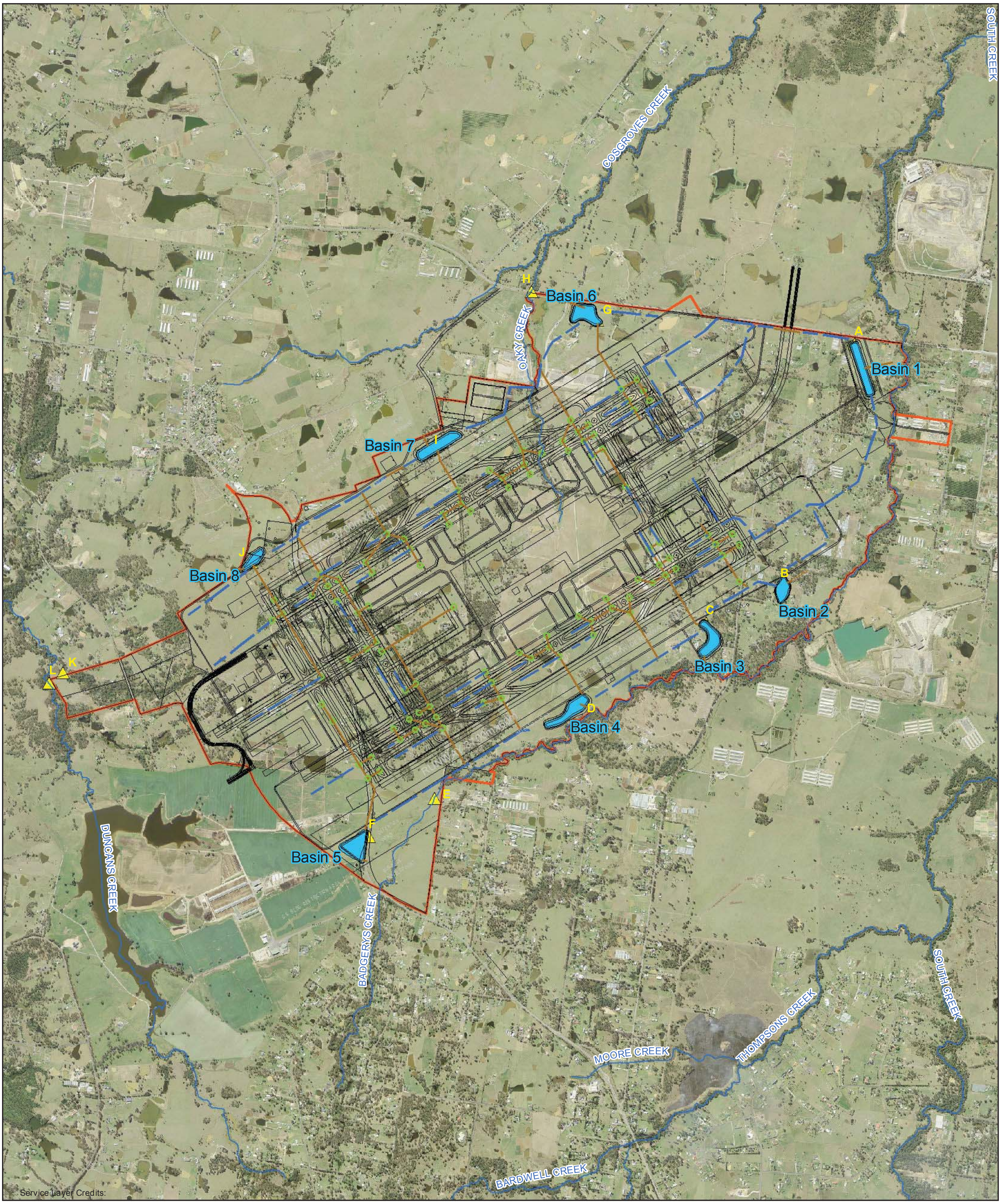
Location	100 year ARI	20 year ARI	5 year ARI	2 year ARI	1 year ARI
Badgerys Creek at Elizabeth Drive	6 hr	6 hr	9 hr	9 hr	9 hr
Oaky Creek at Elizabeth Drive	2 hr	2 hr	9 hr	9 hr	9 hr
Cosgroves Creek at Elizabeth Drive	2 hr	2 hr	2 hr	9 hr	9 hr
Badgerys Creek at South Creek	6 hr	6 hr	9 hr	9 hr	9 hr
Cosgroves Creek at South Creek	6 hr	6 hr	6 hr	9 hr	9 hr
Duncans Creek at Nepean River	6 hr	6 hr	6 hr	9 hr	9 hr

The results indicate that peak flows are typically generated by longer duration storms for smaller ARI events which are reflective of the greater influence of initial storm losses on peak flows for the smaller shorter duration events.

Peak flows at selected locations are shown in Table 4-3 below. Locations correspond to the hydrology assessment reporting locations depicted on Figure 4-3.

Table 4-3 Peak flows at selected locations, existing conditions

Location	Peak flow (m^3/s), 100 year ARI event	Peak flow (m^3/s), 1 year ARI event
A	33.5	8.4
B	8.2	1.9
C	12.9	3.2
D	9.1	2.3
E	26.3	6.5
H	37.6	8.9
I	16.5	4.1
J	10.9	3.3
K	9.6	2.1
L	19.8	4.6



LEGEND

- Airport site
- Hydrology assessment reporting locations
- Watercourses
- Longer term footprint
- Channel
- Culvert
- Pipe
- Pit
- Detention ponds

Paper Size A3

0 250 500 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

Job Number	21-24265
Revision	A
Date	06 Aug 2015

Hydrology assessment reporting locations

Figure 4-3

N:\AU\Sydney\Projects\21\24265\GIS\Maps\Deliverables\KBM.mxd [KBM: 75]

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4.5.2 Hydraulic modelling

Peak flood flows extracted from the flood model for the 100 year ARI event for Badgerys and Oaky Creeks at Elizabeth Drive are included as Figure 4-4 and Figure 4-5 for the critical storm durations for each catchment (refer to section 4.5.1.

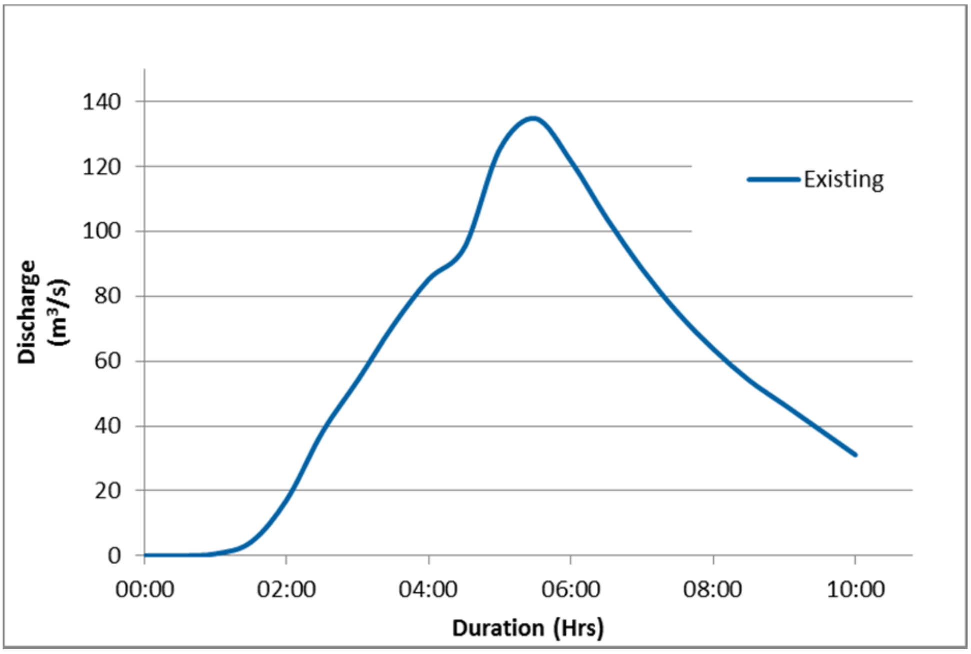

Figure 4-4 Badgerys Creek hydrograph at Elizabeth Drive, 100 year ARI event 6 hour storm duration

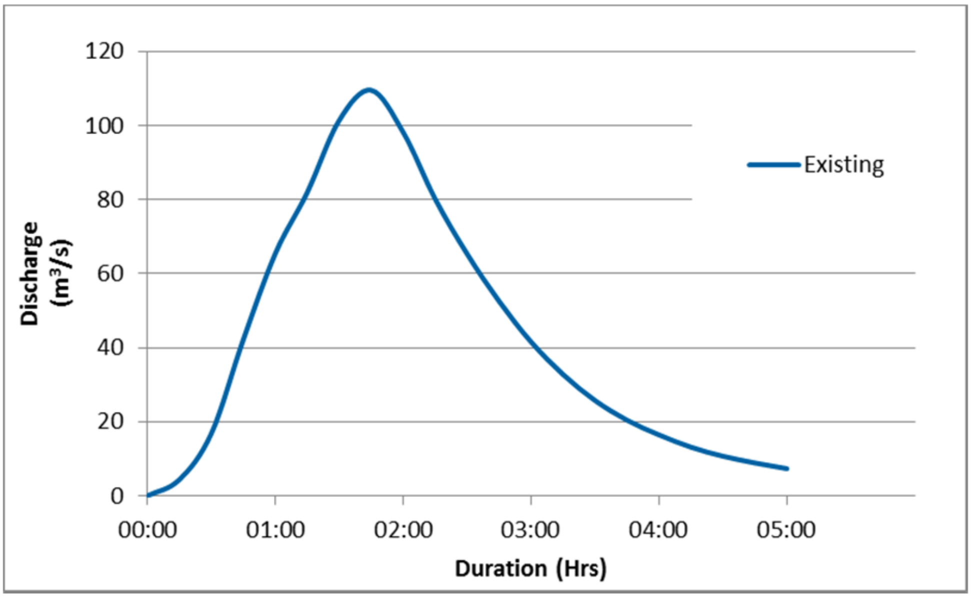

Figure 4-5 Cosgroves Creek hydrograph at confluence with Elizabeth Drive, 100 year ARI event 2 hour storm duration

- The extent of flooding under existing conditions and predicted flood depths are shown in Figure 4-6 to Figure 4-9 for Badgerys Creek and Cosgroves and Oaky Creeks.
- In the 1 year ARI event, flooding is mostly confined to main watercourse channels and dams.
- In the 5 year ARI event, much more out of bank flooding is expected of depths up to around 0.6 metres on Oaky and Cosgroves Creek and deeper flood depths on Badgerys Creek, particularly upstream of Elizabeth Drive.
- In a 100 year ARI event, significant out of bank flooding is also expected. On Badgerys Creek near the downstream area, the floodplain is more extensive on the airport side (western bank) than on the eastern bank due to the wider and flatter floodplain in this location.

A number of the flood-affected rural residential lots outside the airport site are located in Bringelly in the area bounded by the airport site, The Northern Road and Badgerys Creek Road. Based on the available imagery, though a number of lots would experience some inundation in a 100 year ARI event, most existing dwellings in this area remain outside the flood extent. There are a number of existing dwellings located within the flood extent or in close proximity to the flood extent clustered on Badgerys Creek upstream of the site (Figure 1-1). Two dwellings in close proximity to the flood extent were also identified downstream of the airport site on Cosgroves Creek. On the eastern bank of Badgerys Creek are a number of flood affected lots, though the existing dwellings are located beyond the 100 year flood extent. This includes dwellings on the parcel of land located on the eastern side of Badgerys Creek that may in future become part of the airport site which are not within the 100 year flood extent and are therefore not marked on the map.

LEGEND

Airport site	**Flood depth (m)**	0.6 - 0.8	2 - 2.5
	0.1 - 0.2	0.8 - 1	2.5 - 3
	0.2 - 0.4	1 - 1.5	3 - 4
	0.4 - 0.6	1.5 - 2	>4

Paper Size A3

0 250 500 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

Job Number	21-24265
Revision	A
Date	05 Aug 2015

Existing flood depths
1-year ARI event

Figure 4-6

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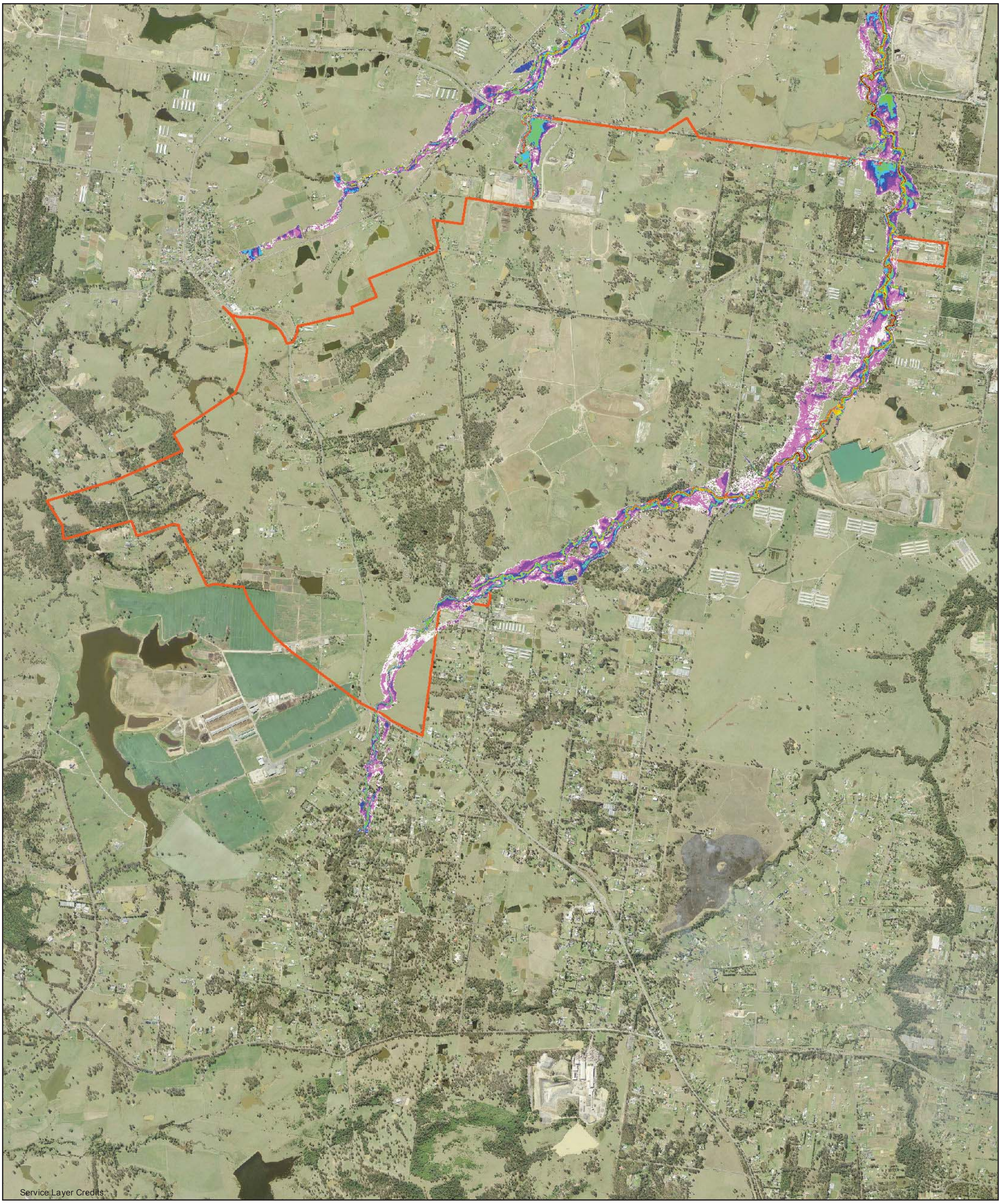

LEGEND

Airport site

Flood depth (m)

- 0.1 - 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 4
- >4

Paper Size A3

0 250 500 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

Job Number	21-24265
Revision	A
Date	05 Aug 2015

Existing flood depths
5-year ARI event

Figure 4-7

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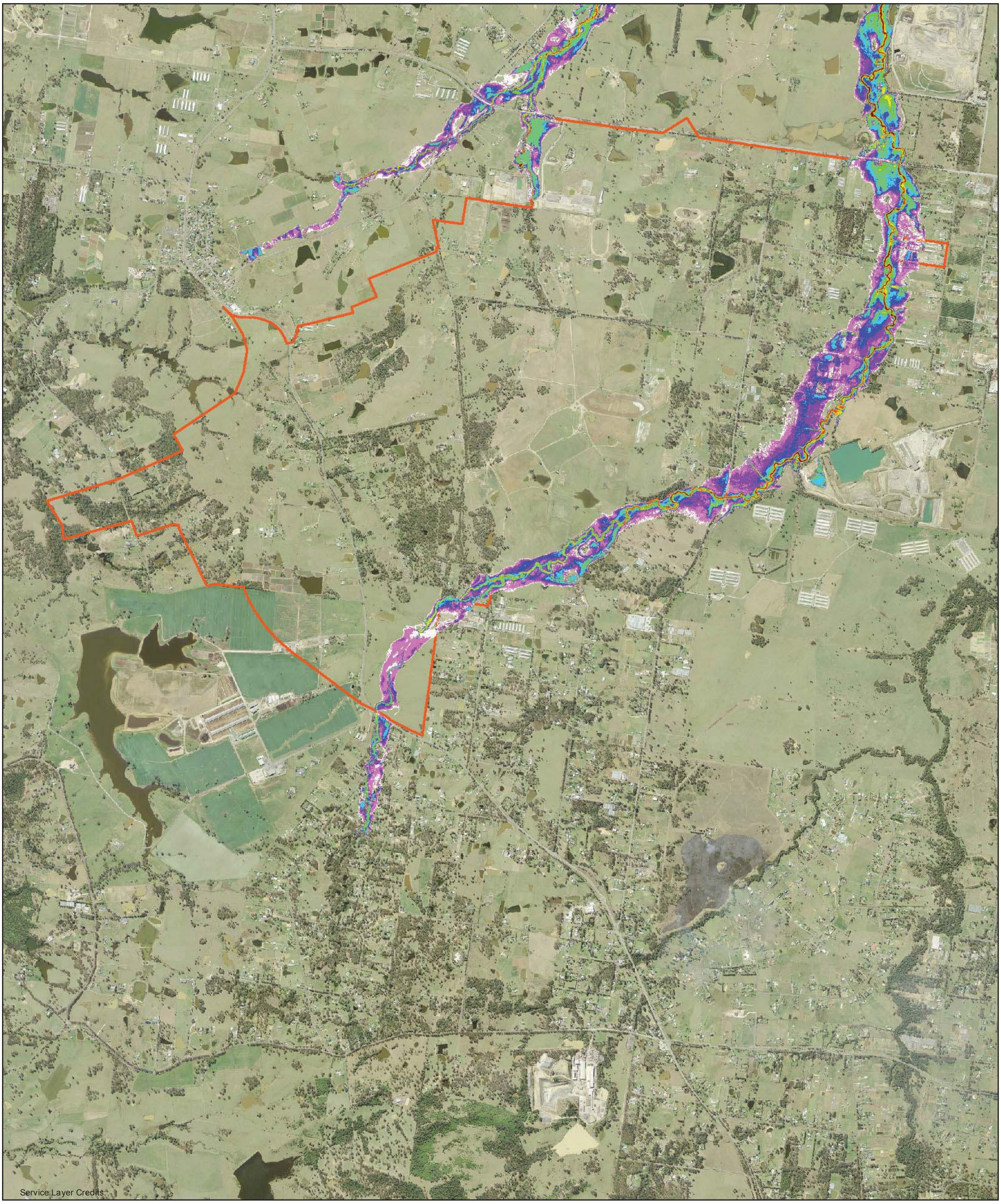
Data source: Data source: General Topo - NSW LPI DTDB 2012, Imagery - ESRI 2015 Created by: afoddy



LEGEND

Airport site	Flood depth (m)	0.6 - 0.8	2 - 2.5
	0.1 - 0.2	0.8 - 1	2.5 - 3
	0.2 - 0.4	1 - 1.5	3 - 4
	0.4 - 0.6	1.5 - 2	>4

Paper Size A3

0 250 500 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

GHD

Job Number	21-24265
Revision	A
Date	05 Aug 2015

Existing flood depths
100-year ARI event

Figure 4-8

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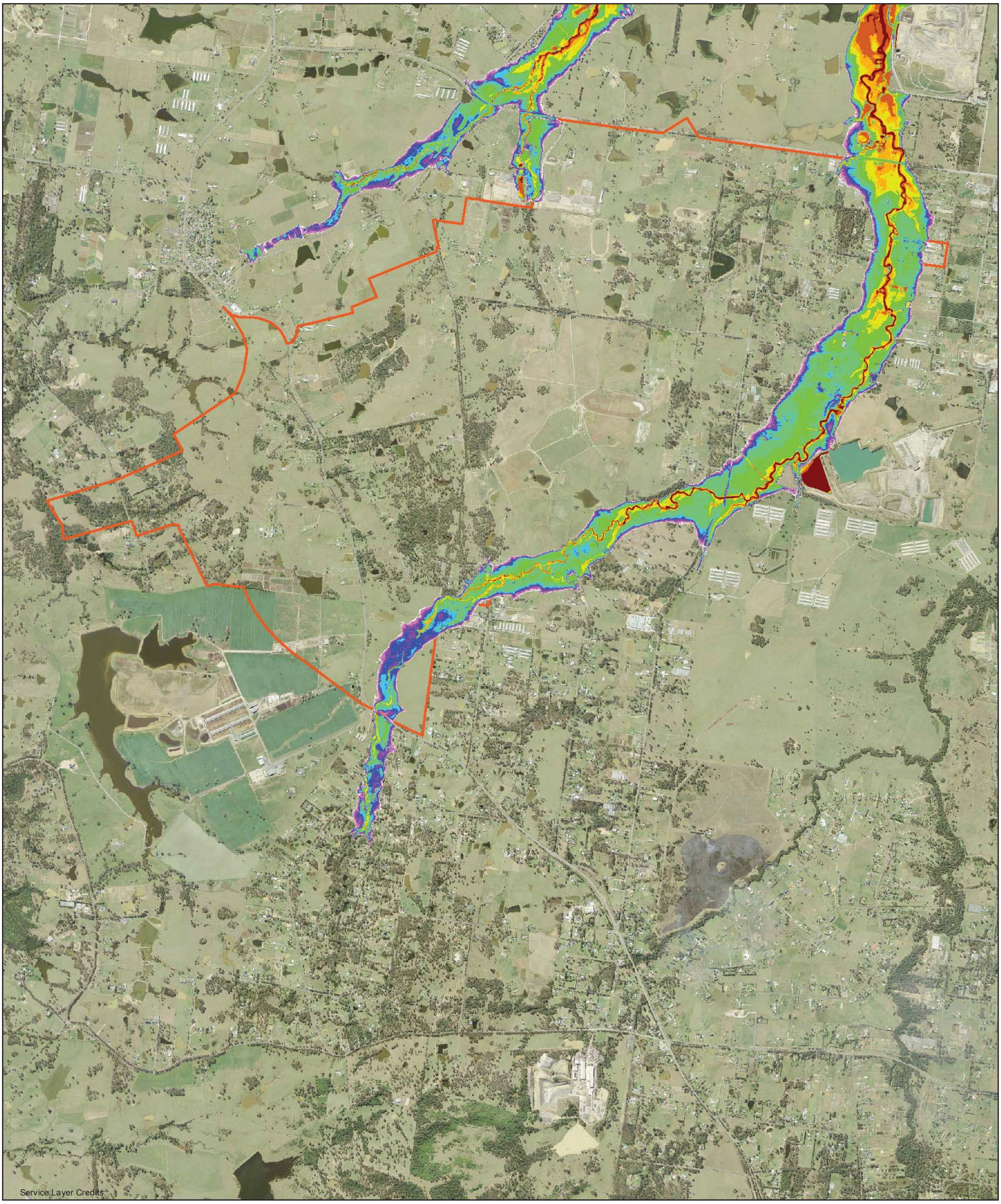
Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Data source: Data source: General Topo - NSW LPI DTDB 2012, Imagery - ESRI 2015 Created by: afoddy



LEGEND

Airport site	**Flood depth (m)**	0.6 - 0.8	2 - 2.5
	0.1 - 0.2	0.8 - 1	2.5 - 3
	0.2 - 0.4	1 - 1.5	3 - 4
	0.4 - 0.6	1.5 - 2	>4

Paper Size A3

0 250 500 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

GHD

Job Number 21-24265
Revision A
Date 05 Aug 2015

Existing flood depths
PMF

Figure 4-9

N:\AU\Sydney\Projects\21\24265\GIS\Maps\Deliverables\KBM.mxd [KBM: 54]

Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

Data source: Data source: General Topo - NSW LPI DTDB 2012, Imagery - ESRI 2015 Created by: afoddy

4.6 Watercourse geomorphology

The general topography of the airport site is undulating, with rolling, broad crested hills developed on the geology of the Wianamatta Group shales. These shales are generally composed of claystones, siltstones and carbonaceous shales with sparse sandstone lenses. As a result, the primary weathering products derived from the airport site will consist of fine grained sediments (clay and silt). Existing drainage from the airport site predominantly flows either easterly to the northerly flowing Badgerys Creek or northerly to Cosgroves Creek. Watercourses in the south–western section of the site drain to the westerly flowing Duncans Creek.

4.6.1 Stream orders

The Strahler stream order of mapped watercourses on the airport site is displayed in Figure 4-10. The majority of watercourses are first and second order, accounting for approximately 70% of the total length of the mapped watercourses on the airport site. Badgerys Creek attains the highest stream order on the site, being fourth order for most of its length along the eastern boundary of the airport site.

4.6.2 Watercourse types

A total of five watercourse geomorphic types were identified during the desktop and field assessment of the watercourses across the airport site. These are as follows:

- poorly defined drainage lines;
- steep confined watercourses;
- valley fill systems;
- channelised fill systems; and
- partly confined to unconfined, fine grained watercourses.

There are also numerous farm dams constructed along watercourses, accounting for 16 per cent of the mapped watercourse length on the airport site.

The mapped distribution of watercourse types and farm dams located on defined watercourses is shown in Figure 4-11 and their characteristics are described below.

Poorly defined drainage lines

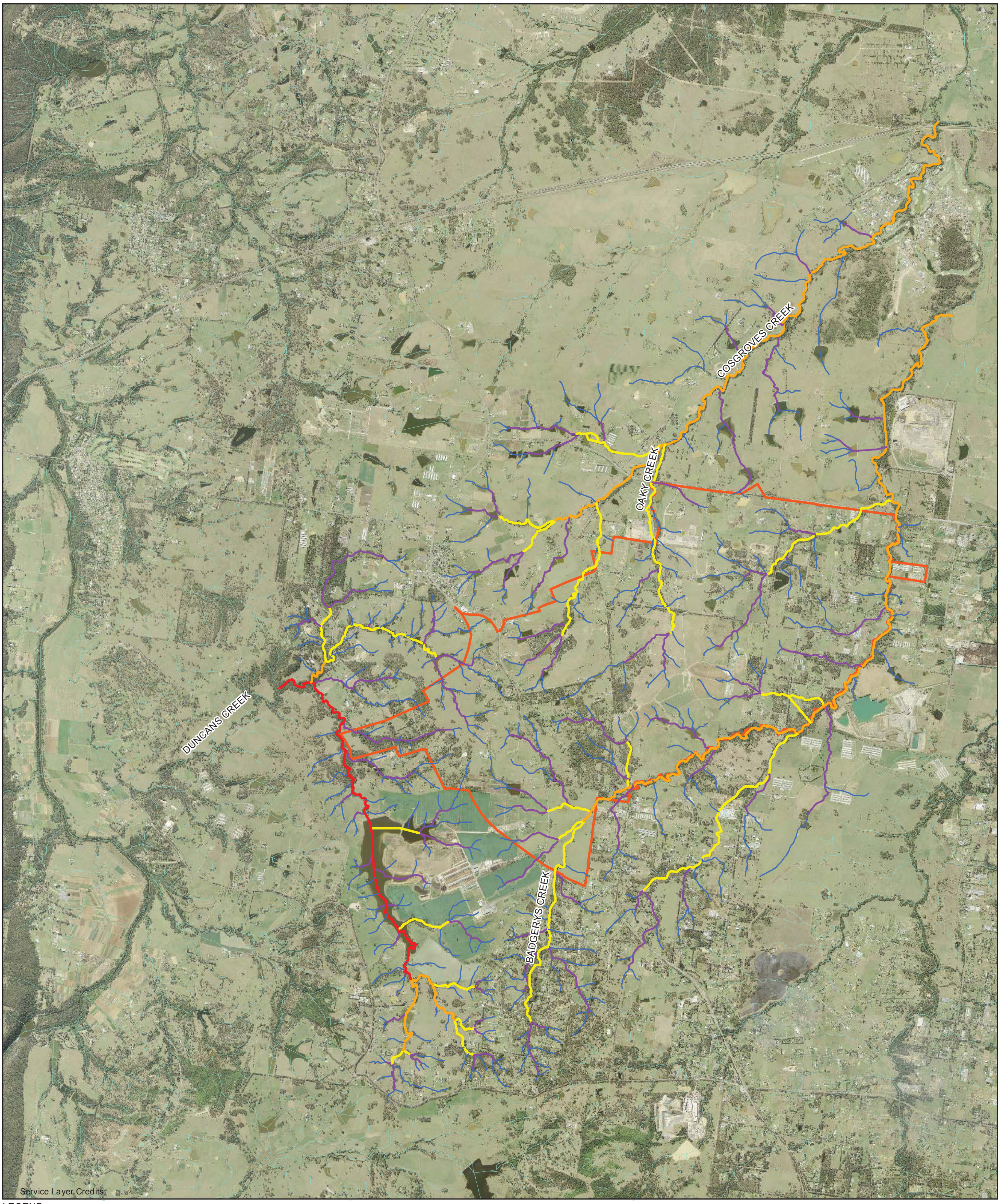
Poorly defined drainage lines are primarily located along first order watercourses within the airport site. These systems consist of a narrow depression set within a gently concave valley. There are no defined channels and as a result flow occurs via sheet flow during rainfall events. Typically, these watercourses are geomorphologically stable with no visible signs of erosion or instability.

Poorly defined drainage lines are predominantly first order watercourses and account for 31 per cent of the mapped watercourse length on the airport site.

Steep confined watercourses

This watercourse type is characterised by a steep gradient channel occupying a narrow v-shaped valley. The channel is laterally and vertically stable, although the channel may slowly erode the valley wall if it consists of weathered bedrock or colluvium. Floodplains are absent such that sediment storage is limited to small bars and benches.

This watercourse type is only located in the south-western section of the airport site and accounts for 3 per cent of the mapped watercourse length on the airport site.



LEGEND

Airport site	**Strahler Stream Order**		3
	Not classified		4
	1		5
	2		

Paper Size A3

0 380 760 1,520

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

Job Number	21-24265
Revision	A
Date	05 Aug 2015

Strahler stream order

Figure 4-10

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Data source: Data source: General Topo - NSW LPI DTDB 2012, Imagery - ESRI 2015 Created by: afoddy

LEGEND

- Airport site
- Watercourses

Type

- Not assessed
- Poorly defined drainage line
- Steep confined channel
- Valley fill
- Channelised fill
- Low to moderate sinuosity fine grained
- Dam

Paper Size A3

0 250 500 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

Job Number	21-24265
Revision	A
Date	05 Aug 2015

Watercourse type

Figure 4-11

N:\AU\Sydney\Projects\21\24265\GIS\Maps\Deliverables\KBM.mxd [KBM: 37]

Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

Data source: Data source: General Topo - NSW LPI DTDB 2012, Imagery - ESRI 2015 Created by: afoddy

Valley fill systems

Valley fill systems consist of flat valley floors with no defined channel such that the whole valley floor acts as a channel with valley margins as the banks. During high intensity rain events, water flows across the surface as sheet flow. As such, the flow energy is dissipated across the valley floor, resulting in the deposition of fine-grained suspended sediments. Low energies associated with flow dissipation lead to long term accumulation of sediments derived from upstream. If the valley floor is disturbed, a headcut may be initiated (refer also to *Channelised fill,* below*)*. This will form a continuous channel that will incise, enlarge and progress up stream with each subsequent flow event.

Valley fill systems are located throughout the study area along first to third order streamlines and account for 32 per cent of the mapped watercourse length on the airport site.

Channelised fill systems

Channelised fill systems exhibit a continuous channel that has incised, probably since European settlement, into valley fill through headcut retreat and channel expansion. The floodplains represent former valley fill surfaces and are generally flat and featureless. Channelised fill systems generally have an intermittent flow regime and do not usually retain surface water between flow events. Moderate stream energies generated during higher flow events can re-activate erosional processes. Headcuts will progress upstream and unprotected banks will erode. Most channels have incised to a point where all flows are contained within the channel such that the former fill surfaces are rarely inundated. Consequently, flow energy concentrates within the channel resulting in increased rates and occurrences of channel erosion.

Channelised fill systems have a scattered distribution along first to fourth order streamlines and account for 3 per cent of the mapped watercourse length on the airport site.

Partly confined to unconfined, fine grained systems

This waterway type exhibits a single channel set within floodplain deposits of alluvial silt and sand. For the most part, floodplains flank either side of the channel, however, in some locations the channel abuts the bedrock valley margin.

The channel generally holds water in isolated pools between flows. The channel itself is of low gradient and low energy such that sediment transported is predominantly limited to fine grained silts and clays in suspension. The low capacity channel allows overbank flows to be readily dissipated across the floodplain surfaces, activating flood channels and depositing fine grained sediments on the floodplain

Partly confined to unconfined, fine grained systems are located along third and fourth order watercourses and account for 15 per cent of the mapped watercourse length on the airport site.

4.6.3 Watercourse geomorphic condition

Both through and downstream of the airport site, Badgerys and Cosgroves Creeks display evidence of past and ongoing bed degradation. This is evidenced through the presence of active headcuts and over-steepened eroding banks. As a result, despite having a generally well-vegetated riparian zone, these watercourses are considered to be in moderate geomorphic condition.

As a result of past clearing, the construction of online dams and ongoing agricultural activities, tributaries of Badgerys and Cosgroves Creeks across the airport site are also considered to be in largely moderate geomorphic condition.

4.7 Related features

4.7.1 Ecology and groundwater

Based on available mapping discussed in the biodiversity assessment conducted for this EIS (GHD 2015), none of the watercourses on the site or immediately downstream is considered to be a groundwater dependent ecosystems (GDEs) that is reliant on the surface expression of groundwater (groundwater seepage). South Creek to the east and the Nepean River to the west are both mapped as this type of GDE.

Many farm dams and ponds on the airport site are considered to be artificial freshwater wetlands, some of which are in good condition and feature predominantly native plant species. They are associated with artificial dams and flooded depressions that have been formed by the construction of barriers across small drainage lines. Because they are not natural geomorphic features, they do not comprise a local occurrence of the Threatened Ecological Community (TEC) 'Freshwater wetlands on coastal floodplains'. Nonetheless, they are considered to have ecological value.

The biodiversity assessment found that the Australian Painted Snipe (*Rostratula australis*) bird may occur at wetlands and nearby flooded grassland within the airport site. Even though there are no local records of this birdspecies, and none were recorded during surveys, the species is cryptic. Wetlands at the airport site provide potential foraging and breeding habitat for this species.

Other receptors in the catchment include ecologically sensitive riparian vegetation which is reliant on occasional flooding.

An aquatic ecology assessment found the macroinvertebrate communities downstream of the site to be in generally poor health, though the sampling undertaken occurred in a limited season. Fish communities identified were found to be "indicative of a disturbed habitat". Fish habitat downstream of the site was found to be mostly minimal, with some reaches of some moderate habitat present.

5. Construction impacts

5.1 Flooding and waterlogging

Stage 1 of the airport would be constructed over a period of approximately ten years. During this timeframe, the likelihood of a large rainfall event occurring is high. The historical record indicates that the likelihood for large rainfall events is skewed towards summer occurrence (refer also to Section 4.3). It is possible that impacts could occur both on the site, with general disruption to construction activities, and off the site, with impacts to surrounding properties and watercourses.

As the site is constructed and impervious area is added, the volume of runoff from the site would increase due to a reduction in ground surface infiltration. Without mitigation, this would result in increased peak flows from the site and the potential for associated flooding and geomorphological impacts downstream. However, detention basins have been incorporated into the site design to mitigate the increase in runoff, reducing offsite impacts of potentially increased peak flows. The detention basins would be utilised during the construction phase and subsequently, following construction, they would be used to manage operational stormwater.

The airport site will include substantial and large-scale earthworks which will modify drainage direction and overland flow paths, changing the nature of flooding on site. Without progressive introduction of formal drainage designed to cater to the new site conditions, there is potential for disruption to construction activities due to flooding and waterlogged soils, as well as the potential for downstream flooding.

5.2 Mobilisation of soils

Impacts of increased sedimentation are discussed in detail in the surface water quality assessment report prepared for this EIS (GHD, 2015) but are mentioned here for their potential to change surface water flows.

There is potential for large quantities of sediment to be directed into the network of temporary drainage as it is progressively constructed. If not appropriately managed, this would cause blockage of the on-site stormwater management network, reducing its effectiveness and increasing the likelihood of flow breakouts and overland flow paths with the effect of causing on-site flooding or flooding downstream.

5.3 Watercourse geomorphology

The primary impact on watercourse geomorphology during the Stage 1 construction will be the loss of natural drainage lines and watercourses within the construction footprint (Figure 5-1). The total length of mapped watercourses within the Stage 1 construction footprint is approximately 36.5 km, predominantly consisting of first and second order watercourses (Table 5-1). In addition, approximately 4.4 km of third order watercourses lie within the Stage 1 construction footprint.

Table 5-1 Length of watercourses by stream order within the Stage 1 construction footprint

Stream Order	Length (km)
1	22.2
2	9.9
3	4.4

The construction footprint for the longer term development is not yet well defined. However, further expansion of the airport facilities is expected to occur between the Stage 1 construction area and Badgerys Creek. This expansion will subsume additional watercourses, primarily first and second order tributaries of Badgerys Creek.

Without appropriate erosion and sediment controls, the disturbance as a result of construction may also result in higher rates of offsite sediment generation, leading to sedimentation within pools along watercourses adjoining and downstream of the airport site. However, it is expected that construction practices would be in accordance with current erosion and sediment control standards and the offsite movement of sediment would be minimal. Hence, the risk of significant pool sedimentation is considered low.

5.4 Groundwater seepage

Groundwater seepage is expected during construction and will be required to be collected and managed, either by discharge back to the environment and/or removal offsite and disposal at an appropriately licensed treatment facility. Further details of the activities expected to generate seepage are provided in the groundwater assessment prepared for this EIS (GHD, 2015).

If treated water is discharged to the environment, there are a range of potential water quality impacts that could occur which are discussed separately in the surface water quality assessment. Whether treated or undertreated, there is also potential for impact on downstream flows and associated ecology if the volume of discharge disrupts the natural flow regime downstream of the point of discharge. The groundwater seepage disposal strategy is still to be determined, however the groundwater assessment determined that seepage volumes are expected to be low.

5.5 Construction water use

It has been estimated (refer to the project description) that construction would require, on average, 1.3ML of water per day during bulk earthworks.

Additional high water demand activities would be associated with the asphalt and concrete batching plants.

It is envisaged that within the earthworks footprint, temporary basins would be constructed to catch any runoff for reuse in the earthworks. This would be insufficient to meet the estimated 1.3 ML/day requirement for the bulk earthworks. At other times, potable would be used to supplement construction water requirements. To avoid constraints in potable water supply capacity, potable water would be extracted from the network in off peak times and used to fill the temporary basins for later use.

There are two existing potable water supply pipes located adjacent to the site. The first is located along Elizabeth Drive, the second on The Northern Road. Connection points would be determined in consultation with Sydney Water Corporation. The Contractor may also investigate alternative water sources, and seek appropriate approvals for their use.

LEGEND

- Airport site
- Earthworks area
- 1
- 2
- 3

Paper Size A3

0 250 500 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

Job Number	21-24265
Revision	A
Date	05 Aug 2015

Stage 1 earthworks

Figure 5-1

N:\AU\Sydney\Projects\21\24265\GIS\Maps\Deliverables\KBM.mxd [KBM: 74]

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Data source: Data source: General Topo - NSW LPI DTDB 2012, Imagery - ESRI 2015 Created by: afoddy

6. Operational impacts

6.1 Stage 1 development

6.1.1 Impacts on hydrology and flooding

Identified changes and potential implications

The establishment of the Stage 1 Development would result in major modification to existing flow paths and catchment boundaries with resultant potential impacts on surface water flows and the receiving watercourses.

In general, as part of the Stage 1 works, a portion of the airport site draining towards the Oaky and Cosgroves Creeks' catchments to the north would be diverted south towards Badgerys Creek whilst a portion of the airport site draining to Badgerys Creek would be diverted to Duncans and Oaky Creeks.

Under the existing case, a tributary of Badgerys Creek crosses Elizabeth Drive around 350 metres west of the main crossing and joins with Badgerys Creek downstream of Elizabeth Drive. Under Stage 1, the crossing would be removed and the tributary catchment at Elizabeth Drive diverted into Basin 1 and then to Badgerys Creek. A summary of changes to catchment areas is provided in Table 6-1 based on Geographical Information System (GIS) area calculations.

Table 6-1 Catchment area comparison between existing and Stage 1

Location	Catchment area (existing) (ha)	Catchment area (Stage 1) (ha)	% impervious (existing)	% impervious (Stage 1)
Badgerys Creek at Elizabeth Drive	2,052	2,362 ↑	12%	14%
Oaky Creek at Elizabeth Drive	361	292 ↓	10%	49%
Cosgroves Creek at Elizabeth Drive	536	603 ↑	14%	20%
Badgerys Creek at South Creek	2,799	2,800	12%	14%
Cosgroves Creek at South Creek	2,163	2,148 ↓	14%	21%
Duncans Creek at Nepean River	2,379	2,385 ↑	14%	15%

The table shows that there would be, as a result of the Stage 1 development:

- a net increase in catchment area draining to Badgerys Creek at Elizabeth Drive and a minor net increase in percentage imperviousness of the resulting catchment area;
- a net decrease in catchment area draining to Oaky Creek due to diversions to Badgerys Creek and a substantial net increase in catchment percentage imperviousness;
- a net increase in catchment area draining to Cosgroves Creek at Elizabeth Drive and a moderate net increase in catchment imperviousness;
- a negligible change in catchment for Badgerys Creek at South Creek;
- a net decrease in catchment area draining to Cosgroves Creek at South Creek and a moderate net increase in catchment imperviousness; and
- a negligible net increase in catchment area draining to Duncans Creek and negligible increase in catchment percentage imperviousness.

Under Stage 1, bulk earthworks including extensive cutting and filling across the site to level it would result in changes to storage characteristics, as would the removal of the farm dams. The model results account for these changes with respect to the representation of changes to catchment slope, boundary and rainfall losses.

The airport would change surface run-off conditions in the catchments it intersects, which may also create minor incidental losses associated with evaporative changes.

A decrease in catchment area, dependent on impervious fraction, would tend to decrease flows downstream and conversely, in the case of an increase in catchment area, would tend to increase flows downstream.

The increase in catchment imperviousness would, without intervention, tend to increase the peak flows and the potential to influence timing of flows by causing flows to peak earlier.

The effect of the change in catchment area, whether major or minor, is dependent on the changes in flows and hydraulics that result from the changes. The changes in flow are discussed later in this report.

Design control measures

Detention basins are proposed at most site discharge points for the dual purpose of treating water quality and mitigating potential increases in peak flows (refer to Figure 3-3). Where no basin is proposed, this is because it was not deemed necessary during design development. In general, detention basins used for construction would be reused in the longer term, though only a portion of the eventual longer term water capacity would be provided in the initial development stage.

The proposed storage basin volumes are presented in Table 6-2, together with the percentage size of the basin in Stage 1 compared to that proposed in the longer term.

Table 6-2 Detention basin attenuation volume

Basin Number	Initial basin volume (m^3) compared to longer term volume (%)
1	64,000 (80%)
2	8,100 (30%)
3	15,900 (30%)
4	10,400 (20%)
5	*Not included in Stage 1 and 65,000 in longer term*
6	75,000 (100%)
7	82,000(100%)
8	41,000 (100%)

Predicted impacts

Comparison of flows under existing and Stage 1 conditions for a 1 year ARI and 100 year ARI events are provided in Figure 6-1 to Figure 6-10. The figures show, at the various locations indicated in Figure 4-3:

- the existing flows;
- the flows entering the detention basins (where there is a detention basin proposed); and
- the flows leaving the detention basin or point of discharge.

The plots show flows for the critical duration at each location. Plots for a short and a long duration storm are included in Appendix B.

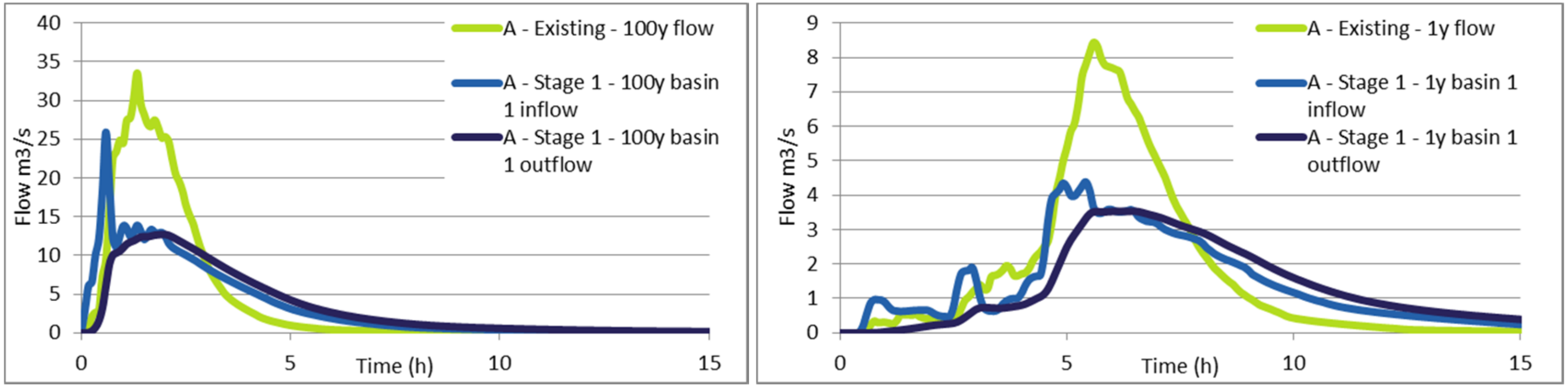


Figure 6-1 Location A at Basin 1, comparison of existing and Stage 1 flows

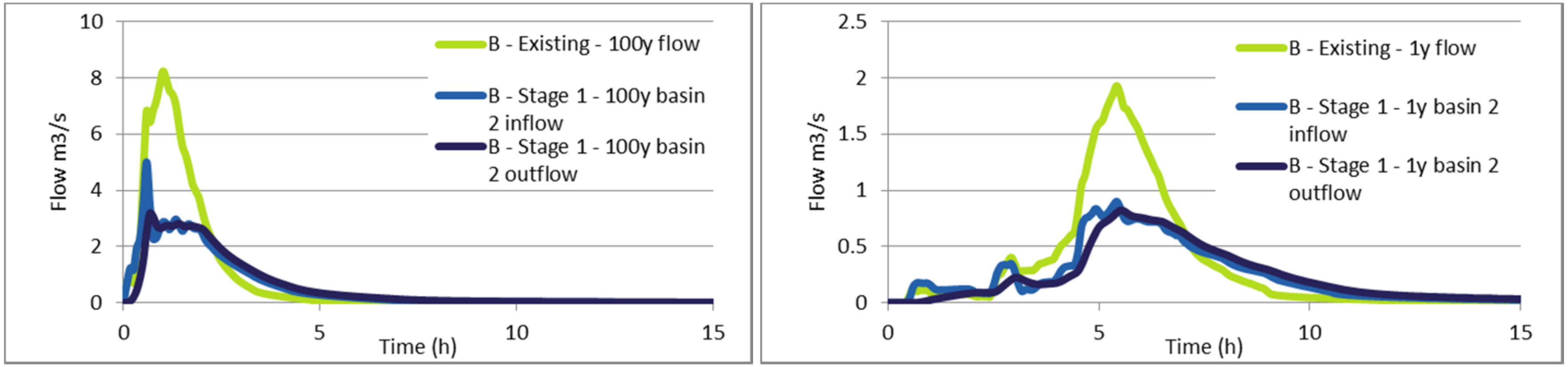


Figure 6-2 Location B at Basin 2, comparison of existing and Stage 1 flows

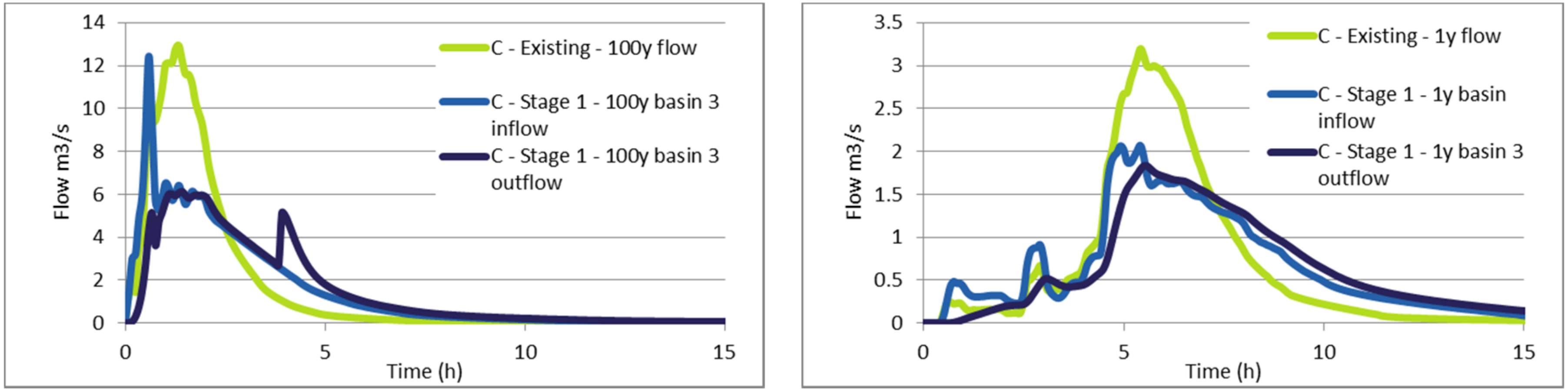


Figure 6-3 Location C at Basin 3, comparison of existing and Stage 1 flows

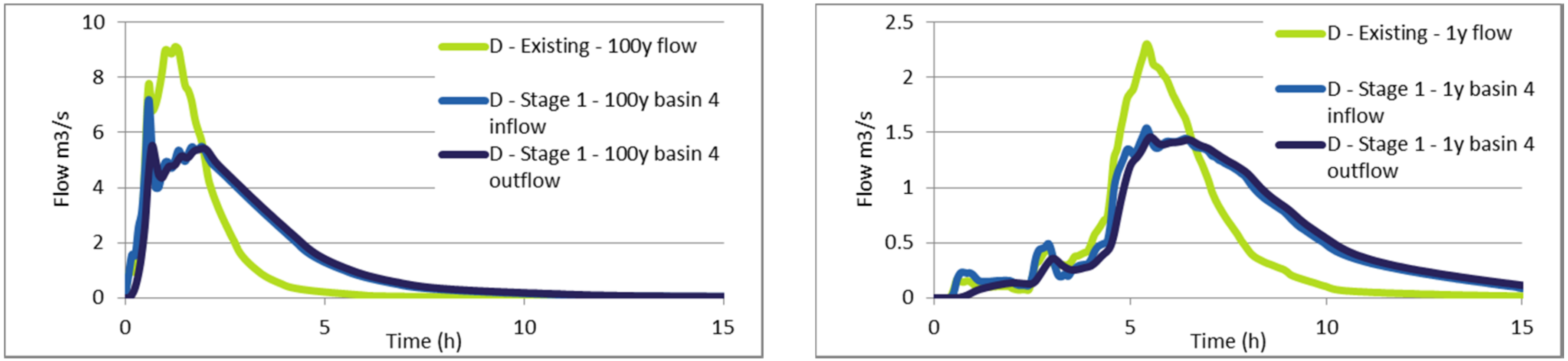


Figure 6-4 Location D at Basin 4, comparison of existing and Stage 1 flows

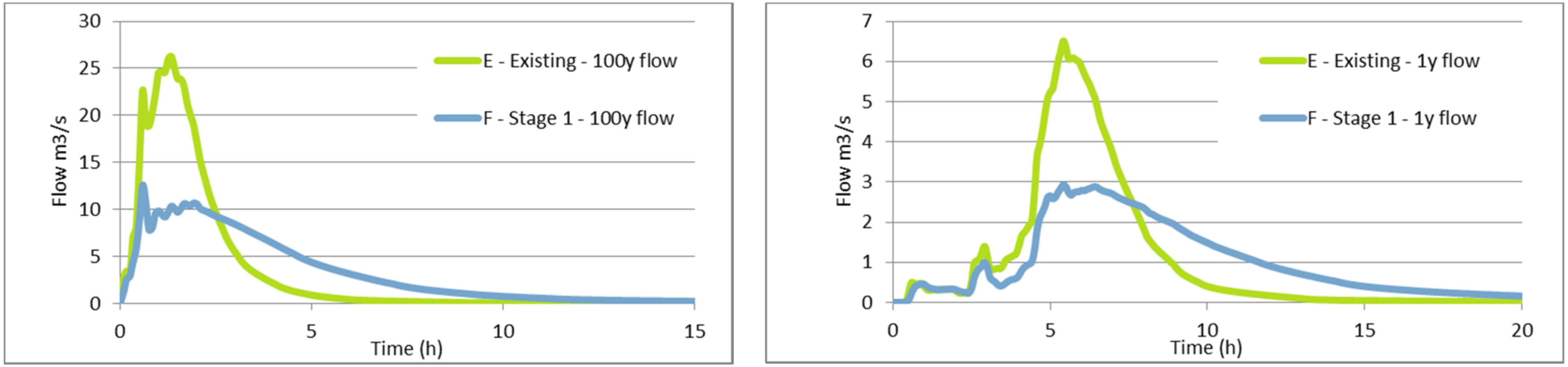


Figure 6-5 Location E and F, comparison of existing and Stage 1 flows (no basin proposed)

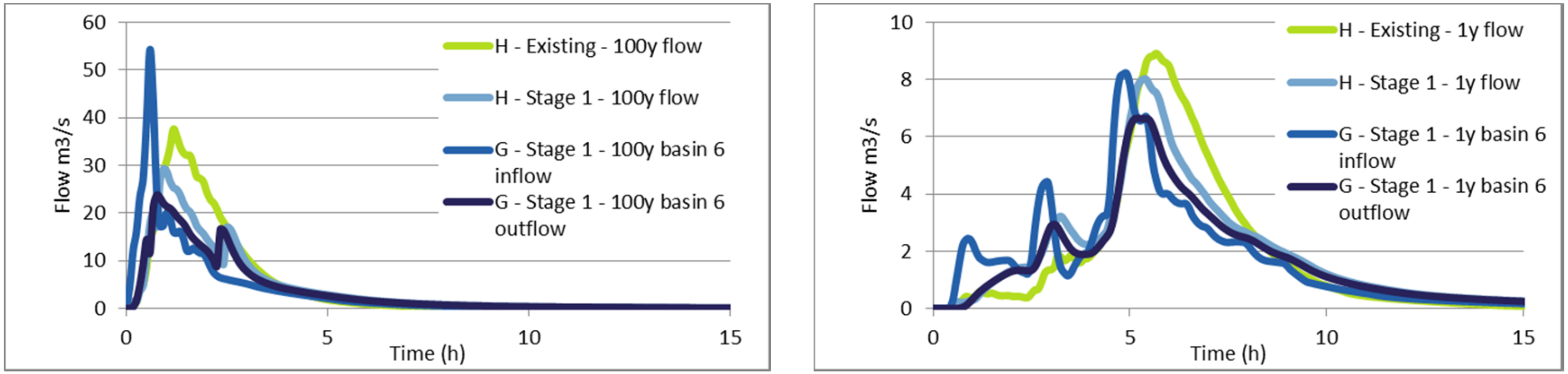
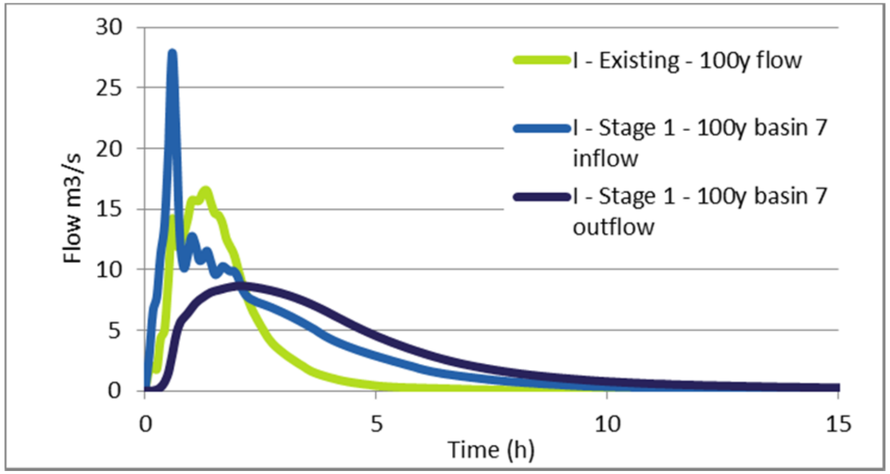


Figure 6-6 Locations G and H, comparison of existing and Stage 1 flows



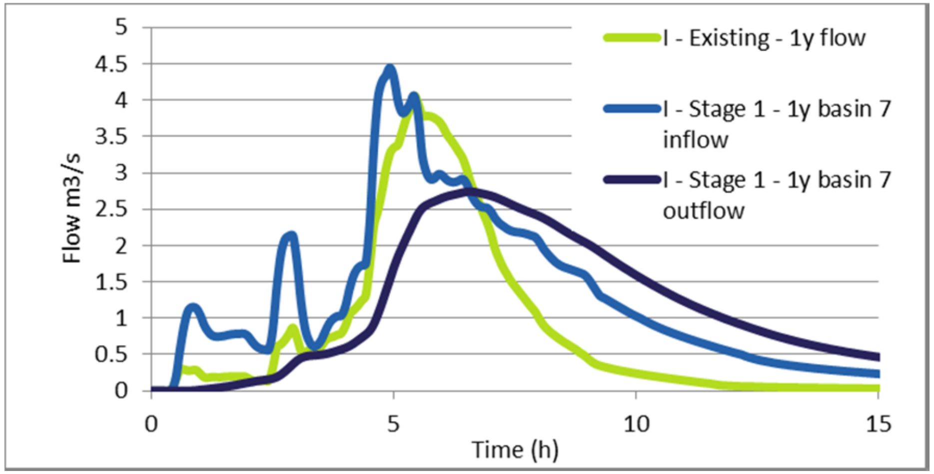
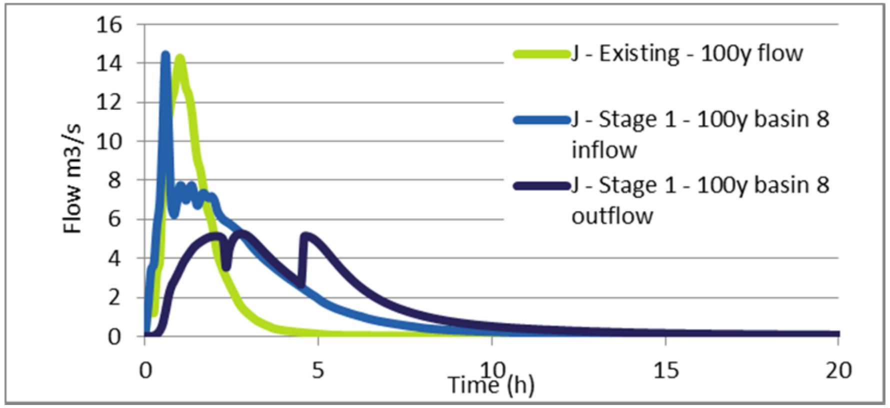


Figure 6-7 Locations I, comparison of existing and Stage 1 flows



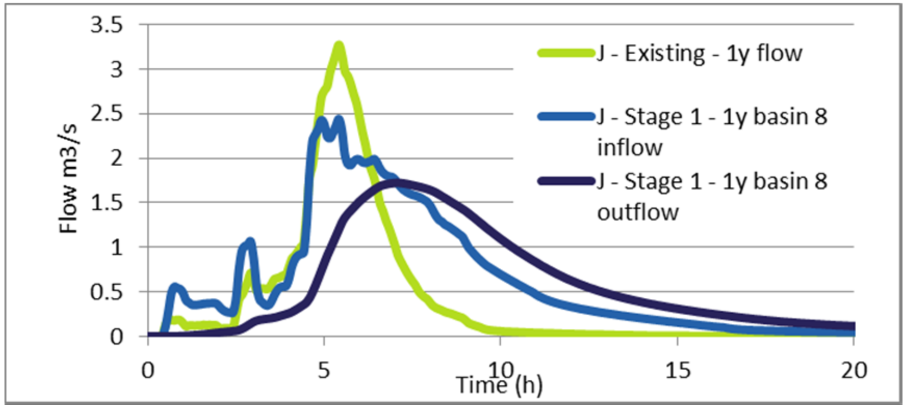


Figure 6-8 Locations J, comparison of existing and Stage 1 flows

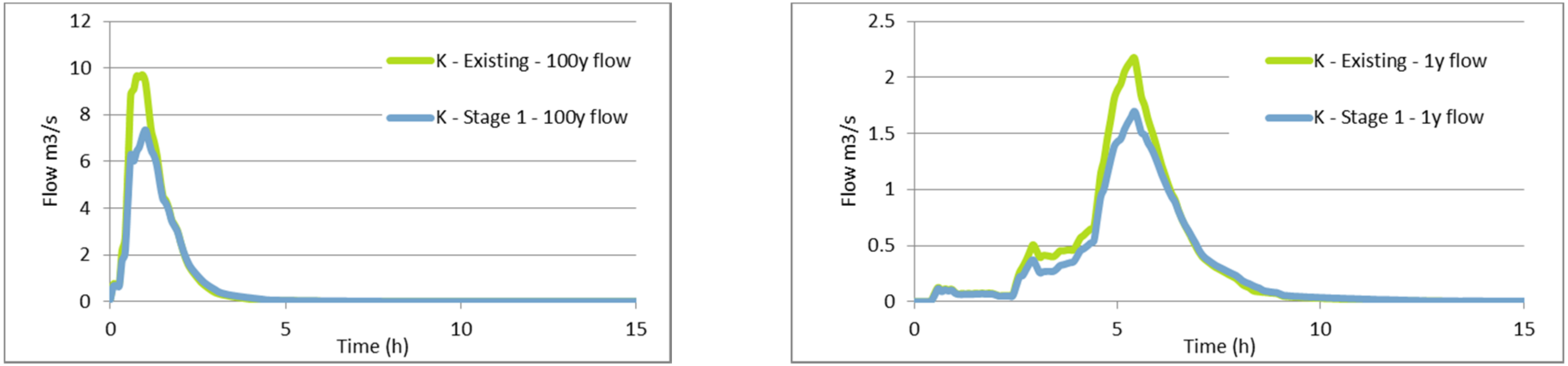


Figure 6-9 Location K, comparison of existing and Stage 1 flows

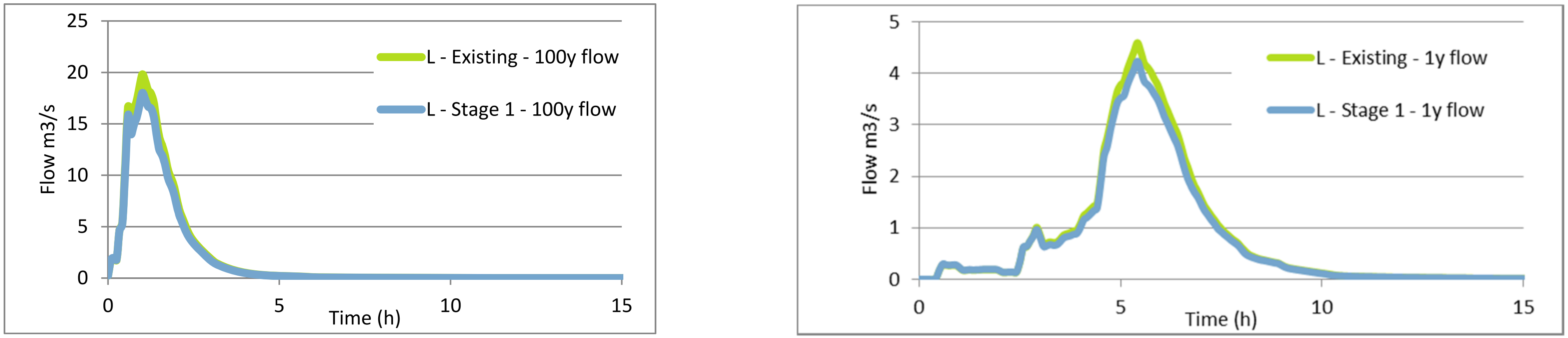


Figure 6-10 Location L, comparison of existing and Stage 1 flows

It is noted that, due to changes in catchment configuration between the existing case and Stage 1, some of the reported locations vary slightly between the two scenarios.

Where the existing flows are indicated to be greater than the flows entering the basins under Stage 1 (basins 1 to 4), this is generally because a portion of the total catchment flow would bypass the basin in Stage 1. The basins attenuate the flows substantially, to compensate for the volume of un-attenuated flows bypassing the basins. This effect would be particularly notable in Stage 1 for the flows discharging to the southern portion of the site. The management of surface water would need to be developed further during the Stage 1 detailed design process to refine the sizing of the basins.

In the south-east portion of the site, a moderately sized area of the catchment draining under existing conditions to Badgerys Creek would be modified to drain north, resulting in less flow to Location F under Stage 1.

For the basins 6 to 8, there is some variation in discharge between existing and Stage 1 conditions. The basins are generally effective at mitigating peak flow increases from the site in the 100 year event and 1 year event.

The plots for location J and K show the predicted flows into tributaries of Duncans Creek. Marginal decreases are expected for the critical duration storm events. However, a small potential increase in flow is predicted at location K for a 100 year ARI short duration event. Propagation of increased flooding or change in watercourse stability is expected to be limited to localised areas around the point of discharge. However, as there are dwellings in the upper reaches of this tributary, mitigation measures need to be considered.

A review of the plots in Appendix B, indicates that for small (1 year ARI) short duration events, the increase in impervious area in Stage 1 influences the peak more than for longer duration events, with some evidence of a potential increase in flows at the point of discharge (for example, at location 6).

It is possible that localised scour and erosion at the points of discharge may occur and mitigation measures to address this are discussed in Section 8 of this report.

The influence of the current Stage 1 design on downstream hydraulics is assessed below and in Section 6.1.2.

Impacts on low flows and watercourse flooding

The impacts of the proposed Stage 1 airport on flood depths are shown in Figure 6-11 to Figure 6-13. In the figures, a positive value indicates an increase in flooding in Stage 1 over the existing case, and a negative value indicates a decrease. Extents of flooding in Stage 1 are included in Appendix C.

Oaky and Cosgroves Creeks

In a 1 year ARI event, flood impacts downstream of Elizabeth Drive include decreases in flow depth of up to around 50 mm in overbank areas. Within the channels, increases in level are within 100 mm of existing flow depth, except for a 200 m reach of Oaky Creek immediately downstream of Elizabeth Drive and upstream of its confluence with Cosgroves Creek where increases in flow depth of up to 250 mm are predicted.

Increases in depth on Cosgroves Creek upstream of the site are less than 10 mm and are considered relatively minor.

For a 5 year flood event, a decrease in flood level (though within 100 mm of existing) is predicted downstream of the airport, except in the case of the 200 m reach of Oaky Creek noted above. For the 100 year flood event, a decrease in flood level is predicted. The variations in results for different ARI events reflect the influence of the basins which varies depending on the magnitude and timing of flows.

The dwellings identified as being located in, or within close proximity of, the 100 year ARI flood event would not experience an increase in flood levels based on the findings of this assessment.

Badgerys Creek

In a 1 year ARI event, flow depths downstream of Elizabeth Drive are predicted to decrease, but generally by less than 120 mm.

The exception is for the tributary of Badgerys Creek that joins Badgerys Creek approximately 300 metres downstream of Elizabeth Drive under existing conditions. Because that creek is proposed to be diverted to Basin 1 upstream of Elizabeth Drive and the stream extent within the site would be removed, there would be little to no flow in the reach of creek downstream of Elizabeth Drive. Measures to address the changed flow condition are discussed in Section 9.

Decreases in water levels along Badgerys Creek of up to around 150 mm would be expected in the critical duration event, generally due to the influence of the basins.

In a 100 year ARI event, the modelling shows some increases in flood level in Badgerys Creek between Basin 2 and Basin 3. This is due to the 3D design model incorporating infrastructure at this location from an earlier version of the concept design. That design version was subsequently superseded and therefore no significant impact on flooding at this location is predicted, other than localised changes at the point of discharge.

No worsening of flooding would therefore be expected to occur in surrounding dwellings and infrastructure during Stage 1 based on the proposed design.

Effectiveness of the basins

The current basin designs result in either a reduction in flows to the downstream creeks, with associated potential impacts on stream stability and ecology, or an increase in peak flows and change in timing at the point of discharge and on a limited reach of Oaky Creek, with associated potential flood and watercourse stability impacts.

There is some vegetation in the riparian corridors outside the site that is considered reliant on occasional flooding based on the biodiversity assessment. Discussion with the ecology team indicated that small changes in flows would be unlikely to influence the vegetation, provided that the vegetation still experienced occasional flooding. This is expected to be the case and the impact on this vegetation would be low as a result of the proposed changes. The exception to this finding is the tributary of Badgerys Creek discussed in the preceding section. Threatened ecological communities have not been mapped outside the site as part of the biodiversity assessment, but there is evidence of some remnant native vegetation along this reach of creek which would be reliant on occasional flooding and would be impacted under the current proposals.

The macroinvertebrate surveys found that the numbers of macroinvertebrates sensitive to changes in flow downstream of the site would generally be low and the influence of minor fluctuations in flow on macroinvertebrates is expected to be limited.

Where increases in flow discharging from the basins are predicted, no major impacts to flood prone residences are predicted, though some increases in flow depths are indicated.

No major impacts to creek stability are predicted, with the exception of a reach of Oaky Creek. Mitigation measures are discussed in Section 8.

LEGEND

Airport site	**Flood depth difference (m)**		
<-2	-1 - -0.5	-0.1 - 0	0.3 - 0.5
-2 - -1	-0.5 - -0.3	0 - 0.1	0.5 - 1
	-0.3 - -0.1	0.1 - 0.3	1 - 2
			>2

Paper Size A3

0 250 500 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

Job Number	21-24265
Revision	A
Date	05 Aug 2015

Flood depth impact - Existing and Stage 1
1-year ARI event

Figure 6-11

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Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Data source: Data source: General Topo - NSW LPI DTDB 2012, Imagery - ESRI 2015 Created by: afoddy

LEGEND

Airport site

Flood depth difference (m)

- <-2
- -2 - -1
- -1 - -0.5
- -0.5 - -0.3
- -0.3 - -0.1
- -0.1 - 0
- 0 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- >2

Paper Size A3

0 250 500 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

Job Number 21-24265
Revision A
Date 05 Aug 2015

Flood depth impact - Existing and Stage 1
5-year ARI event

Figure 6-12

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Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Data source: Data source: General Topo - NSW LPI DTDB 2012, Imagery - ESRI 2015 Created by: afoddy

LEGEND

- Airport site
- **Flood depth difference (m)**
  - <-2
  - -2 - -1
  - -1 - -0.5
  - -0.5 - -0.3
  - -0.3 - -0.1
  - -0.1 - 0
  - 0 - 0.1
  - 0.1 - 0.3
  - 0.3 - 0.5
  - 0.5 - 1
  - 1 - 2
  - >2

Paper Size A3

0 250 500 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

Job Number	21-24265
Revision	A
Date	05 Aug 2015

Flood depth impact - Existing and Stage 1
100-year ARI event

Figure 6-13

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Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

Data source: Data source: General Topo - NSW LPI DTDB 2012, Imagery - ESRI 2015 Created by: afoddy

In summary, there is a degree of variation in how the basins respond to different storm durations and magnitudes which results in a range of potential flow outcomes. The attenuation of the incoming flows by the basins indicates that a basin strategy can be used to manage the increase in flow peaks and impacts to flood peak timing. Hence, it is expected that the basin strategy would mitigate the major impacts of changes to surface water from the development, though refinement of the strategy during design development would be required to reduce impacts to negligible levels and address specific more substantial impacts on Oaky Creek and the identified tributary of Badgerys Creek.

Surplus recycled water

It is proposed that airport wastewater be treated on-site. Sludge would be transported off-site, and the treated water re-used for restrooms, washing of vehicles and aircrafts, cooling towers and landscaping. It is possible that availability of recycled water would exceed demand, in which case an alternative use for the surplus recycled water would need to be sought. A strategy would be developed that may include consideration of options such as on-site subsurface irrigation. Any irrigation scheme would need to be developed to ensure no significant downstream flow impacts, particularly where runoff of additional irrigation water could alter the natural stream flow patterns.

Groundwater discharge

Groundwater seepage into cuts and subsurface basement areas would be required to be kept separate from surface water, treated and discharged back to the environment and/or removed offsite to an appropriately licensed treatment facility. This would present a long term (operational) water quality management and disposal issue. If not managed appropriately, it is possible that groundwater could interact with surface water and pose a risk to downstream water quality (discussed in a separate report) or interrupt the flow regime. However, groundwater seepage is not considered to be likely in significant volumes and discharge of high volumes into the surface water system would not be required.

6.1.2 Impacts on watercourse geomorphology

Changes to catchments and impervious areas have the potential to impact indirectly on the channel morphology of watercourses downstream of the airport site. In particular, catchment changes that result in increasing downstream flow durations and/or increased hydraulic shear stress can exacerbate erosion of the bed and banks of watercourse channels downstream of the airport site.

Figures D-1 to D-6 (Appendix D) display discharge hydrographs derived from the hydraulic model for the reporting location downstream of Elizabeth Drive along both Cosgroves and Badgerys Creeks. The hydrographs are for the modelled 1, 5 and 100 year ARI events for existing, Stage 1 and longer term conditions. These indicate that the modelled flow event durations for the Stage 1 conditions are similar to those of existing conditions along both watercourses downstream of the airport site.

Additionally, with the exception of the 1 year ARI event along Cosgroves Creek, modelled peak discharges reduce in response to the Stage 1 Development. The hydrograph for the 1 year ARI event along Cosgroves Creek indicates a slight increase in peak discharge from approximately 16 m^3/s to 18 m^3/s. This is considered to be a minor increase and is unlikely to lead to any measurable morphological impact along Cosgroves Creek downstream of the airport site. Hence, as flow durations for the modelled events under Stage 1 conditions remain similar to the existing conditions and peak discharges typically reduce, the potential for significant impacts to the morphology of watercourses downstream is considered low.

To further explore the spatial distribution of potential morphological impacts to watercourses adjoining and downstream of the airport site, the modelled shear stress distributions for the Stage 1 and existing conditions were compared. Figures C-8 to C-10 (Appendix C) display maximum modelled shear stress differentials between the Stage 1 Development and the existing conditions for the 1, 5 and 100 Year ARI events. These indicate that changes in shear stress values as a result of the Stage 1 Development largely remain within – 5 to +5 N/m^2 of those in the modelled existing results along Cosgroves Creek and typically reduce compared to the existing levels along Badgerys Creek.

To provide context, Figures C-1 to C-3 (Appendix C) also display the modelled maximum shear stress distributions for existing conditions. These indicate that maximum shear stress values under existing conditions along Cosgroves and Badgerys Creek are typically less than 100 N/m^2, with very localised higher values in the range of 100 to 200 N/m^2 during the 100 Year ARI event.

Based on a synthesis from various studies by Blackham (2006), shear stress thresholds for the disturbance of vegetation and surface erosion lie in the range of 100 to 200 N/m^2, varying largely by vegetation type. Given the modelled shear stress changes under the Stage 1 Development are typically at least less than 5% of this threshold range, the Stage 1 Development is unlikely to result in widespread and significant further exceedances of thresholds for the disturbance of vegetation and surface erosion along watercourses adjoining and downstream of the airport site. This further supports the conclusion that the Stage 1 Development will have a low impact on the morphology of watercourses adjoining and downstream of the airport site.

However, the results indicate higher increases in modelled Stage 1 shear stress values along a reach of Oaky Creek extending approximately 100 to 200 metres downstream from Elizabeth Drive depending on the flow event modelled. Typically, these increases are in the range of 10 to 20 N/m^2 for all events modelled. Existing modelled 100 year ARI event shear stress values lie between 20 to 60 N/m^2 (Figures C-1 to C-3 Appendix C) and with the increases, the thresholds for the disturbance of vegetation and surface erosion are approached. It is therefore considered that there is a potential for the current form of the proposed Stage 1 Development to result in an increase in scour and erosion along this reach of Oaky Creek immediately downstream of Elizabeth Drive.

The results show elevated increases in modelled shear stress values along sections of Badgerys Creek between Basin 2 and Basin 3. However, as a result of changes to the land use plan (refer to the discussion in section 6.1.1), there is no significant impact on flood flow hydraulics predicted at this location.

6.1.3 Impacts on water quantity from wastewater

An estimated 2.5 ML of wastewater per day would be generated during operation of the Stage 1 Development. Wastewater would be reticulated to a treatment facility before being recycled or irrigated at the airport site. Recycled water could be utilised for a range of potential uses.These include the use of reclaimed water in maintenance of plant and infrastructure, industrial cooling processes or landscaping and also in irrigation. Irrigation water has the potential to affect the quantity of flow into receiving waterways depending on the means of application and irrigation technology.

Any irrigation of reclaimed water would likely occur on land previously disturbed by the construction of the Stage 1 Development (the construction impact zone).

The irrigation area would be designed and operated in accordance with the risk framework and management principles contained in the National Guidelines on Water Recycling (Environment Protection and Heritage Council 2006) and the Environmental guidelines: Use of effluent by irrigation (NSW DEC 2004). The following would apply with respect to water quantity (effects on soils are discussed in other chapters of this EIS).

- The irrigation area would be delineated based on the expected rate of irrigation and the drainage characteristics of the receiving soil.
- The irrigation area would be designed to include capacity to store treated water for the duration of typical wet weather events.
- The rate of irrigation would be optimised to avoid the ponding of reclaimed water or creation of excess surface water runoff.
- Soil and groundwater conditions would be monitored to identify and correct trends in soil salinity, sodicity or other potential effects of irrigation.

It is considered that this approach would avoid impacts to the patterns of flow in the downstream environment.

6.2 Longer term development

6.2.1 Impacts on hydrology and flooding

Identified changes and potential implications

As with Stage 1, there would be a change in the on-site catchment area in the longer term as a result of the proposed development. A summary of changes to catchment areas between the existing and longer term developments is provided in Table 6-3. The longer term catchment areas and changes in impervious areas are based on comparison against the existing case absent of any airport development. They incorporate changes which would occur in Stage 1 as well as the subsequent longer term effects.

Table 6-3 Catchment area comparison between the existing environment and the longer term development

Location	Catchment area (existing) (ha)	Catchment area (longer term) (ha)	% impervious (existing)	% impervious (longer term)
Badgerys Creek at Elizabeth Drive	2052	2394 ↑	12%	30%
Oaky Creek at Elizabeth Drive	361	289 ↓	10%	53%
Cosgroves Creek at Elizabeth Drive	536	600 ↑	14%	29%
Badgerys Creek at South Creek	2799	2831 ↑	12%	27%
Cosgroves Creek at South Creek	2163	2142 ↓	14%	24%
Duncans Creek at Nepean River	2379	2360 ↓	14%	17%

The table shows that there would be substantial increases in impervious areas for all catchments. Changes in catchment area are relatively small, though the overall impact of these in terms of the flow patterns that result is examined further in this Section.

The increase in catchment area (where applicable) and in catchment imperviousness would, without intervention, tend to increase the peak flows and have the potential to influence timing of peak flows. Flows may peak earlier, though later peaks could also occur.

A decrease in catchment area, dependent on impervious fraction, would tend to decrease flows downstream. In the longer term, the effects could also create a transfer of water from the Water Sharing Plan's Wallacia Weir Management Zone (in which Duncans Creek is located) to the Upper South Creek Management Zone (in which Badgerys, Oaky and Cosgroves Creeks are located). These zones are discussed further in section 2.2

The increase in imperviousness for the longer term development is, in some catchments, a further increase from that proposed in Stage 1.

Design control measures

An extension of the Stage 1 detention basins is proposed together with provision of an additional detention basin in the longer term.

The proposed storage basin volumes in the longer term are presented in Table 6-4.

Table 6-4 Longer term detention basin attenuation volume

Basin Number	Basin volume (m^3)
1	80,000
2	27,000
3	53,000
4	82,000
5	65,000
6	75,000
7	82,000
8	41,000

Predicted impacts with design control measures in place

Comparisons of flows under existing and longer term conditions for a 1 year ARI and 100 year ARI events are provided in Figure 6-14 to Figure 6-23. The figures show, at the various site discharge points indicated in Figure 4-3:

- the existing flows;
- the flows entering the detention basins (where there is a detention basin proposed); and
- the flows leaving the site (via the detention basins, where there is a detention basin proposed).

The plots show flows for the critical duration at each location. Plots for a short and a long duration storm are included in Appendix B.

On Duncans Creek, there is a predicted increase in flow in a 100 year ARI event at Location K, though this impact is predicted to dissipate once the tributary passing through Location K joins Duncans Creek shortly downstream of the site. Nonetheless, there is potential for localised increase in flooding and scour at this location under large flood events. No basin is currently proposed at this location.

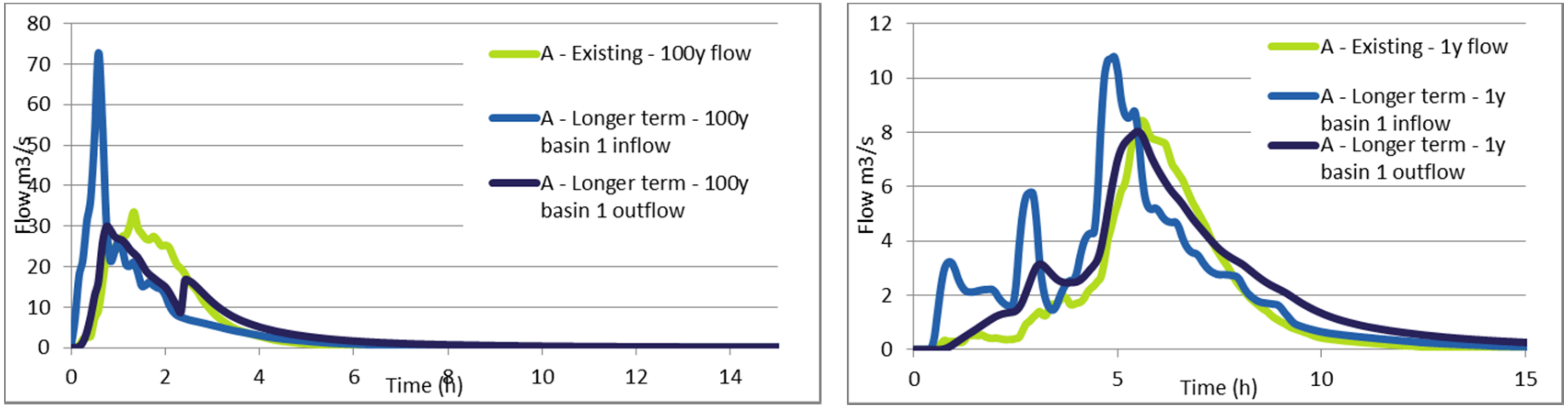


Figure 6-14 Location A at Basin 1, comparison of existing and longer term flows

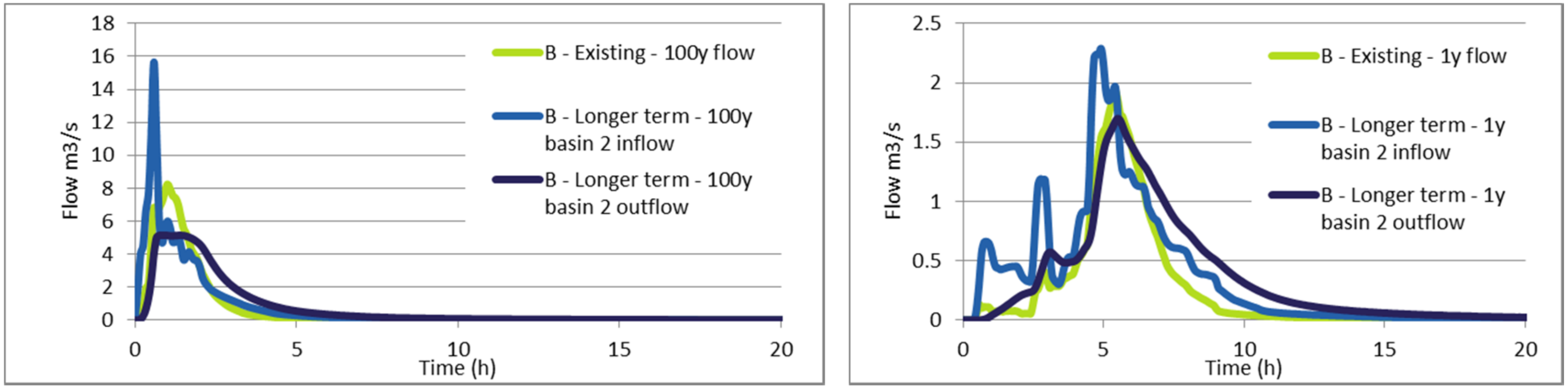


Figure 6-15 Location B at Basin 2, comparison of existing and longer term flows

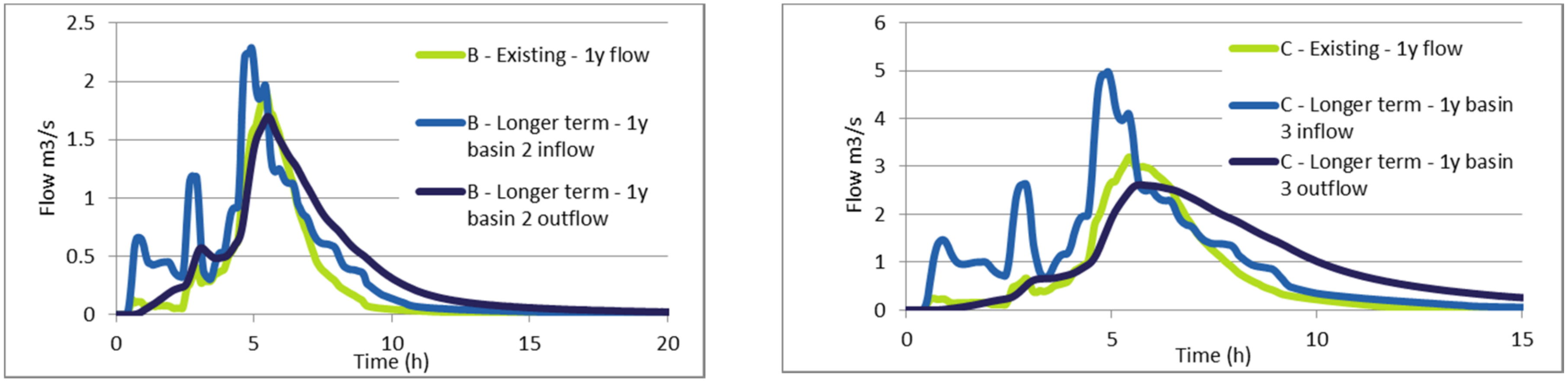


Figure 6-16 Location C at Basin 3, comparison of existing and longer term flows

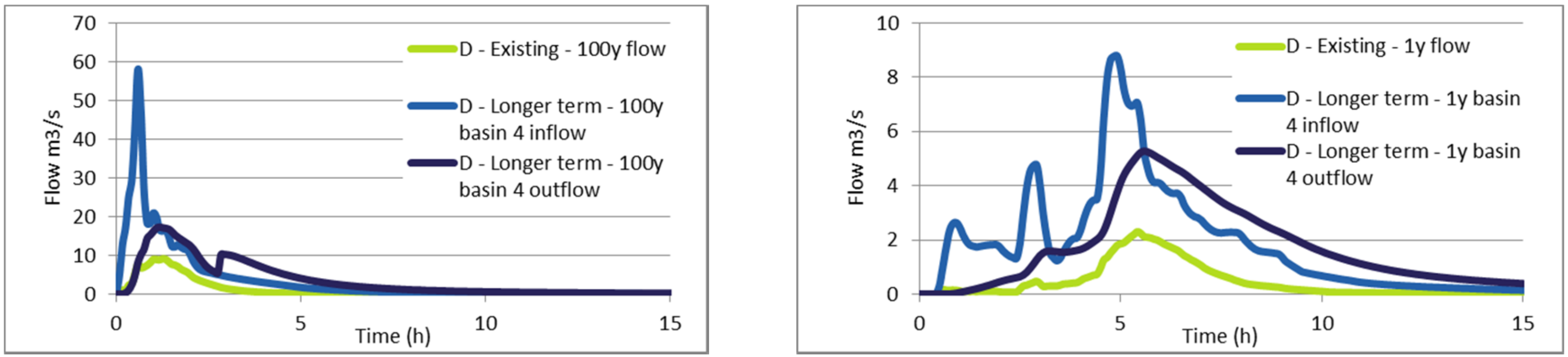
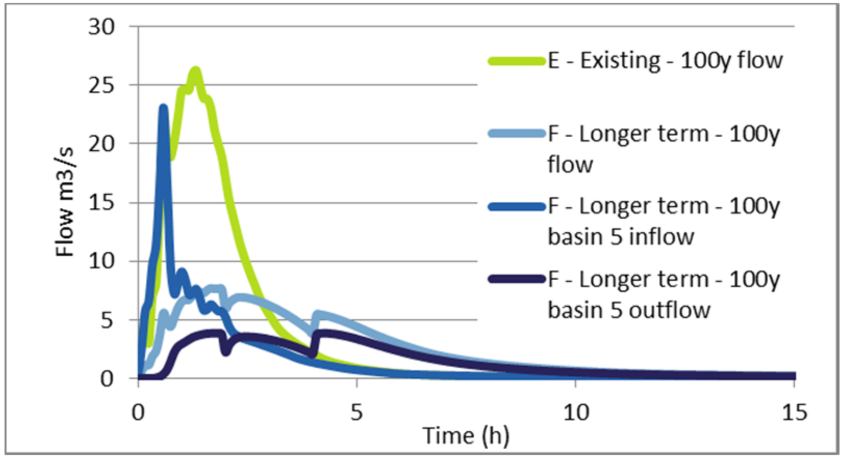


Figure 6-17 Location D at Basin 4, comparison of existing and longer term flows



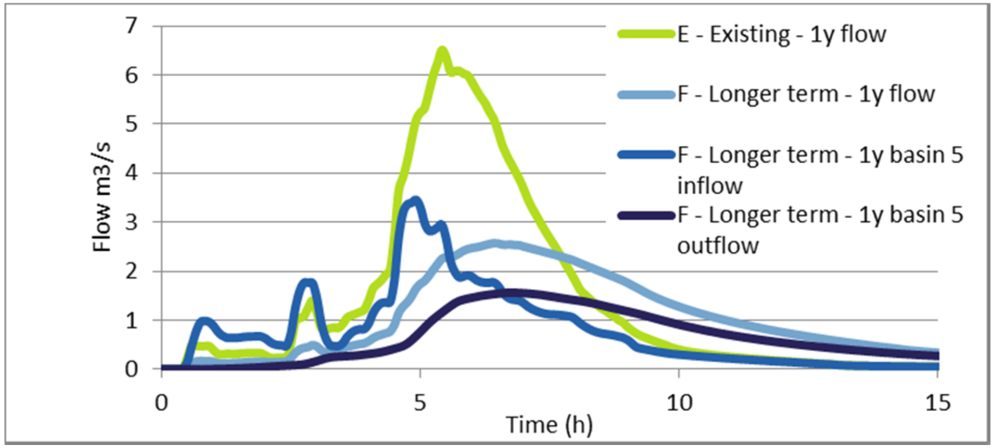
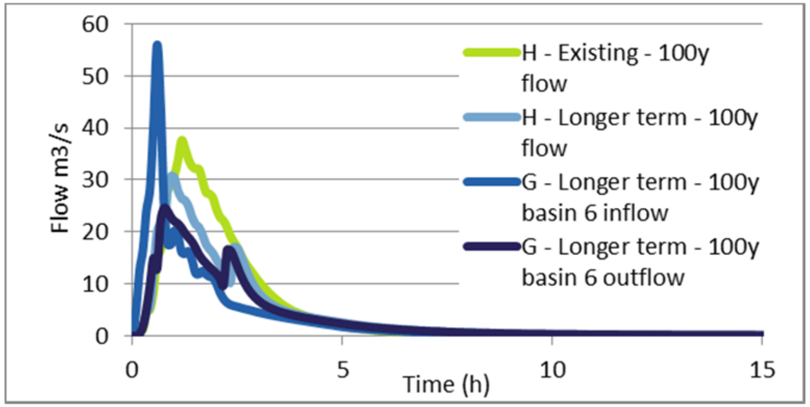


Figure 6-18 Locations E and F, comparison of existing and longer term flows



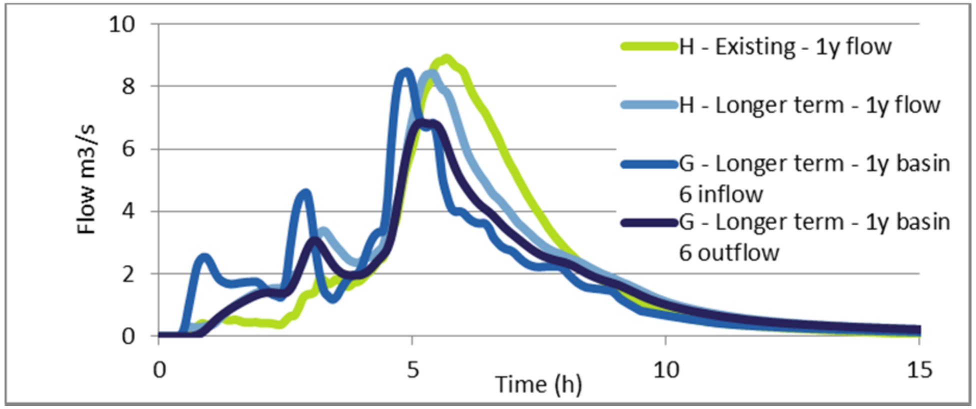


Figure 6-19 Locations G and H, comparison of existing and longer term flows

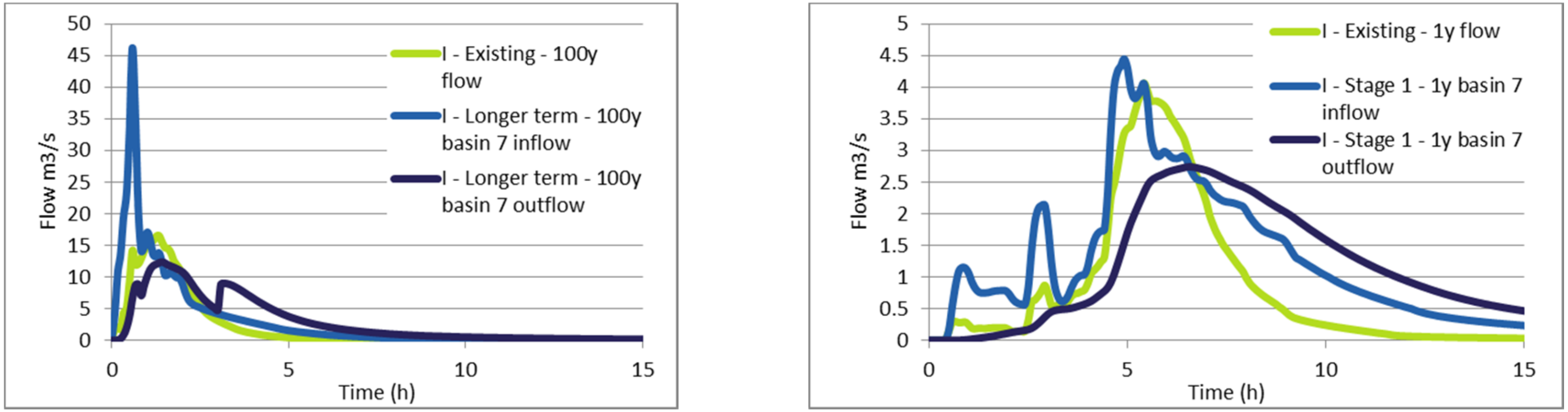


Figure 6-20 Locations I, comparison of existing and longer term flows

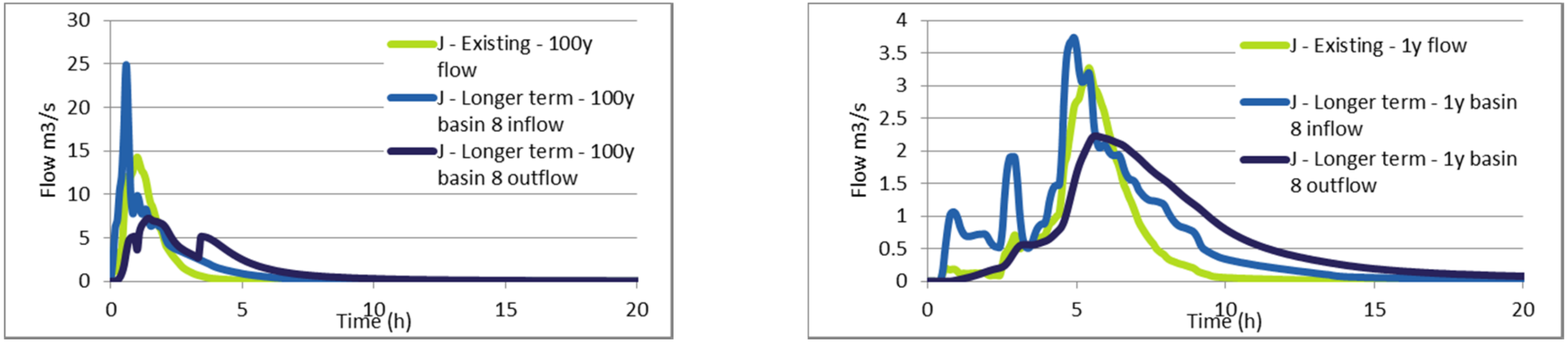
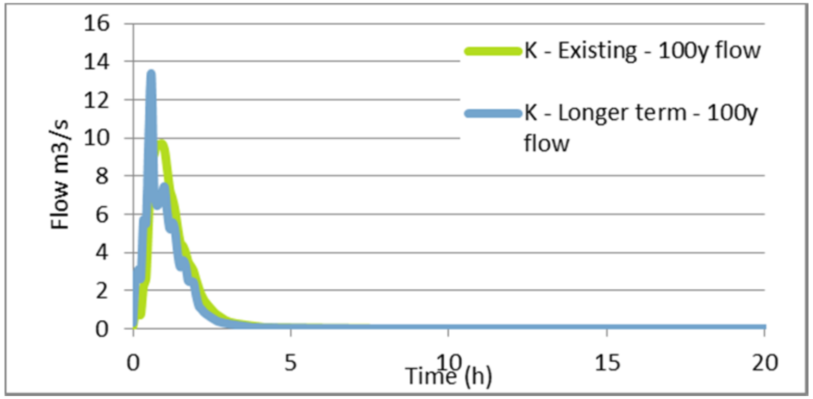


Figure 6-21 Locations J, comparison of existing and longer term flows



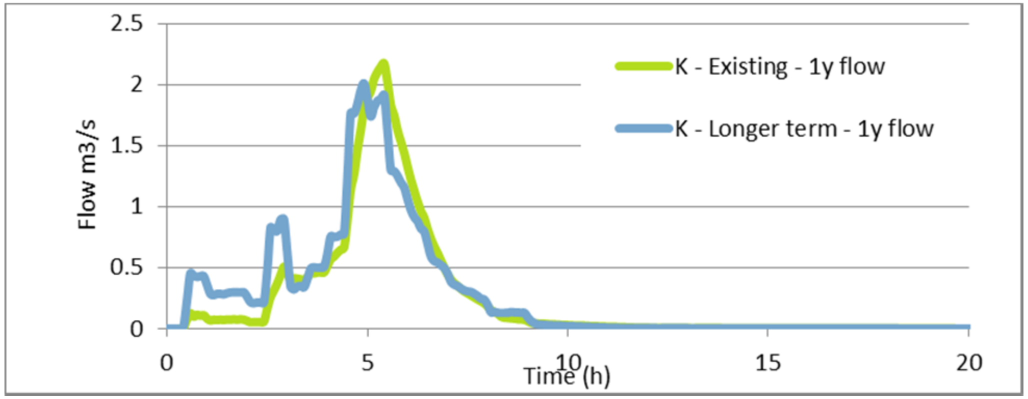
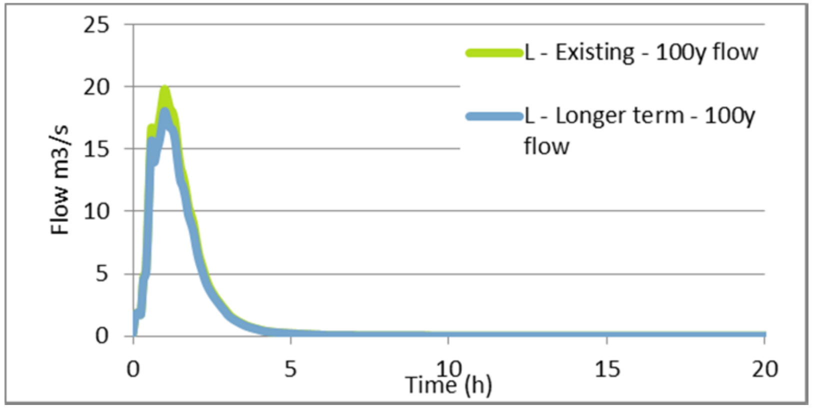


Figure 6-22 Location K, comparison of existing and longer term flows



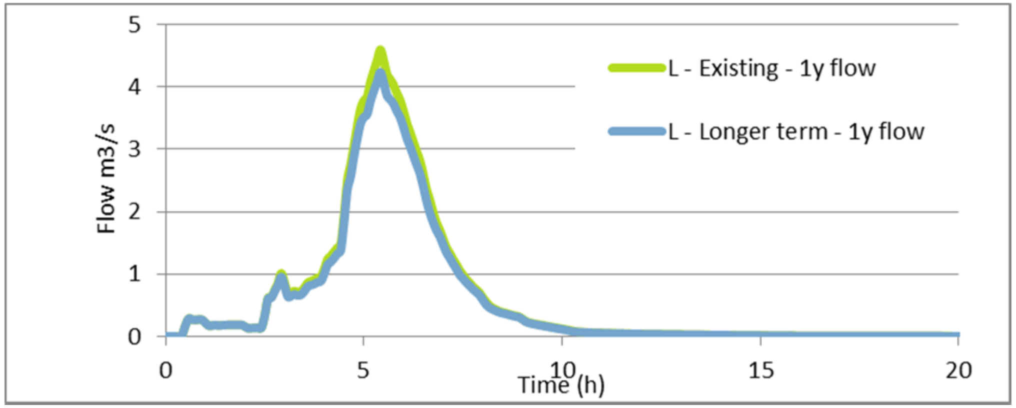


Figure 6-23 Location L, comparison of existing and longer term flows

Impacts on low flows and watercourse flooding

Figure 6-24, Figure 6-25 and Figure 6-26 show the predicted impacts of the longer term development on flood depths for the 1 year ARI, 5 year ARI and 100 year ARI events.

Oaky and Cosgroves Creeks

In a 1 year ARI event, flow depths downstream of Elizabeth Drive are predicted to increase by up to 120 mm generally and up to 250 mm on Oaky Creek upstream of its confluence with Cosgroves Creek.

Increases in depth on Cosgroves Creek upstream of the site are less than 10 mm different to the existing level and are considered relatively minor.

For the 5 year ARI and 100 year ARI, depths are within 25 mm of the existing level and no worsening of flooding to surrounding dwellings and infrastructure is expected.

Badgerys Creek

In a 1 year ARI event, flow depths downstream of Elizabeth Drive are predicted to decrease, but generally by less than 120 mm. The exception is the tributary of Badgerys Creek (discussed under Stage 1).

In other events, decreases in water levels along Badgerys Creek of up to around 150 mm would be expected in the critical duration event, generally due to the influence of the basins.

As with the Stage 1 Development, increases in flood level shown in the vicinity of Basin 2 and 3 is an anomaly which occured as a result of updated design drawings and the previous location of infrastructure which has since been removed.

No worsening of flooding would therefore be expected to surrounding dwellings and infrastructure based on the proposed design.

A portion of Badgerys Creek passes through the proposed longer term development area, in the south of the airport site. This area is proposed for business use in the longer term. There is potential for a range of impacts to Badgerys Creek if the surrounding development is not appropriately managed. Impacts could include increased flooding, and influences on creek geomorphology. Proposals for treatment of the creek where it passes through the site would be developed in subsequent design stages.

6.2.2 Impacts on watercourse geomorphology

Further changes to catchment areas and impervious areas as a result of the longer term development may also indirectly impact the channel morphology of watercourses downstream of the airport site. In particular, further catchment changes that result in increasing downstream flow durations and/or increased hydraulic shear stress can result in exacerbated erosion of the bed and banks of watercourse channels downstream of the airport site.

6.2.3 Impacts on water quantity from wastewater

The principles applying in Stage 1 to the use of recycled water for water quality would also be expected to apply in the longer term. As a result, impacts to surface water would be minimal.

LEGEND

Airport site	Flood depth difference (m)			
	<-2	-1 - -0.5	-0.1 - 0	0.3 - 0.5
	-2 - -1	-0.5 - -0.3	0 - 0.1	0.5 - 1
		-0.3 - -0.1	0.1 - 0.3	1 - 2
				>2

Paper Size A3
0 250 500 1,000
Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Job Number	21-24265
Revision	A
Date	05 Aug 2015

Flood depth impact - Existing and Longer Term
1-year ARI event

Figure 6-24

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Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

Data source: Data source: General Topo - NSW LPI DTDB 2012, Imagery - ESRI 2015 Created by: afoddy

LEGEND

Airport site	**Flood depth difference (m)**	-1 - -0.5	-0.1 - 0	0.3 - 0.5
	<-2	-0.5 - -0.3	0 - 0.1	0.5 - 1
	-2 - -1	-0.3 - -0.1	0.1 - 0.3	1 - 2
				>2

Paper Size A3

0 250 500 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Job Number 21-24265
Revision A
Date 05 Aug 2015

Flood depth impact - Existing and Longer Term
5-year ARI event

Figure 6-25

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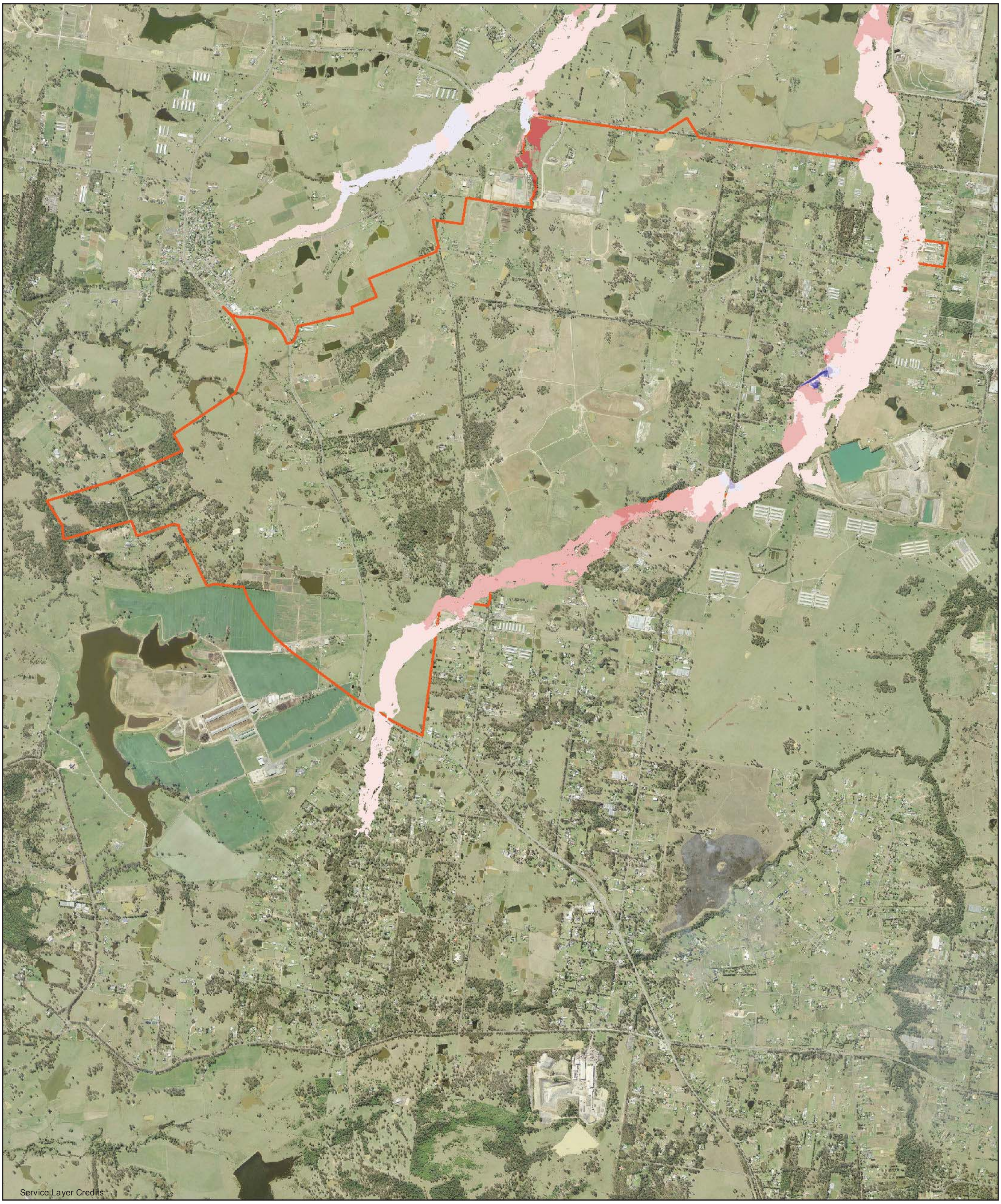
Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Data source: Data source: General Topo - NSW LPI DTDB 2012, Imagery - ESRI 2015 Created by: afoddy



LEGEND

Airport site	**Flood depth difference (m)**	-1 - -0.5	-0.1 - 0	0.3 - 0.5
	<-2	-0.5 - -0.3	0 - 0.1	0.5 - 1
	-2 - -1	-0.3 - -0.1	0.1 - 0.3	1 - 2
				>2

Paper Size A3

0 250 500 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Job Number	21-24265
Revision	A
Date	05 Aug 2015

Flood depth impact - Existing and Longer Term
100-year ARI

Figure 6-26

N:\AU\Sydney\Projects\21\24265\GIS\Maps\Deliverables\KBM.mxd [KBM: 68]

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Data source: Data source: General Topo - NSW LPI DTDB 2012, Imagery - ESRI 2015 Created by: afoddy

Figures D1 to D6 (Appendix D) display discharge hydrographs derived from the hydraulic model for the reporting location downstream of Elizabeth Drive along both Cosgroves and Badgerys Creek. The hydrographs are for the modelled 1, 5 and 100 year ARI events for existing, Stage 1 and longer term conditions. These indicate that the modelled flow event durations for the longer term conditions are similar to that of existing conditions along both watercourses downstream of the airport site.

Additionally, with the exception of the 1 year ARI event along Cosgroves Creek, modelled peak discharges reduce in response to the longer term development. The hydrograph for the 1 year ARI event along Cosgroves Creek indicates a slight increase in peak discharge from approximately 16 m^3/s to 19 m^3/s. This is considered to be a minor increase and is unlikely to lead to any measurable morphological impact along Cosgroves Creek downstream of the airport site. Hence, as flow durations for the modelled events under the longer term development conditions remain similar to existing conditions, and peak discharges typically reduce, the potential for significant impacts to the morphology of watercourses downstream is considered low.

To further explore the spatial distribution of potential morphological impacts to watercourses adjoining and downstream of the airport site, the modelled shear stress distributions for the longer term and existing conditions were also compared. Figures C15 to C17 (Appendix C) display maximum modelled shear stress differentials between the longer term development and the existing conditions for the 1, 5 and 100 year ARI events. These differences are similar to the differences between the existing conditions and the conditions during the Stage 1 Development, with shear stress changes largely remaining within – 5 to +5 N/m^2 to those of the modelled existing results along Cosgroves Creek and typically reducing along Badgerys Creek. This therefore indicates that the longer term development will also have a low impact on the morphology of watercourses adjoining and downstream of the airport site.

However, as per the Stage 1 Development, the longer term results indicate higher increases in modelled shear stress values along the reach of Oaky Creek extending approximately 100 to 200 metres downstream from Elizabeth Drive depending on the flow event modelled. Again, it is considered that there is a potential for the current form of the longer term development to result in an increase in scour and erosion along this reach of Oaky Creek immediately downstream of Elizabeth Drive.

Similarly, the longer term results show increases in modelled shear stress values along sections of Badgerys Creek between Basin 2 and Basin 3. As discussed in 6.1.2, the design layout used in the hydraulic model has been subsequently superseded. Therefore no impact on flood flow hydraulics is predicted at this location.

7. Cumulative impacts

7.1 Influence of climate change

It is possible that impacts of the development on hydrology and geomorphology could be exacerbated through future climatic changes, in particular changes to rainfall seasonality and intensity.

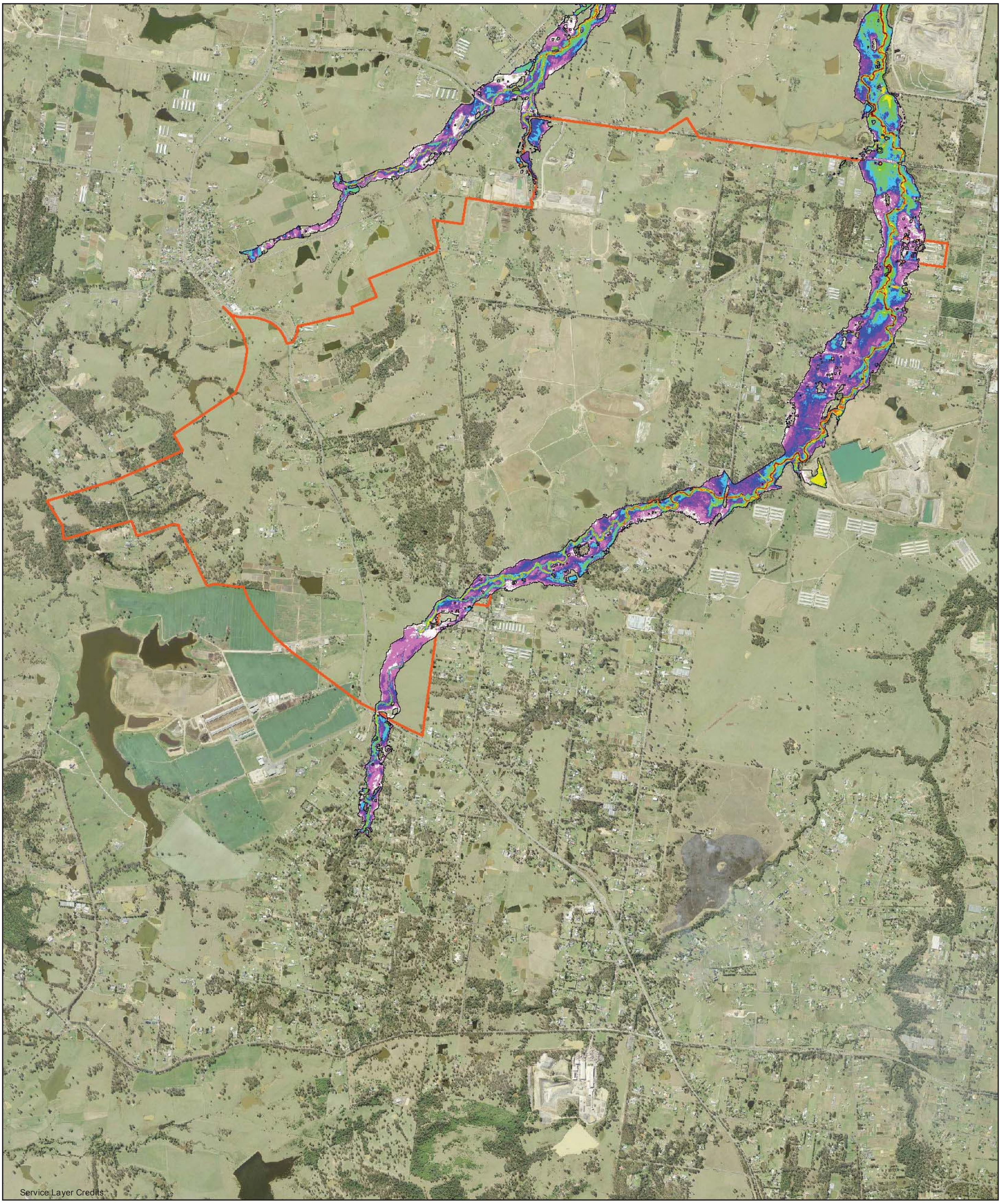
Under current available climate change predictions, decrease in rainfall is predicted during spring, at least in the near future (refer to Section 3.5.3). A decrease in rainfall has the potential for a range of impacts on the surface water environment, including drying of creeks and associated impacts on stream health and ecology. The basins have been designed for existing climatic conditions and have the effect of creating a minor decrease in flows to the downstream creeks (refer to Section 6.1.1 and 6.2.1). If rainfall, and hence runoff, to the basins decreases in the future, together with a general decrease in rainfall in the wider catchment, the airport site impacts on surface water runoff could be exacerbated and could also compound the impacts of climate change locally.

It is predicted that summer rainfall will increase in the future and it is possible that the intensity of flood-producing rainfall events will likewise increase in the future. At present, the design of the airport basins results in no increase in flooding downstream (though localised increases in flow are possible at discharge locations). Because of the proposed basins on the airport site, the future impact of climate change in the area is not predicted to be any worse as a result of the airport than it would be if the airport were not built. The exception is the reach on Oaky Creek downstream of the site where the airport tends to increase flood levels (refer also to Section 6). However, Figure 7-1 and Figure 7-2 indicate that the effects on flood extent would be minimal.

The potential increased localised flows at discharge points do have the potential to cause erosion and scour at basin outlets which can be managed with mitigation measures.

On the airport site, the flood immunity of any runways and associated infrastructure could be reduced in the future as a result of increases in the magnitude of flood events.

The extent of increase in flooding due to climate change is shown on Figure 7-1 and Figure 7-2.



LEGEND

Airport site	Flood depth (m)	0.6 - 0.8	2 - 2.5	Flood extent for Stage 1 without climate change
	0.1 - 0.2	0.8 - 1	2.5 - 3	
	0.2 - 0.4	1 - 1.5	3 - 4	
	0.4 - 0.6	1.5 - 2	>4	

Paper Size A3

0 250 500 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Job Number 21-24265
Revision A
Date 06 Aug 2015

Stage 1 - Climate Change Flooding 100-year ARI Event, 10% Increase in Rainfall Intensity

Figure 7-1

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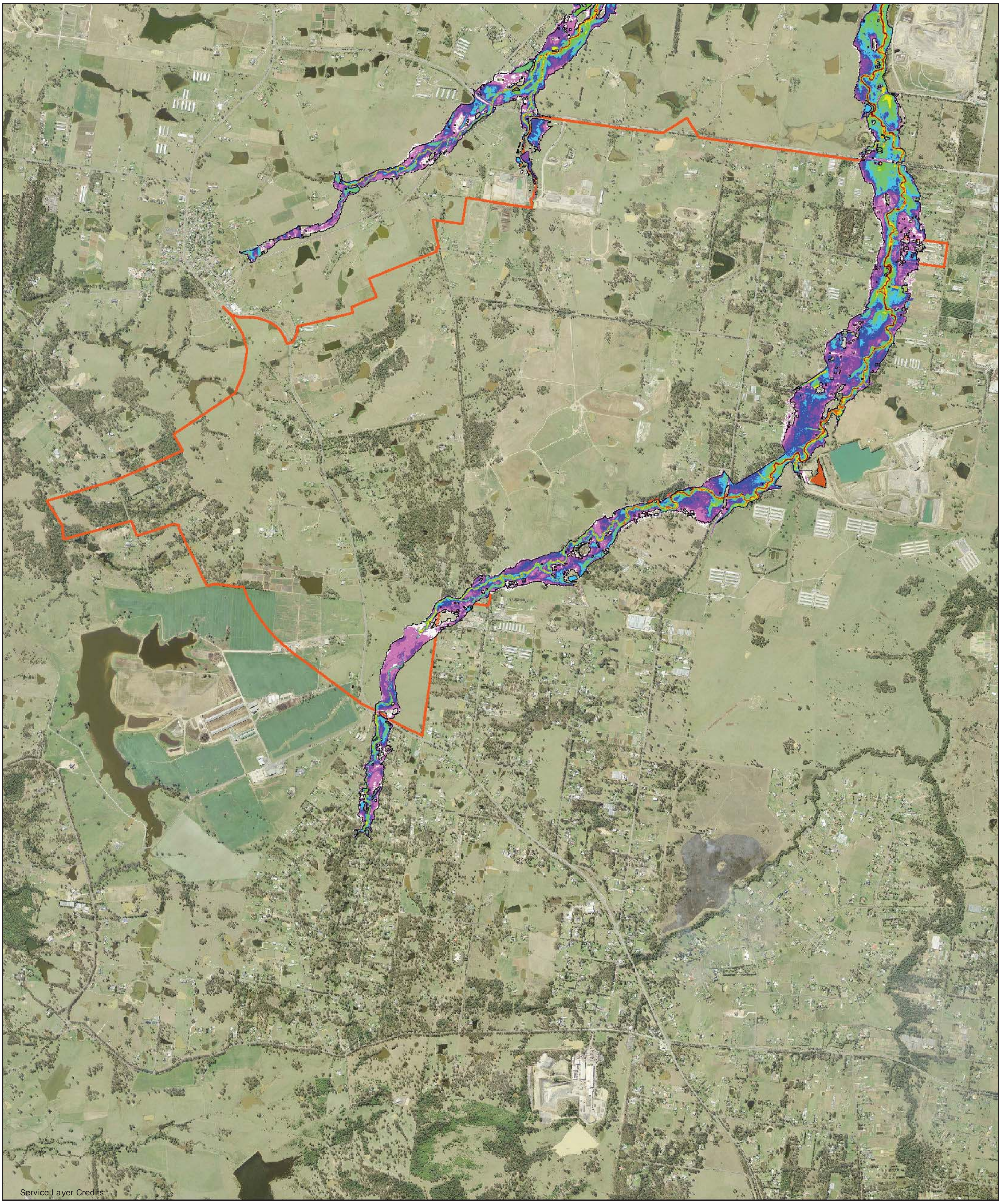
Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Data source: Data source: General Topo - NSW LPI DTDB 2012, Imagery - ESRI 2015 Created by: afoddy



LEGEND

Airport site	**Flood depth (m)**	0.6 - 0.8	2 - 2.5	Flood extent for Longer term without climate change
	0.1 - 0.2	0.8 - 1	2.5 - 3	
	0.2 - 0.4	1 - 1.5	3 - 4	
	0.4 - 0.6	1.5 - 2	>4	

Paper Size A3

0 250 500 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Job Number 21-24265
Revision A
Date 05 Aug 2015

Longer Term - Climate Change Flooding 100-year ARI Event, 30% Increase in Peak Rainfall Intensity

Figure 7-2

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Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

Data source: Data source: General Topo - NSW LPI DTDB 2012, Imagery - ESRI 2015 Created by: afoddy

7.2 Influence of future urban development in the catchment

Though currently largely zoned for agricultural and primary industry uses, the areas downstream of the site to the north include part of the broader Western Sydney Employment Area (WSEA). It is likely that further urban development will take place in the future in these areas. Many of the impacts identified in this report are similar in nature to the range of impacts that could result from surrounding urban development. The cumulative effect of future development may exacerbate changes to the natural flow regime with resultant impacts on creek stability and flooding.

The South West Growth Priority Area incorporates portions of the area upstream of Badgerys Creek and also on to its eastern bank adjacent to the airport site. Should redevelopment occur in the catchment upstream of the site, there would be the potential to influence flooding of the proposed airport. Upstream development could also have the effect of exacerbating impacts from the proposed airport. Any new development would be subject to requirements to review and mitigate impacts downstream through measures such as on-site detention. The implications of potential future development in relation to mitigation measures are considered in Section 8 of this report.

8. Mitigation and management measures

8.1 Construction

The range of potential impacts identified during construction, and potential mitigation and management measures to address those impacts, are summarised in Table 8-1.

The increased impervious surface area associated with the proposed works would have the potential for adverse impacts on the hydrological regime in terms of increased runoff volumes and peak flows as the site is progressively constructed. The Construction Management Report identified that stormwater management features including drains, swales and basins would be constructed progressively to manage potential flow increases.

Where necessary, temporary stormwater drainage would need to be installed to manage on-site surface water, including consideration of potential flooding given the extended timeframe over which the airport will be developed.

There is potential for large quantities of sediments to be directed into the stormwater management network resulting in blockage. This impact is discussed in detail in the water quality report.Mitigation measures would include the development of appropriate erosion and sediment control measures for the construction stage.

Infrastructure to manage surface water on site would also incorporate allowance for the separation of “clean” and “dirty” water. A detailed construction surface water management strategy would be incorporated into a Soil and Water Management Plan (SWMP), which should also consider seasonal variability of rainfall when planning construction stage activities.

Water use during construction is expected to be high and a construction water supply strategy needs to be developed to cater to the needs of the proposed airport development. Consultation with Sydney Water Corporation is required to investigate the capacity of existing potable sources to provide the likely demand for the proposed airport. The possibility of alternative water sources would also be considered during detailed design development.

8.2 Operation

The range of potential impacts identified during operation, and potential mitigation and management measures to address those impacts, are summarised in Table 8-1. The impacts stem from the following key factors discussed in Section 6:

- changes to the catchments in terms of catchment area, configuration and degree of imperviousness;
- resulting changes in the peaks, volumes and timing of flows discharging from the site leading to influence on downstream flow depths and velocities; and
- removal or diversion of watercourses on the site.

The biodiversity assessment concluded that the surface water management systems at the airport site should be designed to avoid substantial alteration to surface water drainage patterns and the volume of downstream flow to minimise the potential for adverse impacts to the downstream environment.

The primary design control measure already proposed to minimise these impacts is the use of detention basins to mitigate increases in peak flow and changes to timing of flows and manage discharge velocities. The assessment undertaken indicates that the current basin strategy does influence flow peaks, though it does not entirely mitigate impacts across all magnitudes and durations of storm events.

There is also potential for some of the impacts to be exacerbated due to the cumulative impact of upstream or downstream development and the possible future effects of climate change.

To mitigate against downstream impacts, the basin configuration, including high and low flow outlet structures and volume characteristics, would need to be further assessed as part of the detailed design of the proposed airport with the aim of mimicking natural flows as closely as reasonably practical.

This would need to consider a range of eventualities, such as low flows, flood flows and storm durations and also management of localised scour and erosion at basin outlets, as well as the cumulative impacts of climate change and surrounding development.

The design of the airport drainage would need to consider the possible future effects of climate change and its impact on flooding of the airport site from the surface water ponding or inundation of the drainage system. Consideration should be given based on emerging climate research on the extent to which allowance for climate change should be incorporated into the design standards.

At Basin 1, consideration should be given to preserving the third order tributary of Badgerys Creek downstream of the site by maintaining a second crossing of Elizabeth Drive.

Where Badgerys Creek passes through the site, any long term development in this area would need to take appropriate consideration of the creek, which is a third to fourth order stream at this location. Management measures would include preserving the riparian corridor and mitigating changes to the flow regime such that there would be no increase in flooding or geomorphological impacts downstream.

Mitigation of groundwater seepage is discussed in detail in the groundwater assessment for the EIS. A monitoring program is proposed that would monitor both groundwater and surface water quality. This would provide warning of excessive groundwater seepage that may have downstream hydrological impacts and would allow remedial action to be taken.

During operation, options for the expansion of potable water supply lines would be investigated in consultation with Sydney Water and in consideration of their existing plans for expansion of the network to supply additional homes associated with the South West Growth Centre.

Table 8-1 Impact and mitigation summary

Section reference	Activity	Description of consequences	Control measures incorporated in design / management plans	Project phases	Mitigation / management measures
5.1	Volume of runoff expected from the site will increase due to reduction in infiltration into the ground as site is constructed	Downstream flooding	Detention basins	Construction	Limited based on current design. Basin design to be refined during airport design development to address flooding across the full range of flood events and appropriate construction phasing
5.1	Flooding and waterlogged soils on site	Disruption to construction activities, damage to equipment	-	Construction	Develop construction surface water management strategy as part of Soil and Water Management Plan
5.1	Water use during construction and operation	Impact on regional and/or local water resources	Use of farm dams on site where practical during construction, use of recycled water during operation to supplement potable water supply	Construction and operation	Strategy for water supply to be developed during ongoing design development and in consultation with Sydney Water Corporation
5.2	Site construction	Permanent removal of watercourses and artificial wetland area including associated habitat destruction	-	Operation (Stage 1 and longer term)	The significance of the habitat removal is assessed in the biodiversity report together with the need for offset measures
6.1.1 and 6.2.1	Diversion of tributary into Badgerys Creek upstream of Elizabeth Drive	Increased likelihood of flooding to Elizabeth Drive	Detention basins to manage peak flows	Operation (Stage 1 and longer term)	Detailed design of detention basins

Section reference	Activity	Description of consequences	Control measures incorporated in design / management plans	Project phases	Mitigation / management measures
6.1.1 and 6.2.1	Diversion of tributary into Badgerys Creek upstream of Elizabeth Drive	Drying of 200 m of third order tributary downstream of Elizabeth Drive	-	Operation (Stage 1 and longer term)	Design for additional crossing of Badgerys Creek to facilitate creek flows and retain existing confluence downstream of Elizabeth Drive
6.1.1 and 6.2.1	Decrease in catchment area draining to Oaky and Cosgroves Creeks	Removal of flow from creek resulting in potential downstream habitat and creek degradation, noting that change in flows is minor	-	Operation (Stage 1 and longer term)	Review design of detention basins during detailed design to achieve appropriate flow at the outlet
6.1.1 and 6.2.1	Increase in site discharge due to increase in site impervious area	Flood impact to residents downstream	Detention basins	Operation (Stage 1 and longer term)	Limited based on current design. Basin design to be refined during airport design development to address flooding across the full range of flood events
6.2.1	Development in south of site where Badgerys Creek passes through	Range of potential impacts to creek on the site and downstream	-	Operation (longer term)	Plans for business area to incorporate strategy appropriate to a third order stream at this location
6.1.2 and 6.2.2	Increases in shear stress due to change in downstream flows	Increase in scour and erosion along this reach of Oaky Creek immediately downstream of Elizabeth Drive.	Detention basins	Operation (Stage 1 and longer term)	Review design of detention basins during detailed design to achieve appropriate flow at the outlet
6.1.1 and 6.2.1	Increase in flows at point of discharge on tributary of Duncans Creek	Localised erosion, scour and flooding, increased flood risk to properties in the immediate vicinity	-	Operation (Stage 1 and longer term)	Review need for basin at this location during design development and incorporate findings if required.

9. Summary and conclusion

A surface water hydrology and geomorphology assessment was carried out to determine the impact of the proposed staged development of the airport on flooding and watercourse geomorphology during both construction and operation. It also explored mitigation and management measures for acceptable design.

The study considered key indicators of changes including:

- changes in discharge from the site;
- changes in watercourse bed shear stress; and
- changes in downstream water level.

The study finds that construction of the airport would result in a major modification of the site in terms of land use characteristics and surface water runoff generated. It would also result in removal of a large number of watercourses and farm dams. The ecology aspects of removal of surface water habitat and associated flora and fauna species is assessed separately in the biodiversity report.

During construction, a detailed surface water management plan would be developed and would need to consider impacts of flooding on-site over the course of the construction period.

Downstream of the site, the assessment finds that the detention basin strategy would be effective at limiting the downstream impacts such that:

- any increases in flood level would not worsen flooding to surrounding roads and dwellings; and
- the risk to changes in creek geomorphology would be low, other than for a short reach of Oaky Creek.

Some localised increases and decreases in water level were predicted downstream of the site. These were generally found to be minor, with the exception of changes to water level at Oaky Creek and on a tributary of Badgerys Creek. These impacts need to be managed through subsequent design development.

The assessment finds that there would be a need to further develop the basin strategy during design development such that the basins would be effective at mimicking natural flows as closely as possible across a range of storm durations and magnitudes including low and high flows. Consideration should be given to the need to introduce a basin or alternative water quantity management measure at one of the site discharge points into a tributary of Duncans Creek.

Another mitigation requirement would be to ensure that any future development in the vicinity of Badgerys Creek where it passes through the site would be appropriate for a third order creek, including protecting and preserving habitat along the riparian corridor and ensuring no worsening of flooding downstream.

During construction of the airport, demands on potable water would be high and there is a need to develop a strategy for water supply to the airport site to meet the construction requirements and also the ongoing operational requirements. During operation of the airport, use of potable water on site would be supplemented with recycled water to reduce demand on potable water.

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Appendices

Appendix A – Additional model development details

Hydrology model

Parameters

Links

Links are used in RAFTS to connect catchments and route runoff downstream. Lagging links were used in the RAFTS models developed for this study. Lagging links are used to delay, or translate, the flow (hydrograph) from an upstream location to a downstream location, to account for the travel time between two points.

Lag times were estimated by calculating travel distances along major flowpaths in mapping software, and converting distance to time by assuming an average flow velocity of 1 m/s. Review of hydraulic model results supported the use of this velocity, and this assumption was tested in the sensitivity analysis of the RAFTS model.

Catchment slope

Catchment slopes were estimated along the major flowpath for each catchment from the catchment boundary to the outlet. The equal area slope method was used. Catchment slopes ranged from 0.5 % – 7.3% and the average slope was 2.0 %.

Losses

An initial/continuing loss model was adopted in RAFTS to estimate runoff from design rainfall. Losses were adopted for pervious and impervious catchments and applied across the model. Pervious catchment losses were selected based on Australian Rainfall and Runoff (1987) recommendations for design loss rates for New South Wales.

Surface roughness (n)

Surface roughness coefficient values were adopted for pervious and impervious catchments and were applied across the model based on industry standard values.

Storage coefficient multiplication factor (BX)

The current study adopted the RAFTS default value for BX of 1 for consistency with the modelling and design work carried out by the business advisor. Previous studies have used BX to calibrate model results to historical flood data.

Table A-1 Comparison of RAFTS parameters for flood studies

Parameter	Current study	1990 South Creek flood study	SMEC study 1991 report for second Sydney airport	Updated South Creek flood study (Worley Parsons 2015)
BX	1.0	1.3	1.3	1.3
Surface roughness	Pervious catchments 0.025 Impervious catchments 0.015	No information available	No information available	0.025
Losses Initial loss/continuing loss (IL/CL)	Pervious catchments IL 10 mm CL 2.5 mm/hr Impervious catchments (100% impervious) IL 1 mm CL 0 mm/hr	IL 35 mm (40 hour storms), or IL 10 mm (9 hour storms), based on critical durations of 9 and 40 hours for most of the catchment CL 1 mm/hr	IL 5 mm CL 0.5 mm/hr	Pervious catchments IL varies 5-37.1 mm CL 0.94 mm/hr Impervious catchments (75-100% impervious) IL 1 mm CL 0 mm/hr

Probable maximum flood derivation

Results of probable maximum flood simulations in RAFTS are provided in Table A-2, with the peak flow and critical duration storm event shown for a range of key locations. Critical durations ranged from two to four hours depending on location.

Hydrographs from the simulation of the two hour probable maximum flood event are shown in Figure A-1 together with the rainfall hyetograph for the event. The hydrographs shown are at the Elizabeth Drive crossing of Badgerys, Oaky and Cosgroves Creek.

Table A-2 Probable maximum flood peak flows

Location	Design PMP event peak flow (m^3/s) (critical duration)
Badgerys Creek at Elizabeth Drive	883 (2.5 hr)
Oaky Creek at Elizabeth Drive	205 (2 hr)
Cosgroves Creek at Elizabeth Drive	371 (2 hr)
Badgerys Creek at South Creek	1055 (4 hr)
Cosgroves Creek at South Creek	967 (2.5 hr)
Duncans Creek at Nepean River	957 (4 hr)

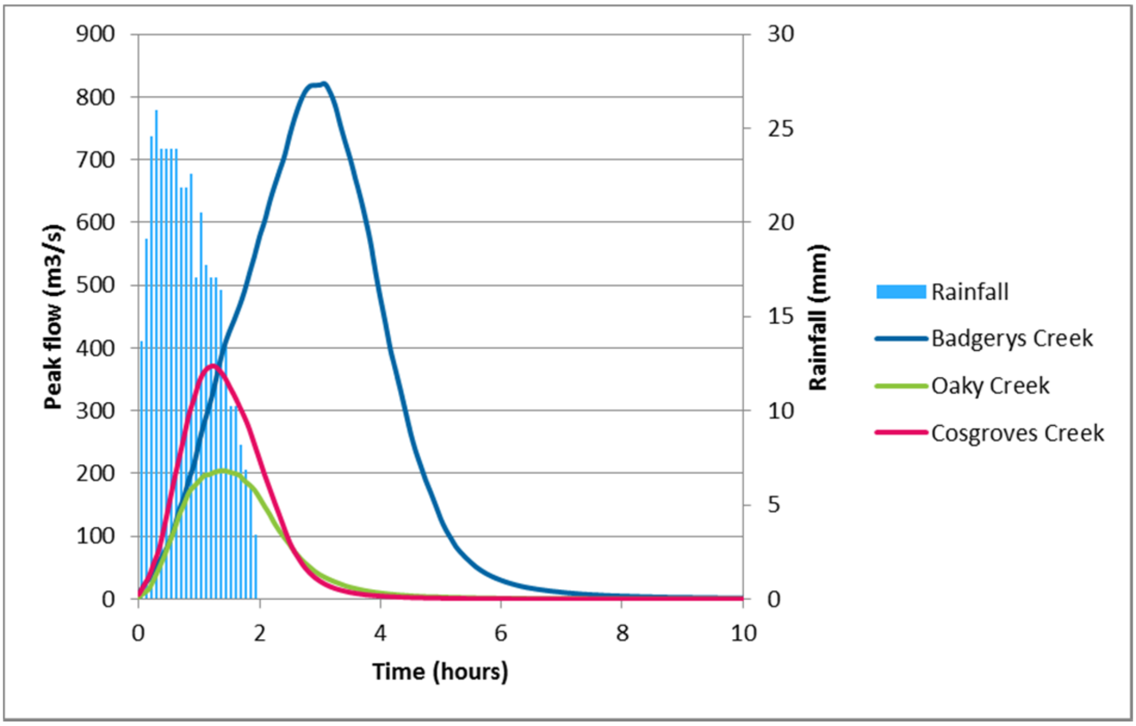


Figure A-1 Probable maximum flood (2 hr event) simulation results at Elizabeth Drive

Hydrology modelling verification

Comparisons against previous studies

Results of the RAFTS model were compared to design storm flow estimates from other sources, including previous flood studies and the probabilistic Rational Method for eastern New South Wales as described in *Australian Rainfall and Runoff* (Institute of Engineers Australia 1987).

Peak flows for the 100 year average recurrence interval (ARI) storm event are compared in Table A-2, and the critical duration storm that resulted in the reported flow is provided in brackets where known. For the probabilistic Rational Method results, the time of concentration for Badgerys Creek, Cosgroves Creek and Duncans Creek were all approximately 2.5 hours.

The current study produced higher flow estimates than reported peak flows at the same locations in the Updated South Creek Flood Study. This was expected because the Updated South Creek Flood Study flows were for long duration storm events that were critical for the South Creek catchment as a whole, but the critical duration for the catchments in the current study were shorter. This may also be the case for the earlier South Creek flood study and floodplain management study, where South Creek was the watercourse of interest and the storm duration reported on was the one producing the largest flows in South Creek. A in 100-year ARI storm was simulated in the RAFTS model for comparison with the Updated South Creek Flood Study and the results are also indicated in the table at key locations.

The flows calculated in RAFTS in the current study compared well with rational method estimates for the 100 year ARI event, particularly for Badgerys Creek. Duncans Creek had the highest peak flow according to the RAFTS results, reflecting the higher impervious fraction for its catchment associated with large dams. The rational method calculation only considers differences in total area for catchments in the same region, and so Badgerys Creek, with the largest catchment area, was estimated to have the highest peak flow.

The RAFTS results correspond well with the 1991 Concept Design study, with peak flows from the two studies within 5% of one another.

For the purposes of comparison with the Updated South Creek Flood Study, a 100 year 36-hour storm went through simulation in the hydrology model. The results are shown in Table A-3.

Table A-3 Comparison of 100 year ARI design storm flow estimates

Location	100 year ARI peak flow (m^3/s) (critical duration)					
	RAFTS (current study)	Rational method (current study)	1990 South Creek Flood Study (1)	1991 South Creek Floodplain Mgmt. Study (1)	1991 Concept Design for Second Sydney Airport	2015 Updated South Creek Flood Study
Badgerys Creek at Elizabeth Drive	150.6 (6 hr) 125 (36 hr)	-	112	126	153 (2-6 hrs)	126 (36 hr (2))
Oaky Creek at Elizabeth Drive	37.6 (2 hr)	-	-	-	39 (2-6 hrs)	-
Badgerys Creek at South Creek	179.5 (6 hr) 136 (36 hr)	172	151	151	-	138 (36 hr (2))
Cosgroves Creek at South Creek	179.2 (6 hr) 136 (36 hr)	135	129	129	-	123 (36 hr (2))
Duncans Creek at Nepean River	181.8 (6 hr)	147	-	-	-	-

Table notes:

(1) This data was reported in the 2015 Updated South Creek Flood Study (Worley Parsons)

(2) This duration is not critical at these locations – but is for South Creek as a whole.

Sensitivity analysis of RAFTS model parameters

Sensitivity analysis was conducted by testing the impact of variations to the values of key model parameters, as follows.

- Initial loss: a higher initial loss of 35 mm was tested for pervious catchments, this being the upper limit in the range of recommended losses for this region provided in *Australian Rainfall and Runoff* (Institute of Engineers Australia 1987).
- Continuing loss: a higher continuing loss of 4.1 mm/hr for pervious catchments was tested in combination with both low and high initial losses (10 and 35 mm).
- Roughness: a higher roughness value of 0.05 was tested for pervious catchments.

- Lag times: the lag times assigned to lagging links between nodes in the model were adjusted to test a high velocity (2 m/s) and low velocity (0.5 m/s) scenario.
- BX: the storage coefficient multiplication factor was tested at 1.3, which was the value used in several previous flood studies (see Table A-3).

The sensitivity of the model results on the values of the input parameters has been assessed by comparing the hydrographs and peak flows for the 10 and 100 year ARI events at the downstream boundaries of the model. The peak flows at the end of Badgerys, Cosgroves and Duncans Creeks are compared for the base case (adopted parameterisation) and sensitivity analysis scenarios in Table A-4.

Table A-4 Sensitivity analysis results

	10 year ARI peak flow (m^3/s)			100 year ARI peak flow (m^3/s)		
Storm duration	*9 hr*	*6 hr*	*6 hr*	*6 hr*	*6 hr*	*6 hr*
	Badgerys Creek at South Creek	Cosgroves Creek at South Creek	Duncans Creek at Nepean River	Badgerys Creek at South Creek	Cosgroves Creek at South Creek	Duncans Creek at Nepean River
Base case	109	113	114	177	180	183
High initial loss	91	69	70	142	143	143
High continuing loss	97	106	106	167	172	175
High initial loss, high continuing loss	81	63	64	133	136	137
High pervious catchment roughness	91	92	91	148	155	154
Slow lagging links	77	76	74	119	124	120
Fast lagging links	138	135	136	218	214	221
Bx 1.3	101	104	103	164	170	171

The results were most sensitive to link lagging velocity, with a doubling in link lagging velocity corresponding to an approximate 20 % increase in peak flow, and a halving of link lagging velocity leading to an approximate 30 % decrease in peak flow. The timing of the peak was also impacted, as shown by the comparison of hydrographs for Badgerys Creek below.

A limitation of the model in terms of storage was that data was not available for the Leppington Pastoral site storage structure sufficient to appropriately estimate hydrology for this catchment. Results on Duncans Creek downstream of the site are considered indicative only.

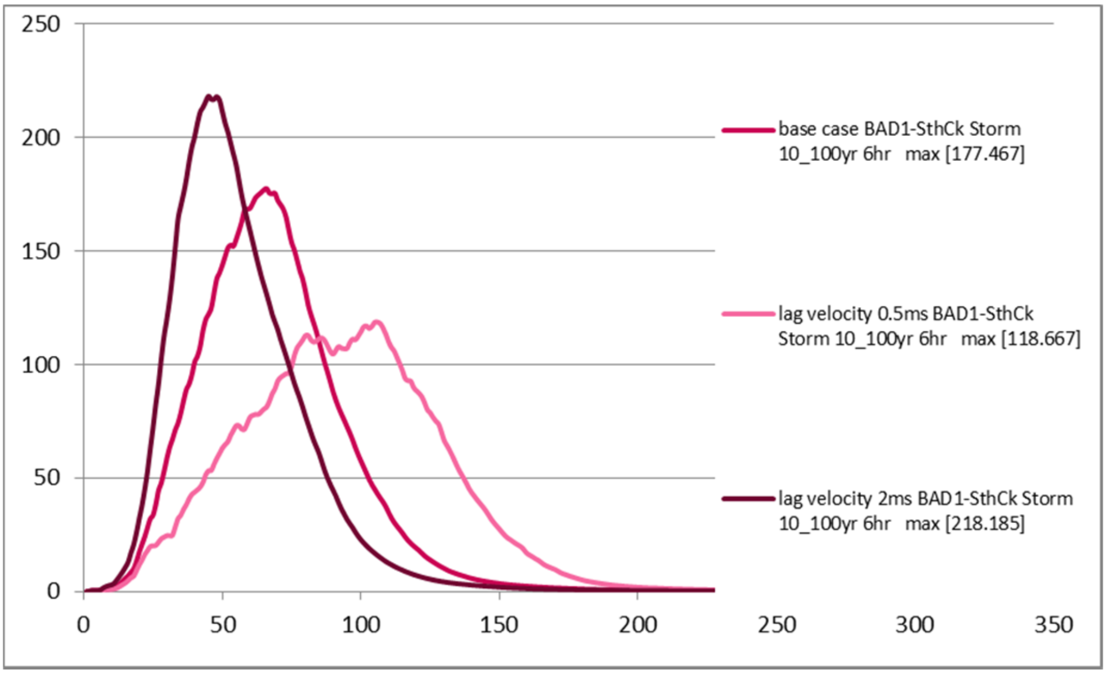


Figure A-2 Badgerys Creek at South Creek – sensitivity of lag velocity

The influence of the lagging assumption on impact assessment findings is expected to be limited. This is because flows for each subcatchment were explicitly routed in the MIKE 21 model rather than in the RAFTS model, meaning that the RAFTS lagging assumptions were not used within the extent of the hydraulic models.

Comparison of 1987 design rainfall IFD data with 2013 rainfall IFD data

Australian Rainfall and Runoff is currently undergoing revision and rainfall Intensity-Frequency-Duration (IFD) data has recently been revised from the 1987 published data to 2013 data. The 2013 data cannot currently be used for detailed studies as the associated temporal patterns and other information used to define the design storm events are still undergoing revision.

However, the 1987 data (used in this study) was compared with the 2013 data to understand the scale of expected change to rainfall because it is expected that, in the future, the airport site would need to be assessed against the revised data.

A comparison of the IFD curves is provided in Figure A-3.

It is important to note that the new data uses Annual Exceedance Probabilities (AEPs) as the probability measure rather than Average Recurrance Intervals (ARIs). ARIs of greater than 10 years are very closely approximated by the reciprocal of the AEP.

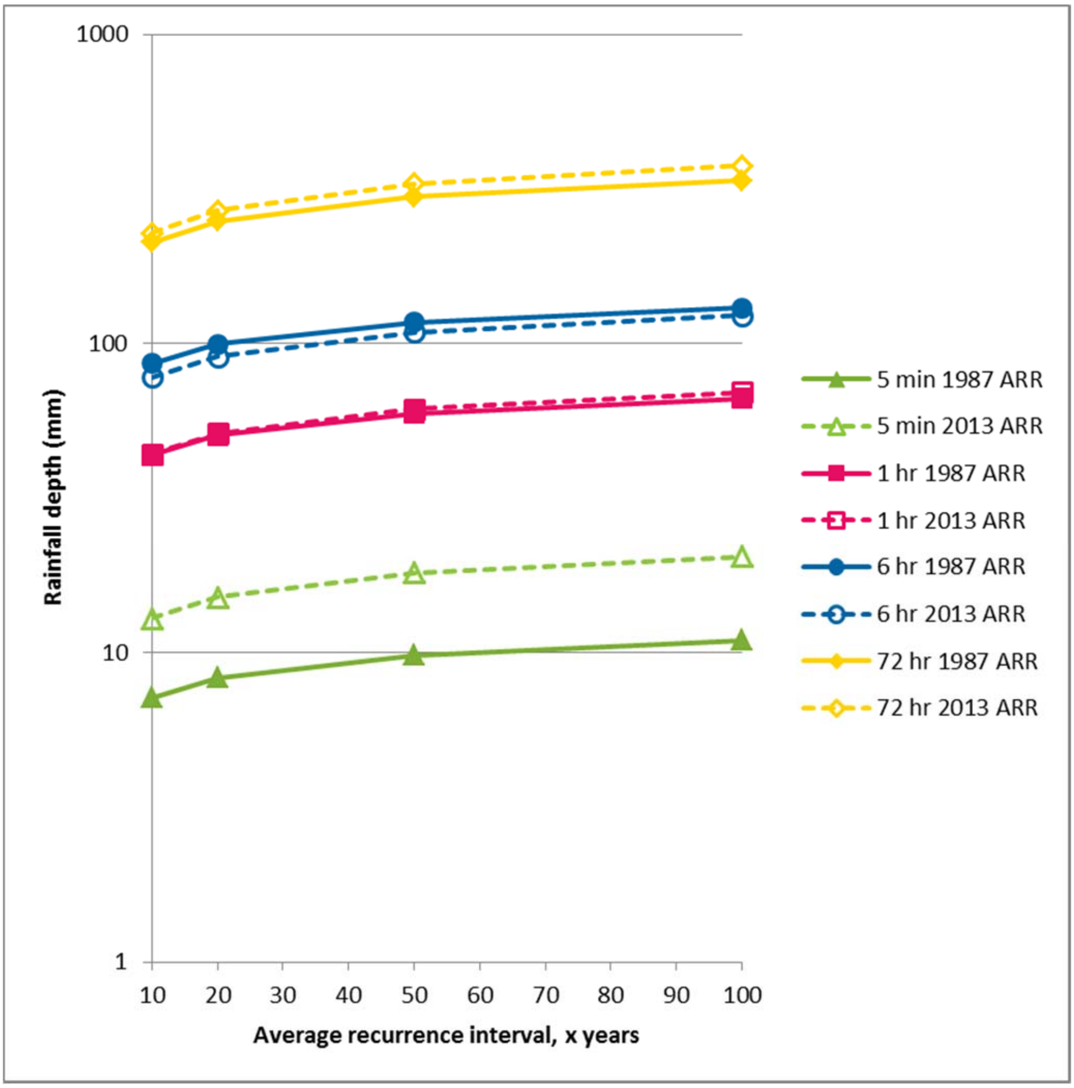


Figure A-3 Comparison of design IFD data for various durations

For very short duration storms, the 2013 IFD is much higher than the 1987 data. For longer duration storms, the rainfall is more closely aligned. On the basis of the available information it is not expected that the findings of the EIS would be materially altered due to the revised IFD data.

Hydraulic model

Photographs of key hydraulic structures from site inspection

Several key hydraulic structures are indicated in the following photographs. The photographs, together with onsite measurements, were used to define hydraulic structures in the MIKE 21 model.

Oaky Creek crossing at Elizabeth Drive

Badgerys Creek crossing at Elizabeth Drive

Badgerys Creek crossing at Badgerys Creek Road

Badgerys Creek crossing at the Northern Road

Hydraulic model verification

The accuracy of hydrologic and hydraulic modelling is influenced by a number of key factors, including:

- inherent uncertainty in the procedures documented in Australian Rainfall and Runoff (Engineers Australia, 1987) which are used to estimate peak flood flows, particularly for large flood events;
- the accuracy and resolution of the underlying data used to represent the model topography; and
- the uncertainty in hydraulic modelling methodology, in particular in estimating factors such as Manning's n which requires a significant amount of engineering judgement.

There was no detailed data available within the study area that could be used directly to calibrate the models, however model checks and validation was carried out on the basis of available information.

Comparison of results was made against those documented in the Updated South Creek Flood Study (WP, 2015). Levels were compared upstream of Elizabeth Drive and are shown in the following table.

Table A-1 Validation of model

Flood event	GHD existing case model, flood level (m AHD)	Updated South Creek Flood Study, flood level (m AHD)
100 year ARI event	47.0	46.6

The modelled water level was higher for the current study, which was expected as the value quoted for the Updated South Creek Flood Study was for a 36-hour duration flood event, which is not critical for the Badgerys Creek catchment. The value quoted for the current study is for a 6-hour storm duration event, which is critical for the catchment.

Other important points to note include:

- the representation of bridges and culverts in the Updated South Creek Flood Study is understood to be based on review of LiDAR rather than detailed information;
- the model validation undertaken for the Updated South Creek Flood Study was to the South Creek Flood Study (1991) which was calibrated to data on South Creek; and
- the focus of the Updated South Creek Flood Study was not Badgerys Creek, Cosgroves Creek or the airport site and it included only limited reaches of these creeks and the airport site within the study.

Whilst general agreement with the findings of the Updated South Creek Flood Study was considered appropriate, for the above reasons it was not considered appropriate to calibrate or otherwise amend the parameters used in this study to match exactly the findings of the Updated South Creek Flood Study.

Predicted water levels for number of model cross-sections of the streamline in a 1 year ARI event were checked against visual inspections on site of bank full levels and were considered generally reasonable.

Rainfall data from the Twin Creeks Golf Course and Country Club was provided for the event of the 21 April 2015 and 22 April 2015 (see section 3.2.3) and was compared to the data from the BOM AWS Badgerys Creek gauge. The gauge recordings are included in Table A-1-2.

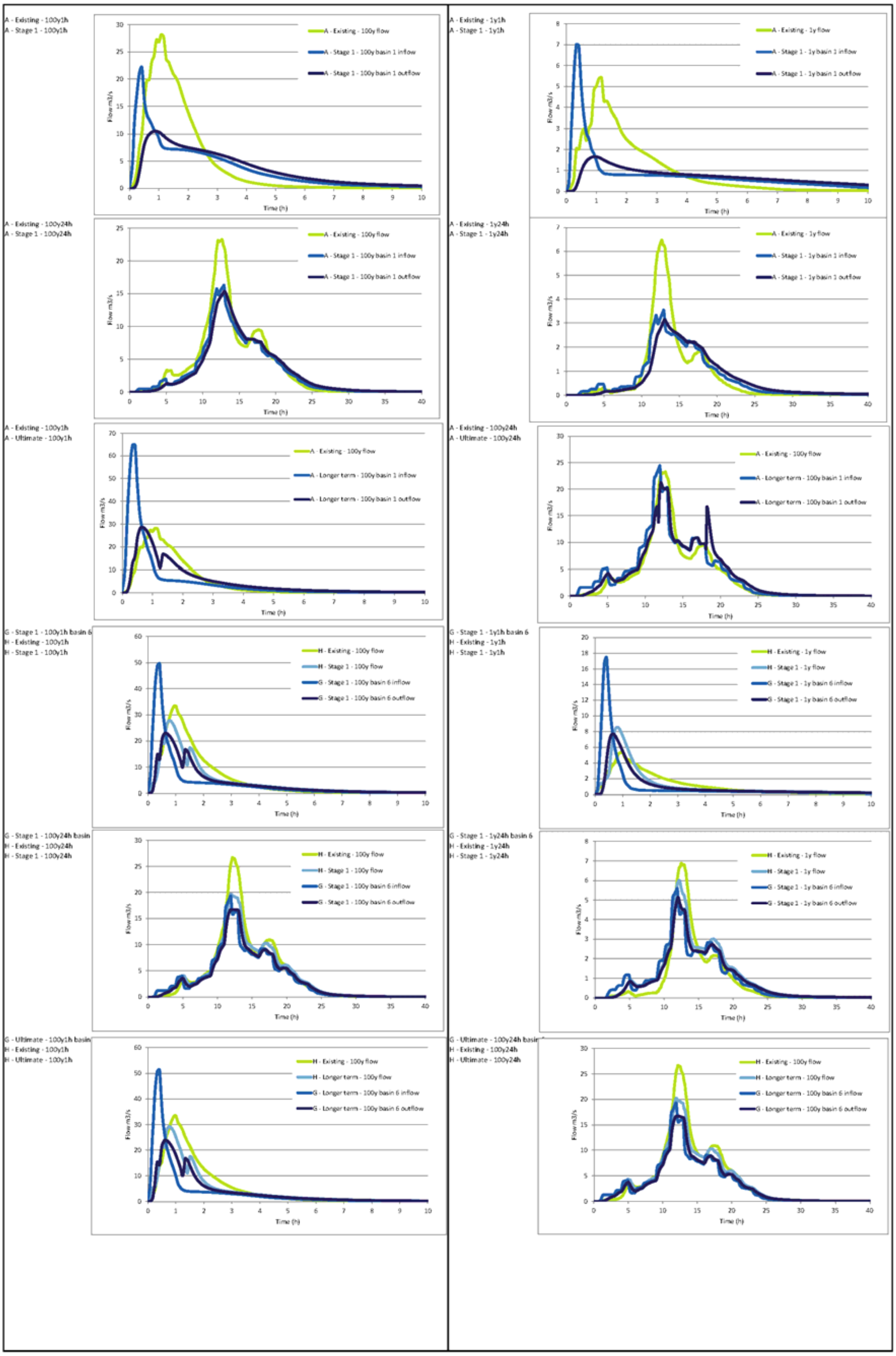
Table A-1-2 Rainfall totals for 21 and 22 April 2015

Gauge	Rainfall total (mm) in 24-hour period	Rainfall total (mm) in 48-hour period
Twin Creeks Golf Course and Country Club rainfall gauge	77	134
Badgerys Creek AWS	84	135

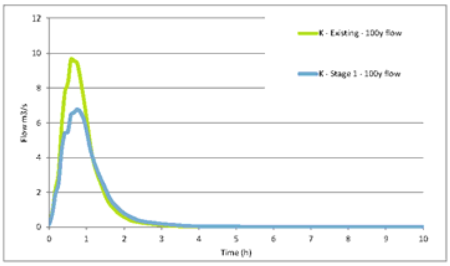
Compared to the BOM IFD for the airport site, these totals equate to around a 5 year ARI event or slightly larger.

Locations of debris marks observed on Badgerys Creek, believed to be from the recent flood events, were compared to modelled 5 year ARI flood events and agreement was found to be reasonable.

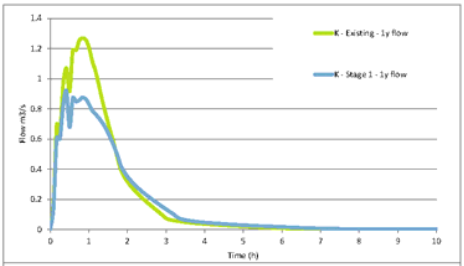
Appendix B – Hydrology results


A - Existing - 100y1h
A - Stage 1 - 100y1h
A - Existing - 100y flow
A - Stage 1 - 100y basin 1 inflow
A - Stage 1 - 100y basin 1 outflow
A - Existing - 1y1h
A - Stage 1 - 1y1h
A - Existing - 1y flow
A - Stage 1 - 1y basin 1 inflow
A - Stage 1 - 1y basin 1 outflow
A - Existing - 100y24h
A - Stage 1 - 100y24h
A - Existing - 1y24h
A - Stage 1 - 1y24h
A - Existing - 100y1h
A - Ultimate - 100y1h
A - Longer term - 100y basin 1 inflow
A - Longer term - 100y basin 1 outflow
A - Existing - 100y24h
A - Ultimate - 100y24h
G - Stage 1 - 100y1h basin 6
H - Existing - 100y1h
H - Stage 1 - 100y1h
H - Existing - 100y flow
H - Stage 1 - 100y flow
G - Stage 1 - 100y basin 6 inflow
G - Stage 1 - 100y basin 6 outflow
G - Stage 1 - 1y1h basin 6
H - Existing - 1y1h
H - Stage 1 - 1y1h
H - Existing - 1y flow
H - Stage 1 - 1y flow
G - Stage 1 - 1y basin 6 inflow
G - Stage 1 - 1y basin 6 outflow
G - Stage 1 - 100y24h basin
H - Existing - 100y24h
H - Stage 1 - 100y24h
G - Stage 1 - 1y24h basin 6
H - Existing - 1y24h
H - Stage 1 - 1y24h
G - Ultimate - 100y1h basin
H - Existing - 100y1h
H - Ultimate - 100y1h
H - Longer term - 100y flow
G - Longer term - 100y basin 6 inflow
G - Longer term - 100y basin 6 outflow
G - Ultimate - 100y24h basin
H - Existing - 100y24h
H - Ultimate - 100y24h
Flow m3/s
Time (h)

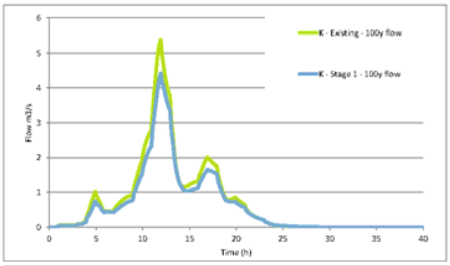
K - Existing - 100y1h
K - Stage 1 - 100y1h



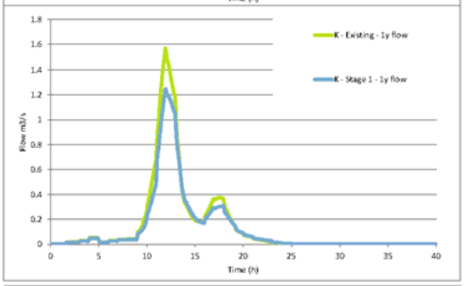
K - Existing - 1y1h
K - Stage 1 - 1y1h



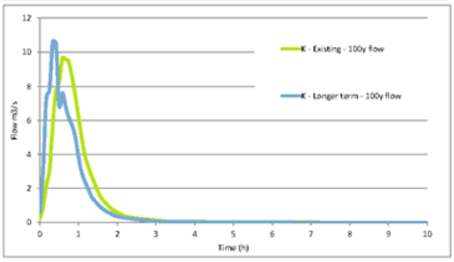
K - Existing - 100y24h
K - Stage 1 - 100y24h



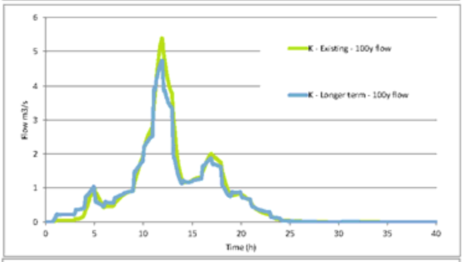
K - Existing - 1y24h
K - Stage 1 - 1y24h



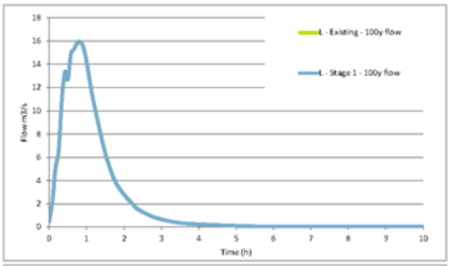
K - Existing - 100y1h
K - Ultimate - 100y1h



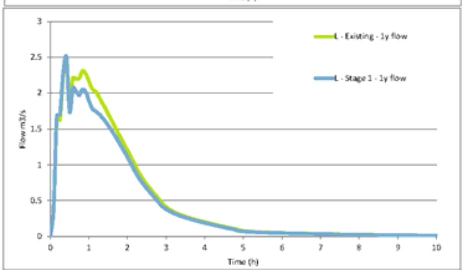
K - Existing - 100y24h
K - Ultimate - 100y24h



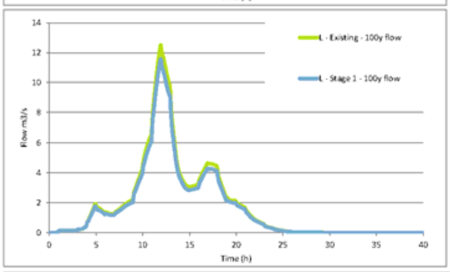
L - Existing - 100y1h
L - Stage 1 - 100y1h



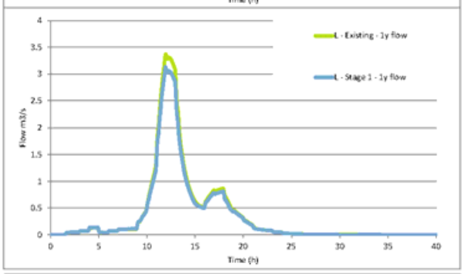
L - Existing - 1y1h
L - Stage 1 - 1y1h



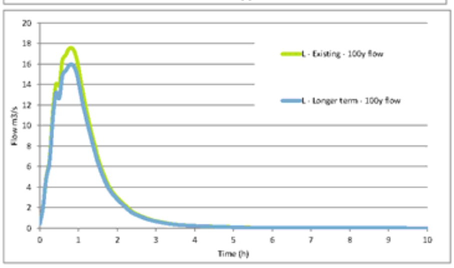
L - Existing - 100y24h
L - Stage 1 - 100y24h



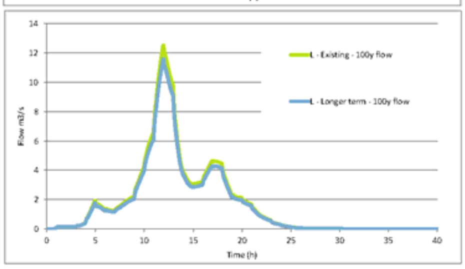
L - Existing - 1y24h
L - Stage 1 - 1y24h



L - Existing - 100y1h
L - Ultimate - 100y1h



L - Existing - 100y24h
L - Ultimate - 100y24h



Appendix C – Hydraulic model results

LEGEND

Airport site **NM^2**

- 20 - 100
- 100 - 150
- 150 - 200
- >200

Paper Size A3

0 250 500 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

Job Number	21-24265
Revision	A
Date	05 Aug 2015

Existing watercourse shear stress maps, 1-year ARI

Figure C-1

N:\AU\Sydney\Projects\21\24265\GIS\Maps\Deliverables\KBM.mxd [KBM: 42]

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Data source: Data source: General Topo - NSW LPI DTDB 2012, Imagery - ESRI 2015 Created by: afoddy

LEGEND

Airport site

NM²

Yellow	20 - 100
Orange	100 - 150
Magenta	150 - 200
Blue	>200

Paper Size A3

0 250 500 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

Job Number	21-24265
Revision	A
Date	05 Aug 2015

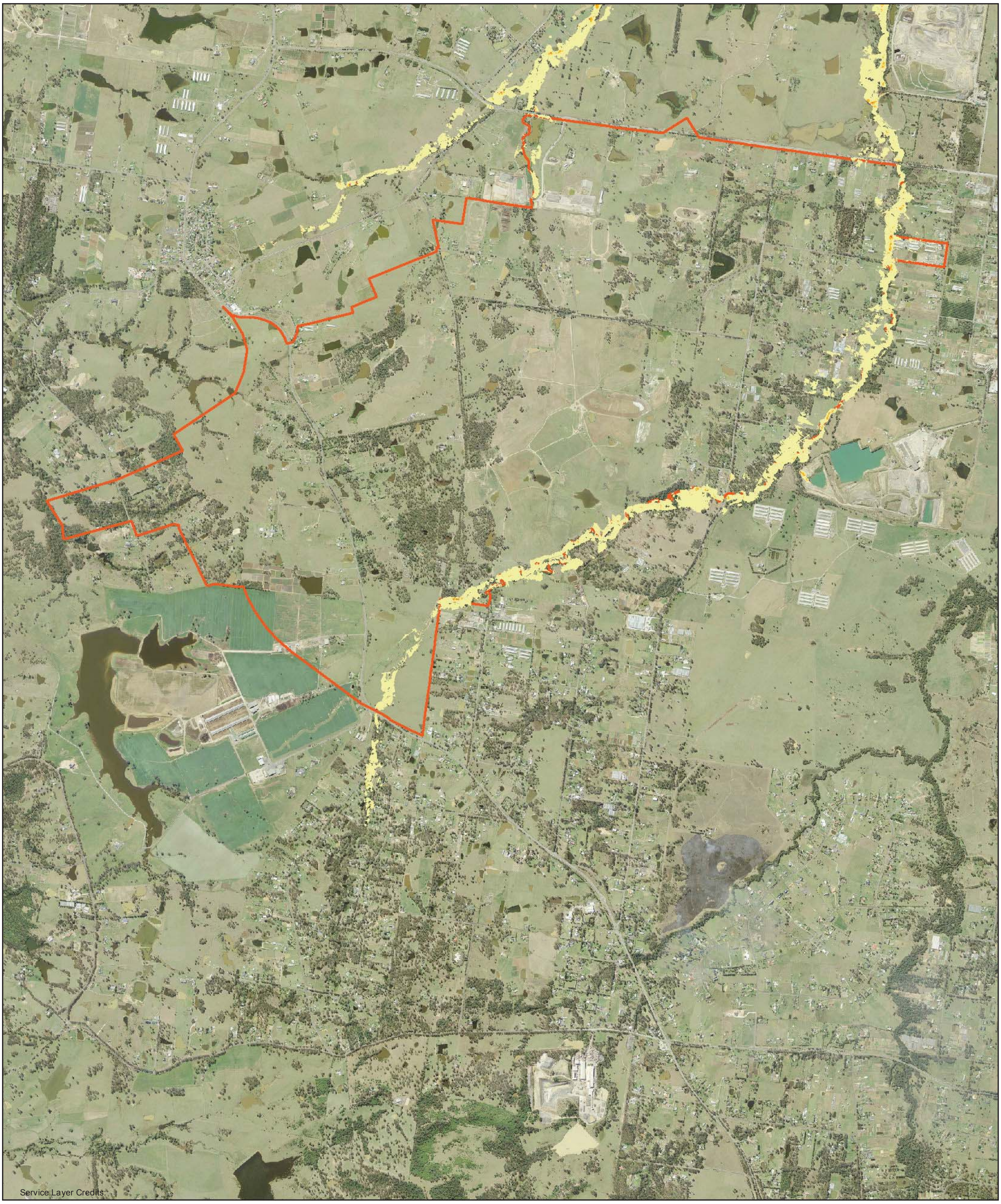
Existing watercourse shear stress maps,
5-year ARI

Figure C-2

N:\AU\Sydney\Projects\21\24265\GIS\Maps\Deliverables\KBM.mxd [KBM: 43]

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

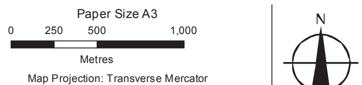
Data source: Data source: General Topo - NSW LPI DTDB 2012, Imagery - ESRI 2015 Created by: afoddy



LEGEND

Airport site **NM²**

- 20 - 100
- 100 - 150
- 150 - 200
- >200



Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

Job Number	21-24265
Revision	A
Date	05 Aug 2015

Existing watercourse shear stress maps, 100-year ARI

Figure C-3

N:\AU\Sydney\Projects\21\24265\GIS\Maps\Deliverables\KBM.mxd [KBM: 44]

Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

Data source: Data source: General Topo - NSW LPI DTDB 2012, Imagery - ESRI 2015 Created by: afoddy

LEGEND

Airport site	Flood depth (m)	0.6 - 0.8	2 - 2.5
	0.1 - 0.2	0.8 - 1	2.5 - 3
	0.2 - 0.4	1 - 1.5	3 - 4
	0.4 - 0.6	1.5 - 2	>4

Paper Size A3

0 250 500 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

Job Number	21-24265
Revision	A
Date	05 Aug 2015

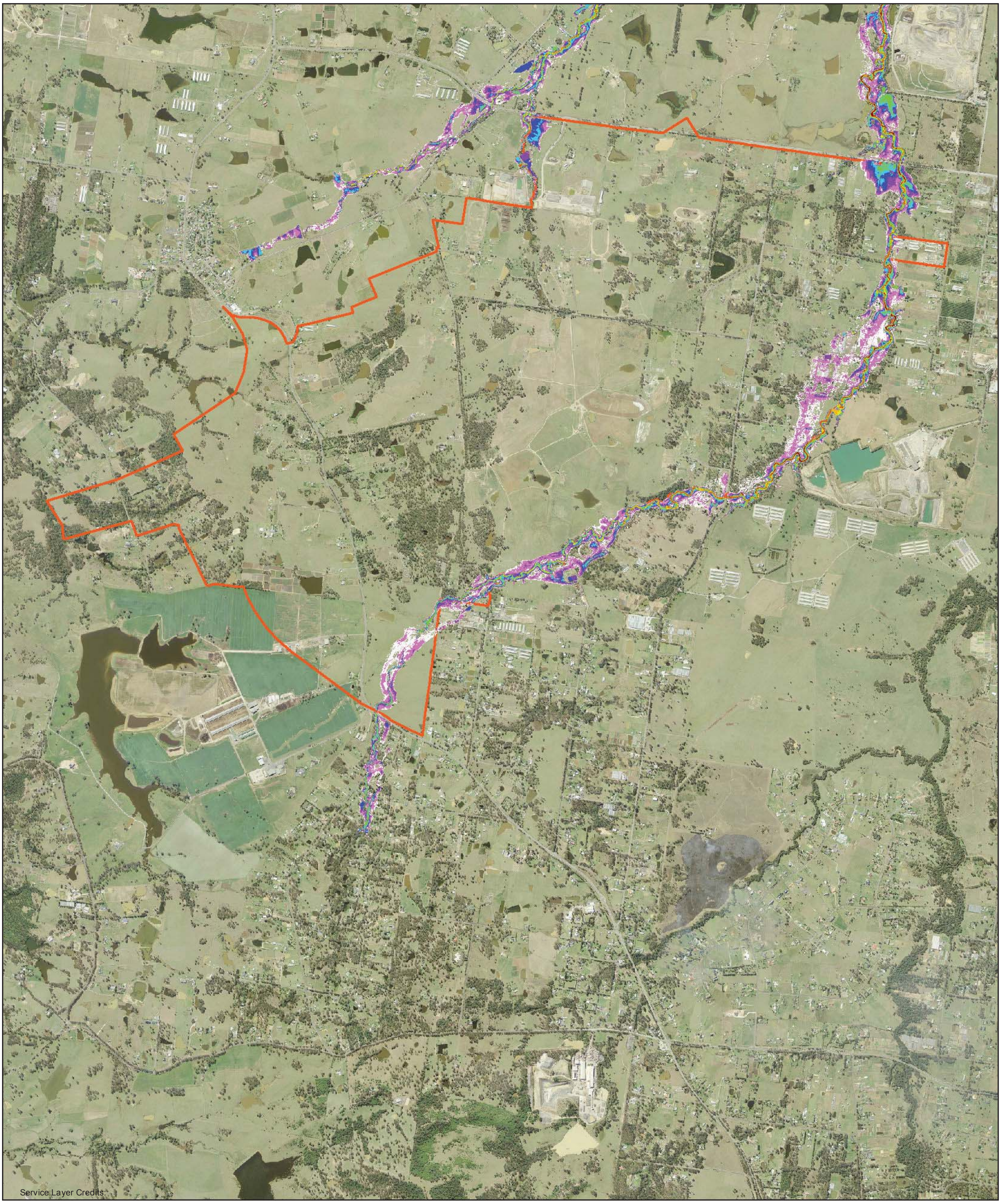
Stage 1 flood depths
1-year ARI event

Figure C-4

N:\AU\Sydney\Projects\21\24265\GIS\Maps\Deliverables\KBM.mxd [KBM: 55]

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Data source: Data source: General Topo - NSW LPI DTDB 2012, Imagery - ESRI 2015 Created by: afoddy



LEGEND

Airport site

Flood depth (m)

- 0.1 - 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 4
- >4

Paper Size A3

0 250 500 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

GHD

Job Number	21-24265
Revision	A
Date	05 Aug 2015

Stage 1 flood depths
5-year ARI event

Figure C-5

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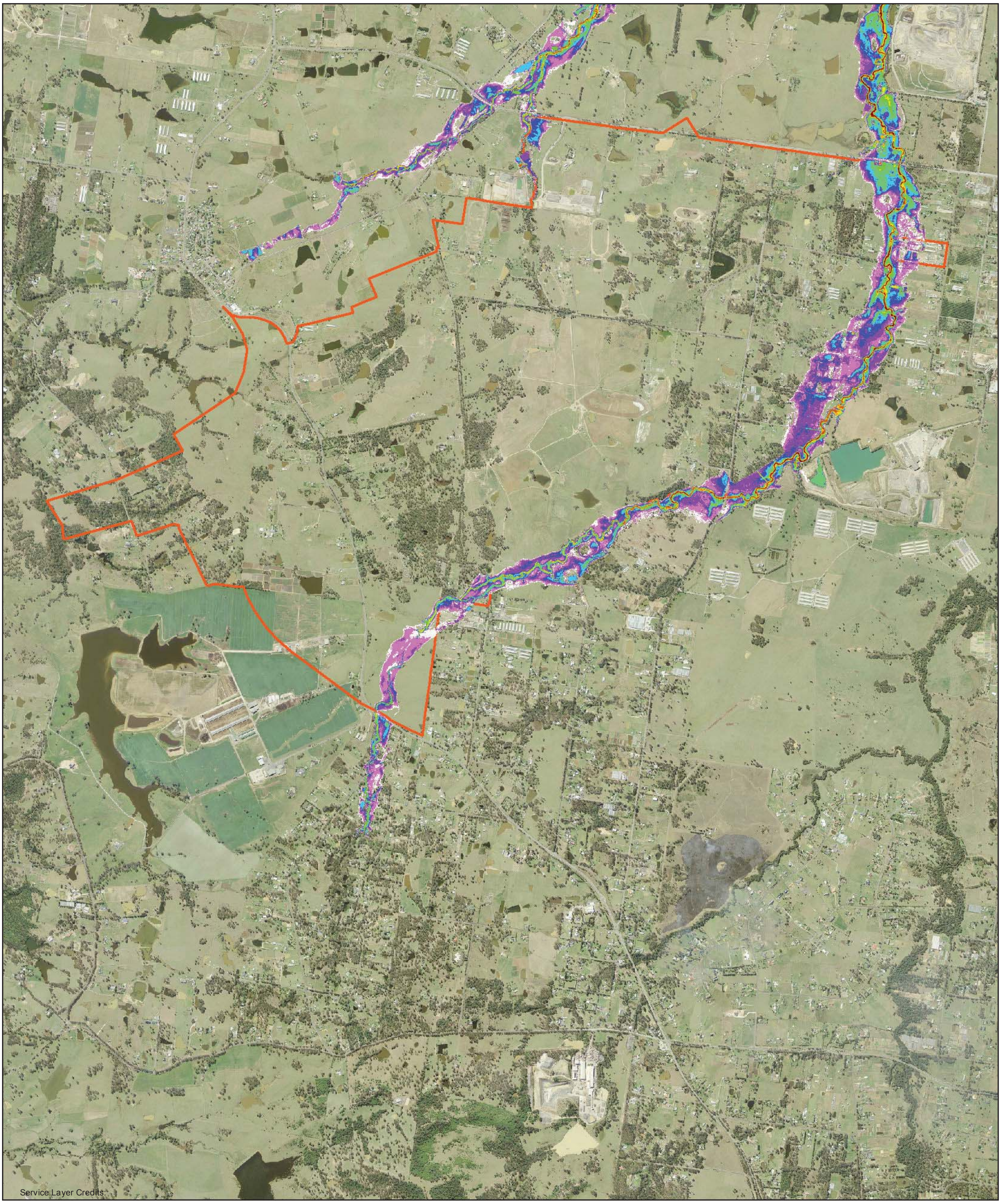
Data source: Data source: General Topo - NSW LPI DTDB 2012, Imagery - ESRI 2015 Created by: afoddy



LEGEND

Airport site	Flood depth (m)	0.6 - 0.8	2 - 2.5
	0.1 - 0.2	0.8 - 1	2.5 - 3
	0.2 - 0.4	1 - 1.5	3 - 4
	0.4 - 0.6	1.5 - 2	>4

Paper Size A3

0 250 500 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

Job Number 21-24265
Revision A
Date 05 Aug 2015

Stage 1 flood depths
100-year ARI event

Figure C-6

N:\AU\Sydney\Projects\21\24265\GIS\Maps\Deliverables\KBM.mxd [KBM: 57]

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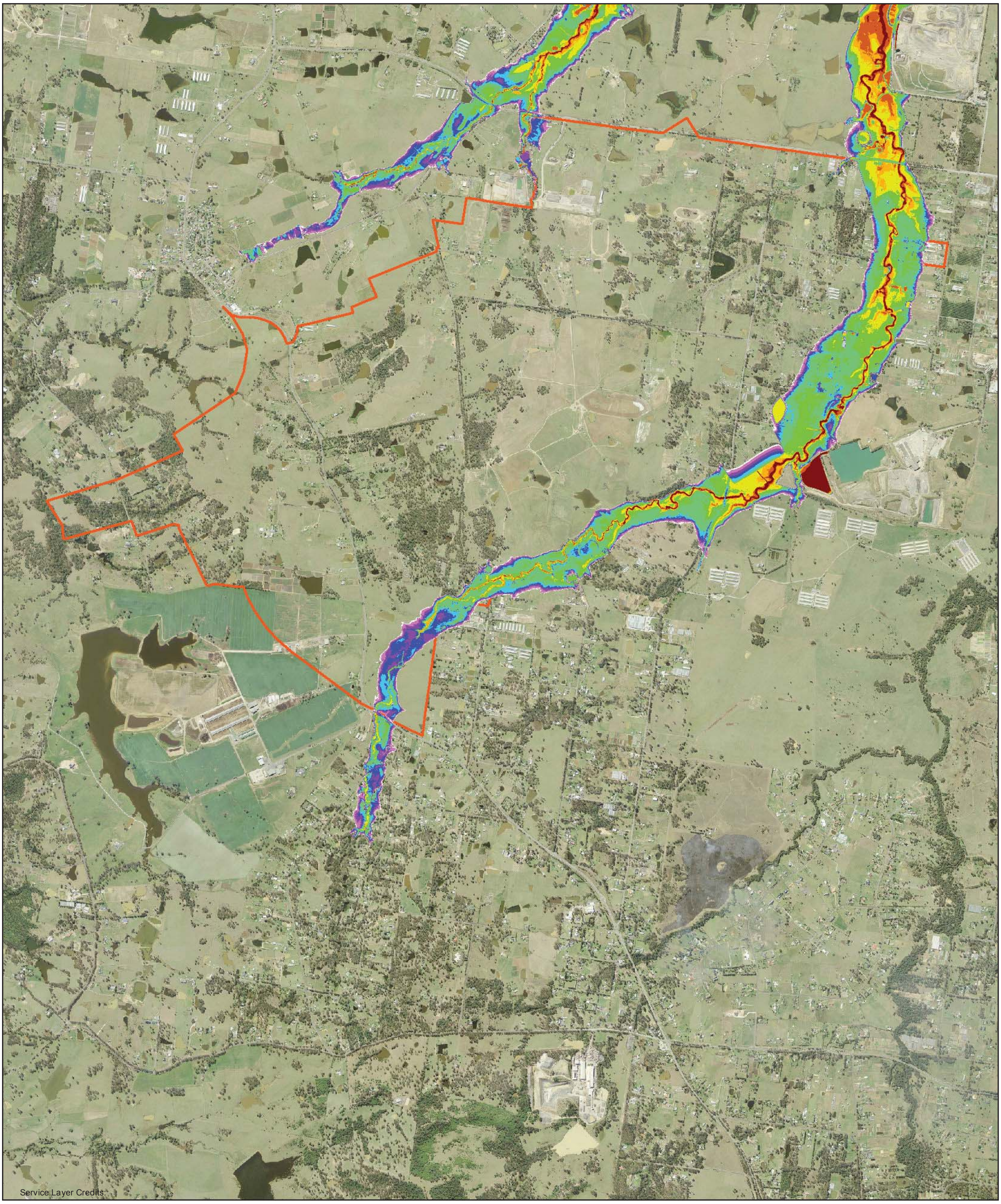
Data source: Data source: General Topo - NSW LPI DTDB 2012, Imagery - ESRI 2015 Created by: afoddy



LEGEND

Airport site **Flood depth (m)**

- 0.1 - 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 4
- >4

Paper Size A3

0 250 500 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

GHD

Job Number	21-24265
Revision	A
Date	05 Aug 2015

Stage 1 flood depths
PMF

Figure C-7

N:\AU\Sydney\Projects\21\24265\GIS\Maps\Deliverables\KBM.mxd [KBM: 58]

Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

Data source: Data source: General Topo - NSW LPI DTDB 2012, Imagery - ESRI 2015 Created by: afoddy

LEGEND

Airport site	**NM²**	-5 to 5
	< -20	5 to 10
	-20 to -10	10 to 20
	-10 to -5	>20

Paper Size A3

0 250 500 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

Job Number	21-24265
Revision	A
Date	05 Aug 2015

Change in shear stress, existing and Stage 1, 1-year ARI

Figure C-8

N:\AU\Sydney\Projects\21\24265\GIS\Maps\Deliverables\KBM.mxd [KBM: 45]

Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

Data source: Data source: General Topo - NSW LPI DTDB 2012, Imagery - ESRI 2015 Created by: afoddy

LEGEND

Airport site

NM²

< -20

-20 to -10

-10 to -5

-5 to 5

5 to 10

10 to 20

>20

Paper Size A3

0 250 500 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

GHD

Job Number 21-24265
Revision A
Date 05 Aug 2015

Change in shear stress, existing and Stage 1, 5-year ARI

Figure C-9

N:\AU\Sydney\Projects\21\24265\GIS\Maps\Deliverables\KBM.mxd [KBM: 46]

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Data source: Data source: General Topo - NSW LPI DTDB 2012, Imagery - ESRI 2015 Created by: afoddy

LEGEND

Airport site	NM²	
	< -20	-5 to 5
	-20 to -10	5 to 10
	-10 to -5	10 to 20
		>20

Paper Size A3

0 250 500 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

Job Number	21-24265
Revision	A
Date	05 Aug 2015

Change in shear stress, existing and Stage 1, 100-year ARI

Figure C-10

N:\AU\Sydney\Projects\21\24265\GIS\Maps\Deliverables\KBM.mxd [KBM: 47]

Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

Data source: Data source: General Topo - NSW LPI DTDB 2012, Imagery - ESRI 2015 Created by: afoddy

LEGEND

Airport site	**Flood depth (m)**	0.6 - 0.8	2 - 2.5
	0.1 - 0.2	0.8 - 1	2.5 - 3
	0.2 - 0.4	1 - 1.5	3 - 4
	0.4 - 0.6	1.5 - 2	>4

Paper Size A3

0 250 500 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

GHD

Job Number	21-24265
Revision	A
Date	05 Aug 2015

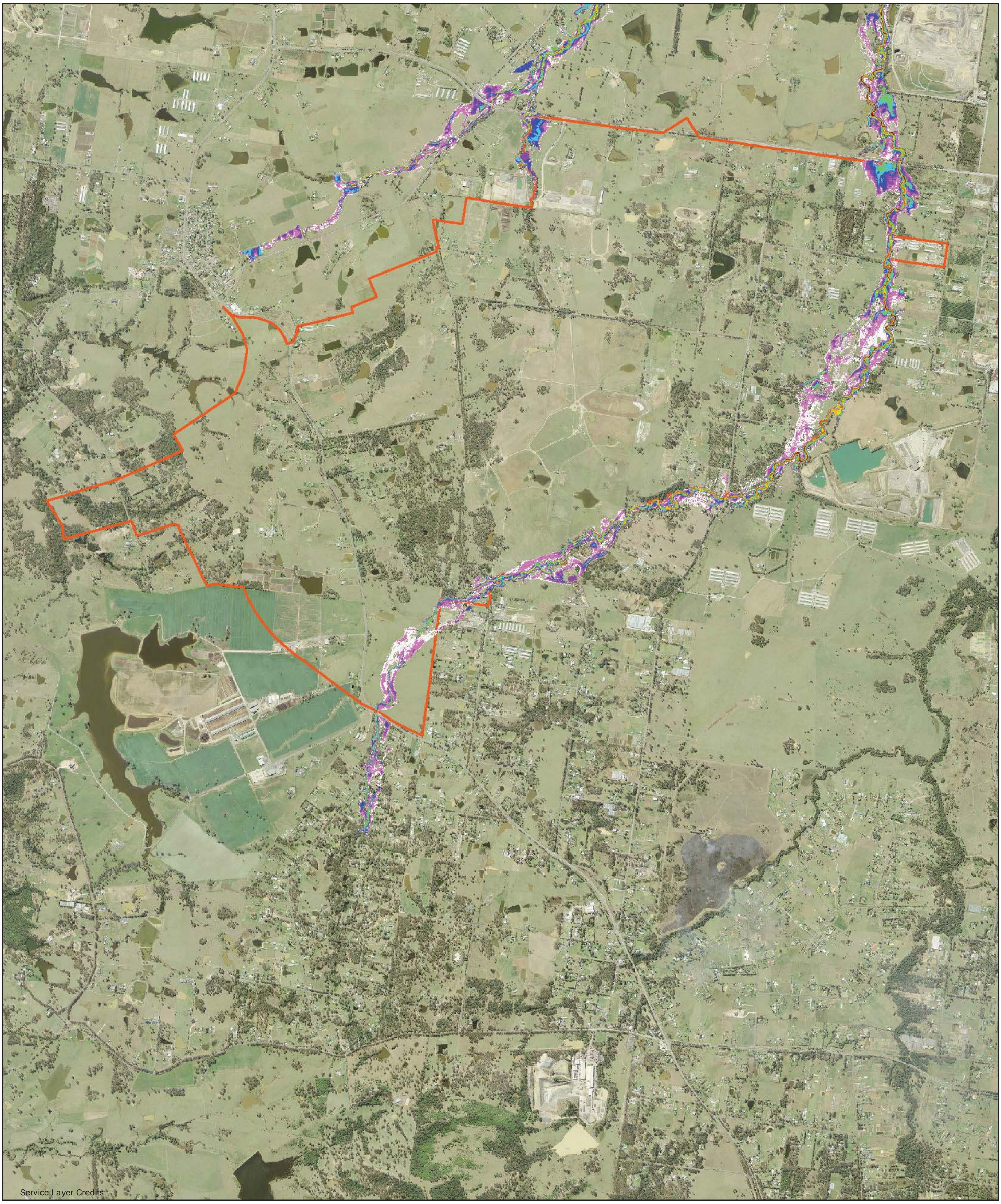
Longer Term flood results
1-year ARI event

Figure C-11

N:\AU\Sydney\Projects\21\24265\GIS\Maps\Deliverables\KBM.mxd [KBM: 62]

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Data source: Data source: General Topo - NSW LPI DTDB 2012, Imagery - ESRI 2015 Created by: afoddy



LEGEND

Airport site	Flood depth (m)	0.6 - 0.8	2 - 2.5
	0.1 - 0.2	0.8 - 1	2.5 - 3
	0.2 - 0.4	1 - 1.5	3 - 4
	0.4 - 0.6	1.5 - 2	>4

Paper Size A3

0 250 500 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

Job Number	21-24265
Revision	A
Date	05 Aug 2015

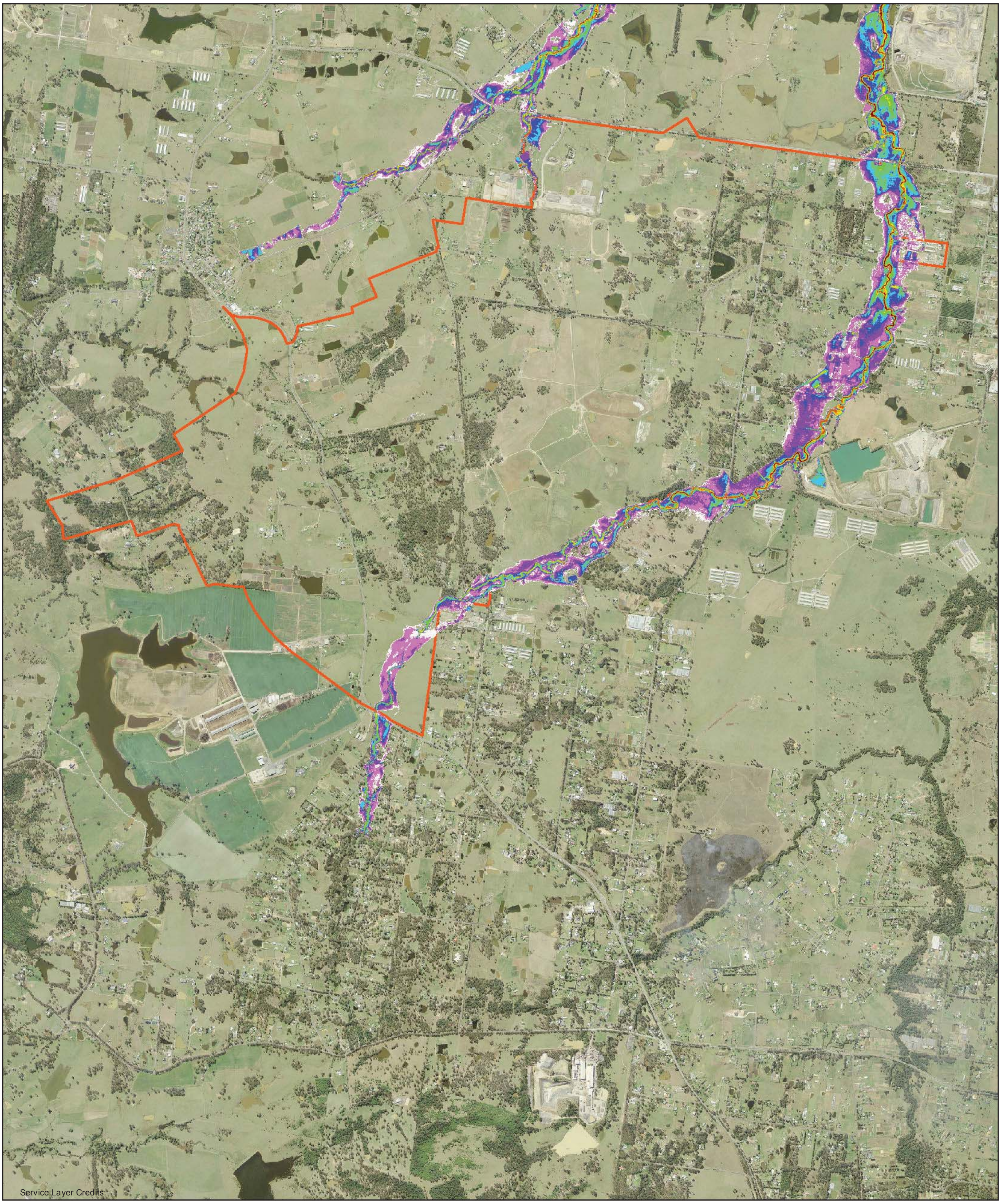
Longer Term flood results
5-year ARI event

Figure C-12

N:\AU\Sydney\Projects\21\24265\GIS\Maps\Deliverables\KBM.mxd [KBM: 63]

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Data source: Data source: General Topo - NSW LPI DTDB 2012, Imagery - ESRI 2015 Created by: afoddy



LEGEND

Airport site	**Flood depth (m)**	0.6 - 0.8	2 - 2.5
	0.1 - 0.2	0.8 - 1	2.5 - 3
	0.2 - 0.4	1 - 1.5	3 - 4
	0.4 - 0.6	1.5 - 2	>4

Paper Size A3

0 250 500 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

Job Number	21-24265
Revision	A
Date	05 Aug 2015

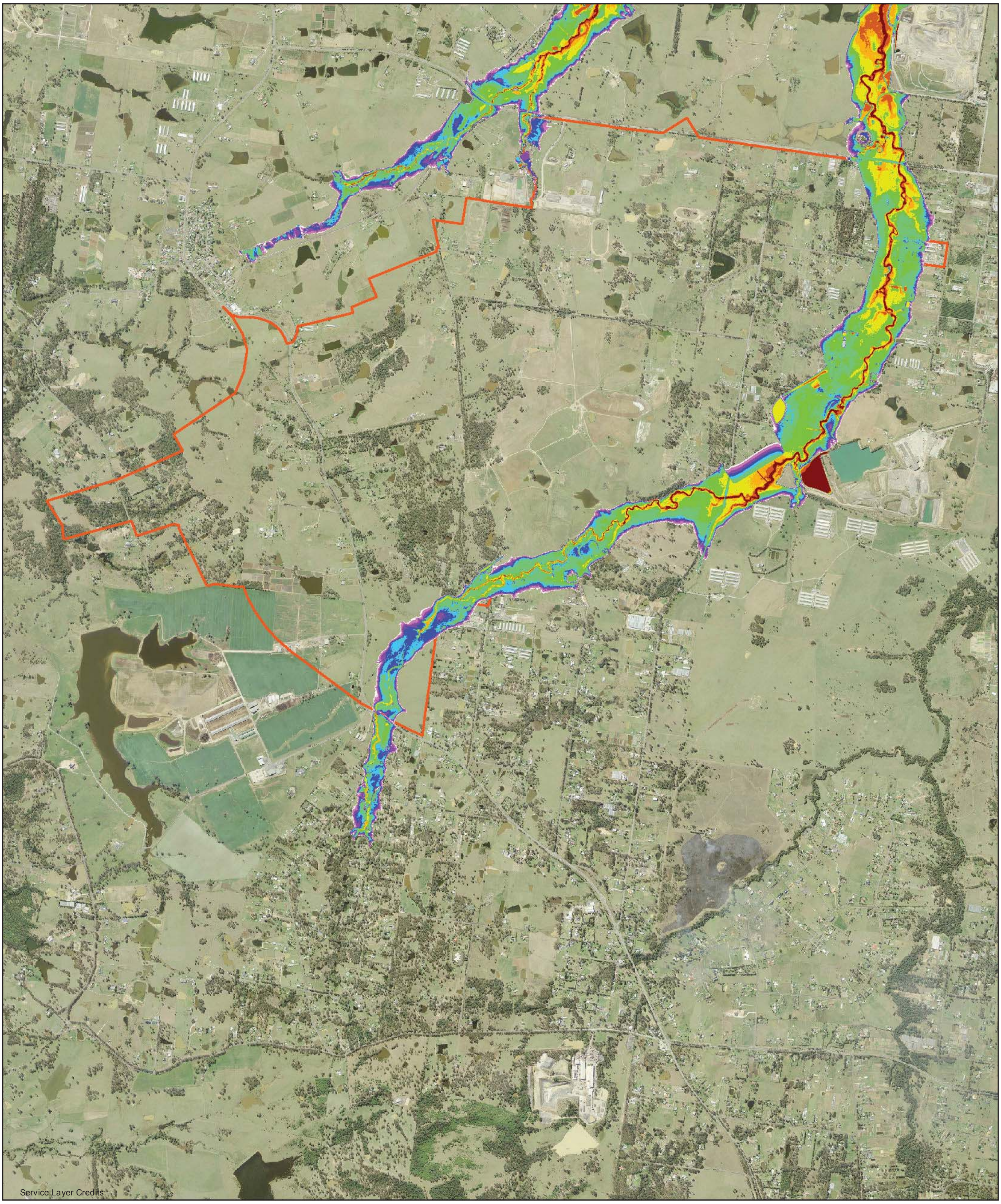
Longer Term flood results
100-year ARI event

Figure C-13

N:\AU\Sydney\Projects\21\24265\GIS\Maps\Deliverables\KBM.mxd [KBM: 64]

Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

Data source: Data source: General Topo - NSW LPI DTDB 2012, Imagery - ESRI 2015 Created by: afoddy



LEGEND

Airport site	**Flood depth (m)**	0.6 - 0.8	2 - 2.5
	0.1 - 0.2	0.8 - 1	2.5 - 3
	0.2 - 0.4	1 - 1.5	3 - 4
	0.4 - 0.6	1.5 - 2	>4

Paper Size A3

0 250 500 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

Job Number	21-24265
Revision	A
Date	05 Aug 2015

Longer Term flood results
PMF

Figure C-14

N:\AU\Sydney\Projects\21\24265\GIS\Maps\Deliverables\KBM.mxd [KBM: 65]

Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

Data source: Data source: General Topo - NSW LPI DTDB 2012, Imagery - ESRI 2015 Created by: afoddy

LEGEND

Airport site

NM²

< -20	-5 to 5
-20 to -10	5 to 10
-10 to -5	10 to 20
	>20

Paper Size A3

0 250 500 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

GHD

Job Number 21-24265
Revision A
Date 05 Aug 2015

Change in shear stress, existing and Longer Term, 1-year ARI

Figure C-15

N:\AU\Sydney\Projects\21\24265\GIS\Maps\Deliverables\KBM.mxd [KBM: 48]

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Data source: Data source: General Topo - NSW LPI DTDB 2012, Imagery - ESRI 2015 Created by: afoddy

LEGEND

- Airport site
- **NM²**
  - < -20
  - -20 to -10
  - -10 to -5
  - -5 to 5
  - 5 to 10
  - 10 to 20
  - >20

Paper Size A3

0 250 500 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

Job Number	21-24265
Revision	A
Date	05 Aug 2015

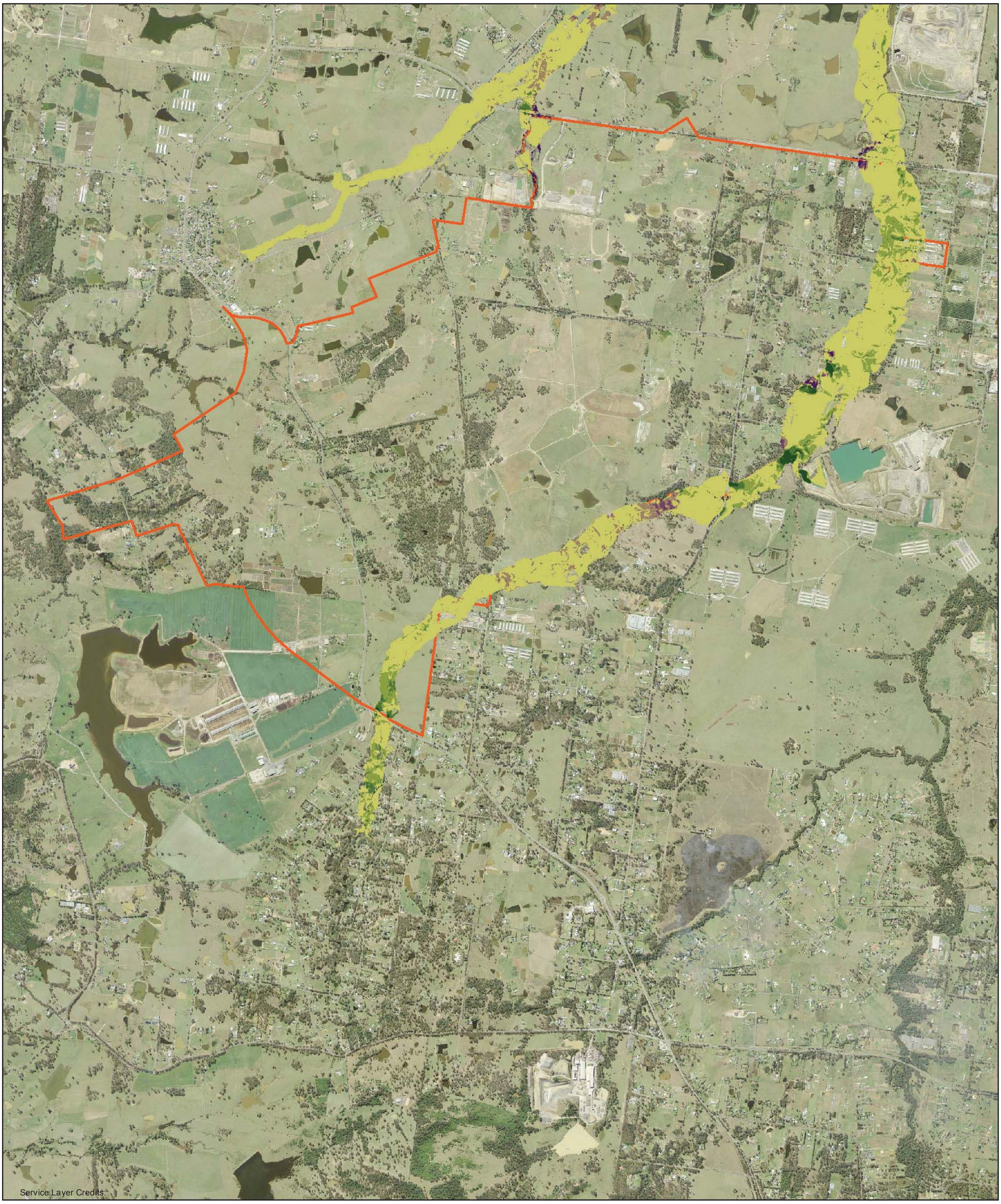
Change in shear stress, existing and Longer Term, 5-year ARI

Figure C-16

N:\AU\Sydney\Projects\21\24265\GIS\Maps\Deliverables\KBM.mxd [KBM: 49]

Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

Data source: Data source: General Topo - NSW LPI DTDB 2012, Imagery - ESRI 2015 Created by: afoddy



LEGEND

Airport site	NM²	-5 to 5
	< -20	5 to 10
	-20 to -10	10 to 20
	-10 to -5	>20

Paper Size A3

0 250 500 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

Job Number 21-24265
Revision A
Date 05 Aug 2015

Change in shear stress, existing and Longer Term, 100-year ARI

Figure C-17

N:\AU\Sydney\Projects\21\24265\GIS\Maps\Deliverables\KBM.mxd [KBM: 50]

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Data source: Data source: General Topo - NSW LPI DTDB 2012, Imagery - ESRI 2015 Created by: afoddy

Appendix D – Hydrographs from hydraulic model

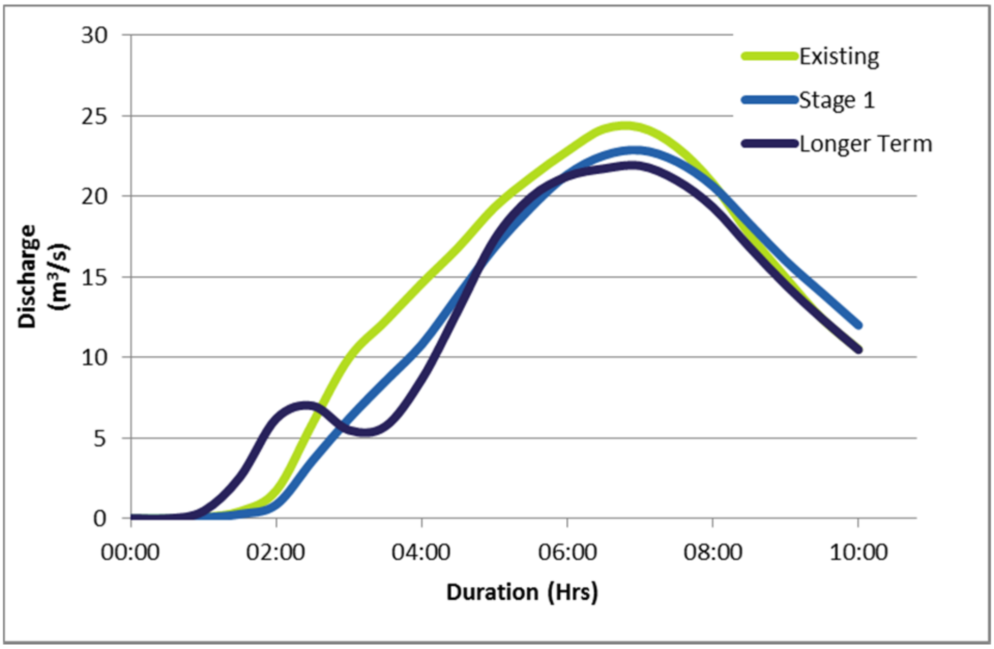


Figure D-1 Badgerys Creek 1 year ARI results downstream of Elizabeth Drive

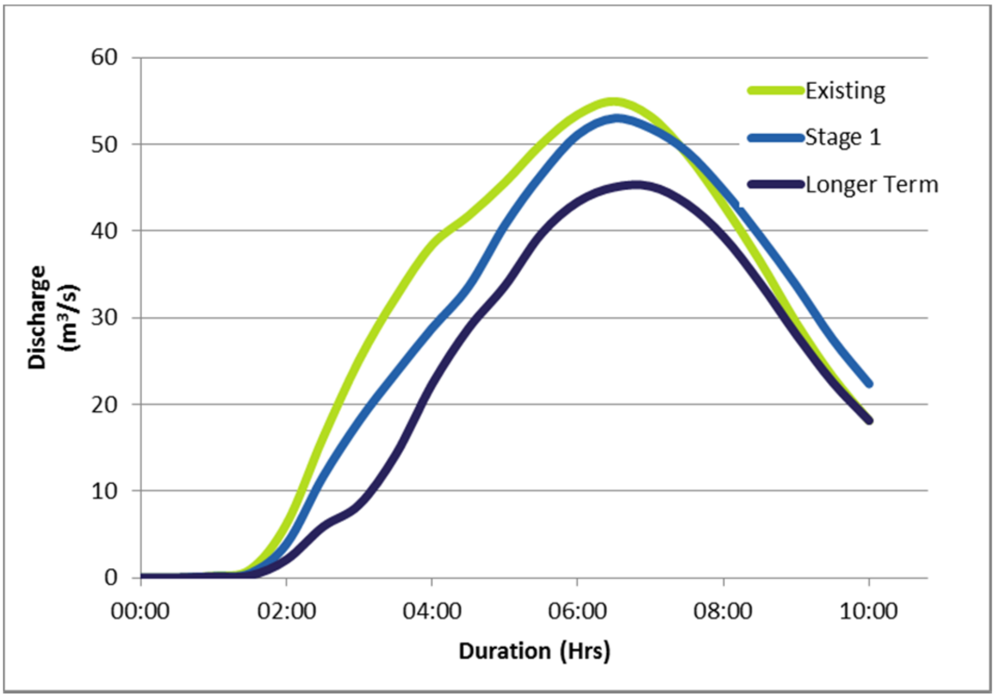


Figure D-2 Badgerys Creek 5 year ARI results downstream of Elizabeth Drive

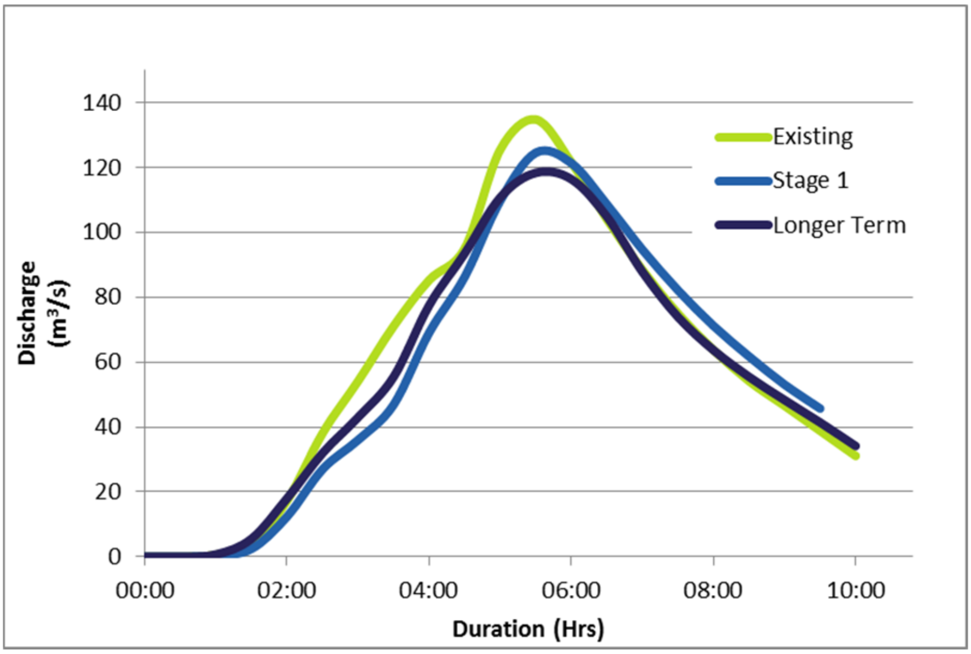


Figure D-3 Badgerys Creek 100 year ARI results downstream of Elizabeth Drive

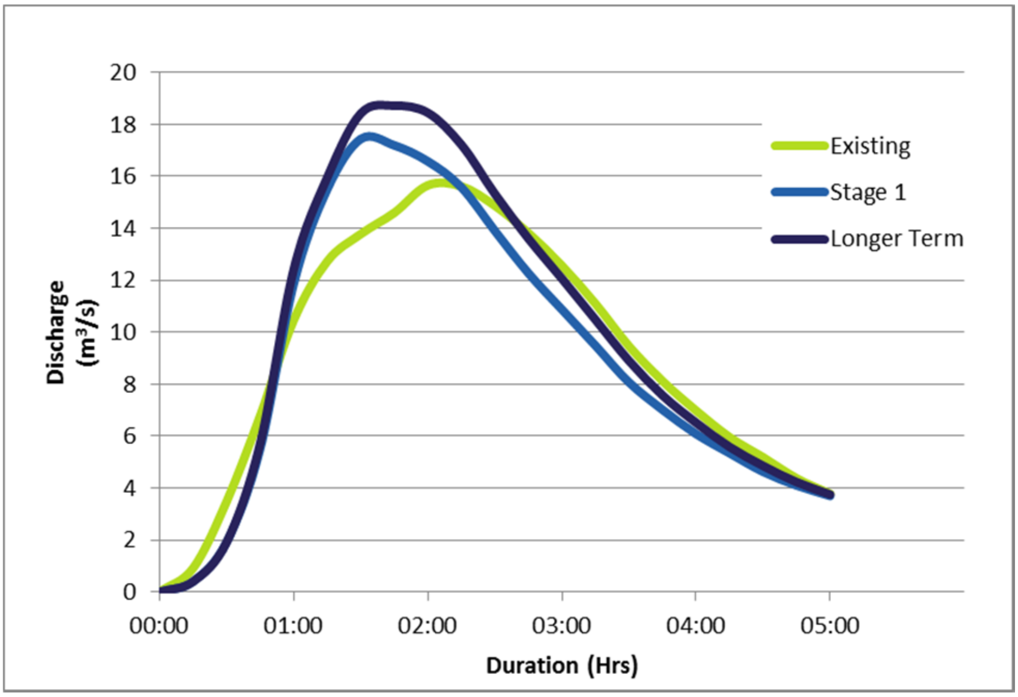


Figure D-4 Cosgroves Creek 1 year ARI results downstream of confluence with Oaky Creek

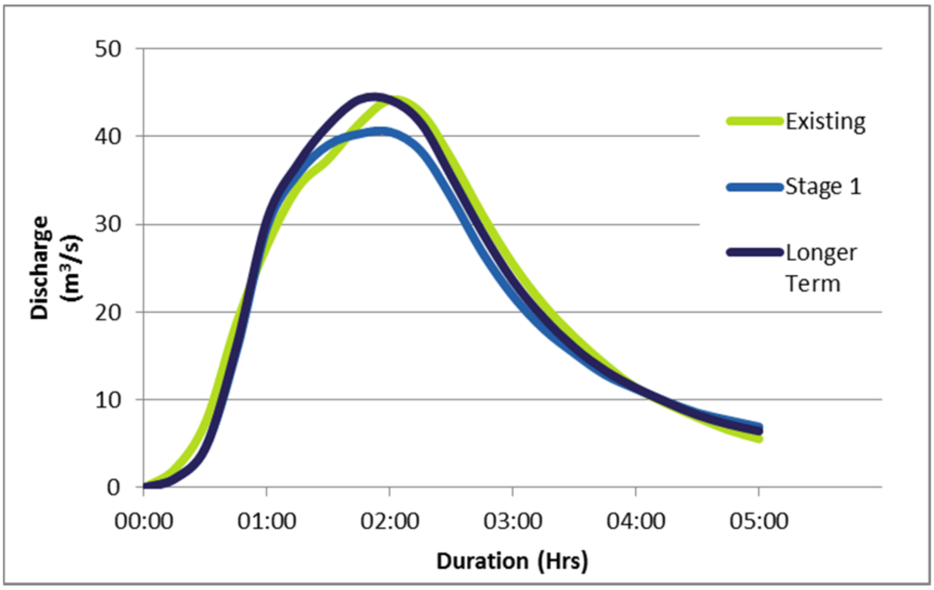


Figure D-5 Cosgroves Creek 5 year ARI results downstream of confluence with Oaky Creek

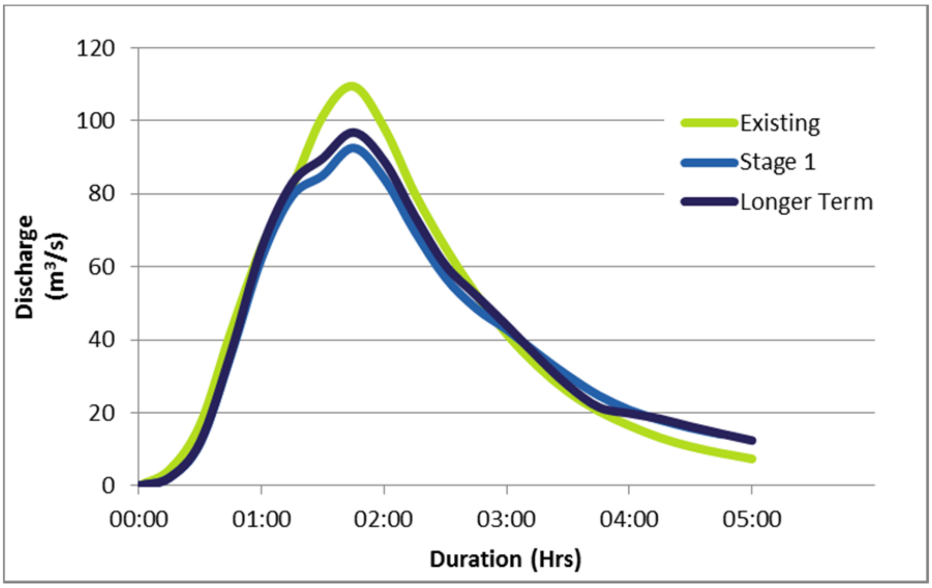


Figure D-6 Cosgroves Creek 100 year ARI results downstream of confluence with Oaky Creek

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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
A Internal Draft	L Thomas G Lampert N Bailey	N Bailey		G. Marshall		17/05/2015
B	L Thomas G Lampert N Bailey	N Bailey		G. Marshall		22/07/2015
C	L Thomas G Lampert N Bailey	N Bailey		G. Marshall		13/08/2015
D	L Thomas G Lampert N Bailey	N Bailey		G. Marshall		28/08/2015

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