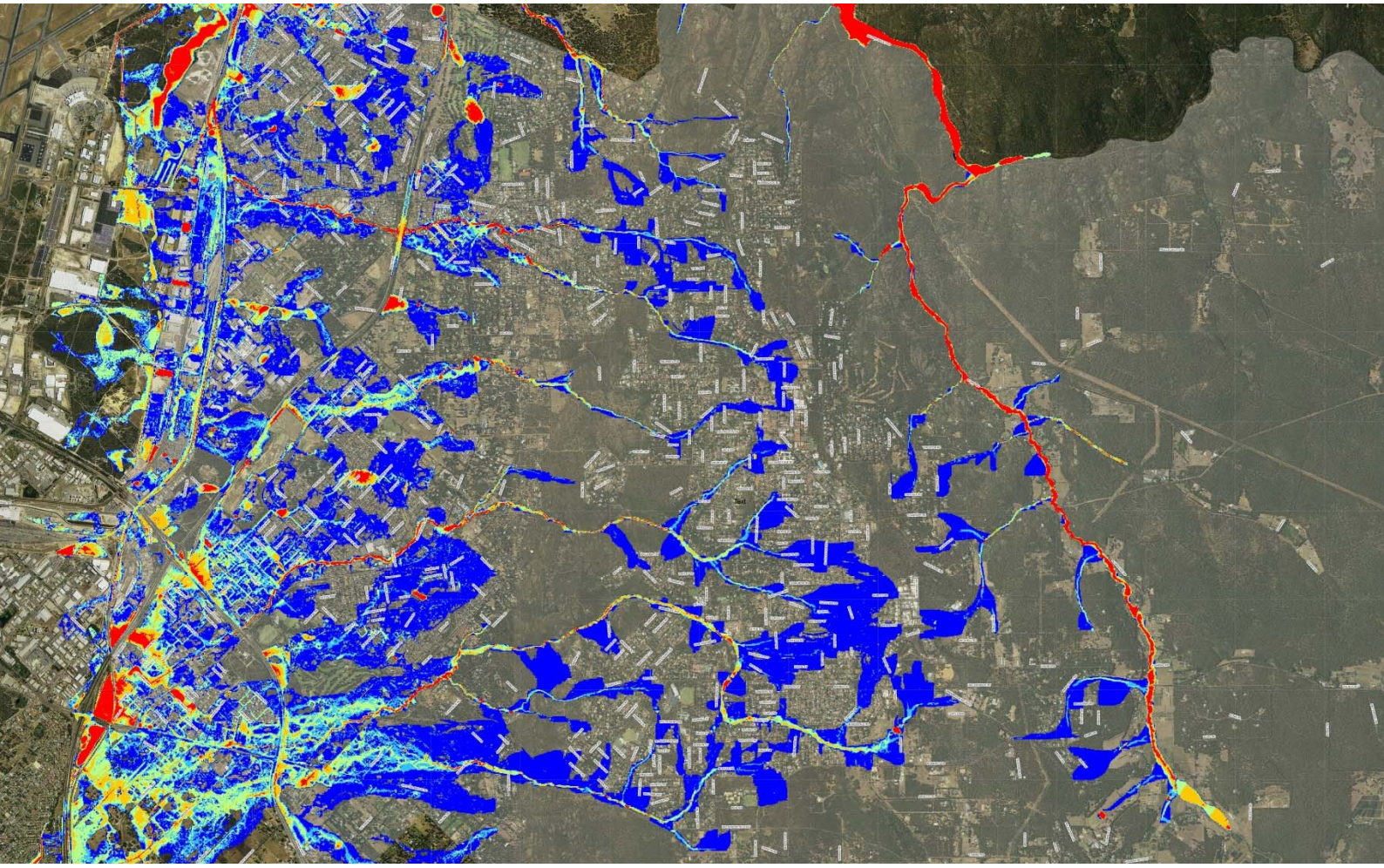

Shire of Kalamunda

Detailed Flood Study of the Kalamunda Region

Existing Drainage System Review Report

May 2016

Executive summary

The Shire of Kalamunda engaged GHD to carryout Detailed Flood Study of the Kalamunda Region. This study is an important initiation to evaluate the existing drainage system within the area and to identify key drainage issues and potential future upgrades. This study will review the nature, extent and efficiency of the existing storm water drainage system, using a robust, reliable and innovative modelling methodology.

The Kalamunda Region stormwater system is predominantly piped network, which is typical within urban residential areas with number of main drains passing through the study area, including Poison Gully; Crumpet Creek; Woodlupine Brook, Whistlepipe Gully; and Yule Brook.

The outcomes of this study are intended to inform drainage improvement decisions and a high level drainage strategy for the Shire, which is to be developed as part of a separate assessment. The scope of this study included the following tasks.

1. Site Investigation and Existing Drainage Data;
2. Existing Drainage System Review Report;

GIS data for the existing stormwater network within the Kalamunda region were obtained from SoK and compiled in a GIS database. Review of the GIS data identified a number of data gaps. These gaps included:

- Missing pit and pipe diameters;
- Missing pipe inverts;
- Missing pit lid elevations;
- Missing topographic data of basins.

Assumptions were made where information was not available.

A MikeURBAN hydraulic model was configured for the Kalamunda region, and simulated during the critical duration 20-, 50- and 100-year ARI design events. Flood hazard maps were generated for each event to indicate the flood extent and depth within the Kalamunda region. Based on information provided from the SoK, flooding depth exceeding 200 mm within the road corridors was considered to be a flood hazard.

The results of this study shows broader picture of overall performance of the catchment flooding issues and key locations. GHD recommends the following;

- Collect missing drainage network data and update the model as required,
- Install flow gauges at key flow locations of the major streams within the catchment;
- Carryout remedial option assessment for the key flooding areas. This should be carried out at local scale in the order of priority.

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Appendix G – Flow monitoring locations

1. Introduction

1.1 Project Background

The Shire of Kalamunda engaged GHD to carryout Detailed Flood Study of the Kalamunda Region.

This study is an important initiation to evaluate the existing drainage system within the area and to identify key drainage issues and potential future upgrades. This study will review the nature, extent and efficiency of the existing storm water drainage system, using a robust, reliable and innovative modelling methodology.

The Kalamunda Region stormwater system is predominantly piped network, which is typical within urban residential areas with number of main drains passing through the study area.

The outcomes of this study are intended to inform drainage improvement decisions and a high level drainage strategy for the Shire, which is to be developed as part of a separate assessment.

1.2 Project Scope

The scope of the overall project includes the following tasks.

3. Site Investigation and Existing Drainage Data;
4. Existing Drainage System Review Report;

1.2.1 Scope of this report

The scope of this memorandum includes reporting of Task 2. The scope of the Task 2 includes simulation of the existing drainage system using 2D flood estimation methods in order to produce a series of flood maps that cover the study area.

1.3 Presentation of Figures

A number of GIS prepared figures relating predominantly data capture and two dimensional flood modelling assessment are presented separately to the main body of this report within Appendices of the report and are referenced where applicable.

1.4 Limitations

This report: has been prepared by GHD for Shire of Kalamunda and *may only be used and relied on by Shire of Kalamunda for the purpose agreed between GHD and the Shire of Kalamunda as set out in Section 1.2 of this report.*

GHD otherwise disclaims responsibility to any person other than Shire of Kalamunda arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer Section .5. of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

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2. Catchment Overview

2.1 Location and Description

The study area is located in the central and western part of the Shire of Kalamunda. The study area drains from the Darling Scarp to the West through to the Swan Coastal Plain and into the Swan River (Appendix A Figure A1). The study area consists of four main catchment areas;

1. Poison Gully;
2. Crumpet Creek;
3. Woodlupine Brook and Whistlepipe Gully;
4. Yule Brook.

Land use is predominantly residential, commercial and a mixture of open spaces including bush lands. The urban and commercial area drainage system is mainly pipe network draining to major creeks.

2.2 Topography

The catchments within the study area grade from East to West from approximately 345 mAHD to around 35 m AHD (Appendix A Figure A2). The average length of the study area (from east to west) is around 12 km and width (from north to south) is 10 km.

Catchment SIM software package was used to generate flow paths within the catchment using the digital elevation model (DEM) provided from the CoB. These flow paths are presented in Appendix A Figure A3.

2.3 Vegetation

The study area has components of residential and commercial land use. There are a number of Public Open Space (POS) areas within the catchment. There is also a broad area of open parkland around the Horseshoe Lake.

The vegetation within the catchment ranges from areas of established gardens with mature trees, and forest. There are also industrial and commercial areas within the catchment, which are typically highly impervious.

2.4 Soil Type

The soils in the catchment are generally gravelly brownish sand, pale brown sands and sands overlaying lateritic duricrust. Soils types within the catchment are shown in Appendix A Figure A4. The local soil type affects the volume of rainfall that will either infiltrate the soil profile or become runoff during a design storm event.

2.5 Land Use

Land use classifications for the study area are required for input into hydrologic and hydraulic models. These classifications were generated based on cadastre plans and building footprints. The catchment land use was distributed based on one of the three primary land use zones within the Horseshoe Lake catchment:

- Lawns, grass, and parks;
- Buildings; and
- Roads and paved areas.

2.6 Stormwater Infrastructure

The stormwater within the urban areas area mainly piped network and discharge to Poison Gully, Crumpet Creek, Woodlupine Brook, and Yule Brook. These streams cross Roe Highway and few other major roads running across the catchment. The culverts at these road crossing locations can be identified as critical drainage infrastructure of the catchment which require sufficient capacity to convey stormwater during major events.

The urban developed areas of the catchment mainly has pit and pipe drainage infrastructure draining to the above major streams within the catchment.

3. Drainage Modelling

3.1 Preliminary review of data

A review of all information related to the study was undertaken in order to identify key gaps in existing data and to provide a high level review and assessment of data gaps.

3.1.1 Data collation and desktop review

A desktop assessment was undertaken to review available data and relevant reports for completeness and consistency, to aid in the identification of data gaps.

The data and information collected are outlined below:

- Aerial photography and topographic data for use in building the digital terrain model for the study area and characterising catchments and land use;
- Catchment contour data provided by SoK for the catchment area;
- Available LIDAR data covering part of catchment extent collected by GHD from DoW;
- Design rainfall data, for use in the hydrology models, sourced from BOM;
- Infrastructure plans and data from SoK;
- Study area drainage network including external catchments contributing to potential pressure on the drainage network capacity; and

A project specific GIS Database was developed, collating all available GIS information relevant to this study. The key GIS data which is included within the database is listed below:

- Background – aerial photo, cadastre, roads, LiDAR;
- Hydrology –catchment boundary; and
- Hydraulic – stormwater pit locations, diameters, and inverts; stormwater pipes, pipe inverts, and diameters.

3.1.2 Gap Analysis

Review of the GIS data identified a number of data gaps. Appendix A Figure A6 highlights missing pipe diameter. Appendix A Figure A7 and Figure A8 shows downstream and upstream missing pipe invert level locations. Appendix A Figure A9 shows missing pit diameter locations. For these cases, junction pits were assigned a diameter of 1.05 m, and catch pits were assigned a diameter of 0.45 m, as agreed with the SoK, to reflect the storage of storm water for modelling purposes. The CoK GIS data of the catchment drainage network, pits and basins are shown in Appendix A Figure A11. As the bathymetry of the basins was not available, it was decided to use LiDAR topography for the modelling as agreed with SoK. In addition GHD noted missing drainage network data within the catchment and agreed with SoK to used available GIS data at this stage for this modelling.

In instances where the stormwater pit lid elevation was unavailable, the lid elevation was assumed to be equal to the ground surface level.

During the modelling process, GHD identified some missing culverts from SoK existing GIS database. Some of the missing culvert details were obtained by SoK from Water Corporation. The culvert information provided is given in Appendix B. These culverts were included in the model.

Pits, pipes and culverts not available from the sources above were excluded from the model.

3.2 Modelling Platform

Hydrological (rainfall / runoff process simulation) and hydraulic modelling (reticulation operation simulation) was undertaken using Mike URBAN Software developed DHI Environmental Ltd. Mike URBAN is an advanced, powerful, and comprehensive surface runoff, open channel flow, pipe flow modelling package for stormwater and wastewater collection systems and water distribution networks. It is based on the ESRI GeoDatabase systems, and has GIS-based model building and management.

3.3 Catchment Delineation

The preferential flow paths within the Kalamunda catchments were generated using CatchmentSim Appendix A Figure A3. The preferential flow paths were used in conjunction with the cadastre, road network and stormwater infrastructure to delineate individual sub-catchments developed within the model (Appendix A Figure A10).

3.4 Model parameters

A summary of key model input parameters are presented below. The Horseshoe Lake catchment was classified based on the three primary land use zones (lawns/grass/parks; buildings; and roads/paved areas), and assigned a Manning's 'M' roughness coefficient.

3.4.1 Hydrology – MIKE URBAN -Model B

Soil type directly influences the volume of rainfall that will either infiltrate the soil profile or become runoff during a storm. For the purposes of modelling surface infiltration rainfall losses, soils are categorised as "Large Pervious", "Medium Pervious" or "Small Pervious" as required for the MikeURBAN Software Hydrological 'Model B: Kinematic Wave' runoff model. "Large Pervious" soils have greatest surface infiltration capacity and "Small Pervious" has the lowest. Note that these categories do not necessarily correspond to soakage capacity for stormwater soak-pits type devices, which utilise soil permeability at depth, rather than the surface.

For modelling purposes, soils within the study area are generally considered to be "Low Pervious".

3.4.2 Land Use

Land use classifications for the Horseshoe catchment were generated based on cadastre plans and building footprints, provided from the CoB. The land use was classified as one of the three primary land use zones within the Horseshoe Lake catchment:

- Lawns, grass, and parks;
- Buildings; and
- Roads and paved areas.

The land use classifications are shown in Appendix A Figure A5.

The following table summarises the Manning's 'M' values assigned to each land use zones, which were adopted for modelling purposes. The Manning's 'M' value is a roughness coefficient, and is the inverse of the commonly used Manning's 'n' (M = 1/n).

Table 1 Manning's M used for modelling

Land use type	Manning's 'M'
Lawn, grass, parks	34
Buildings	50
Road, paved areas	70

3.4.3 Imperviousness Allowances

The land use of a catchment affects the quantity and quality of stormwater runoff. For stormwater runoff assessment and model development purposes, the percentages of impervious land uses were used to simulate stormwater runoff.

The following table summarises the average pervious and impervious percentage of roads, residential lots, commercial lots, and parks applied in this modelling.

The type of land use for the existing scenario was identified using aerial maps and cadastre data provided by SoK. The local planning strategy (Refer Appendix C) provided by SoK is used to identify future development areas to simulated future land use flooding.

Table 2 Impervious allowances used for modelling

Type	Pervious percentage	Impervious percentage
Road	10	90
Residential High	40	60
Residential Low	70	30
Commercial Lots	10	90
Parks	95	5

3.4.4 Rainfall – Intensity-Frequency-Duration (IFD)

The intensity frequency duration (IFD) rainfall data used to generate rainfall hydrographs for the design storm events was sourced from the Bureau of Meteorology IFD program, in accordance with AR&R (1987), at the Kalamunda study area (coordinates: 31.975 S, 116.025 E). The following table summarises the IFD design rainfall depth for rainfall durations (5 minutes to 72 hours) for various return periods (1 year to 100 years) adopted for modelling purposes.

Table 3 IFD design rainfall depth (mm)

DURATION	Average Return Period						
	1 Year	2 years	5 years	10 years	20 years	50 years	100 years
5Mins	5.2	6.8	8.8	10.3	12.3	15.3	17.8
6Mins	5.8	7.6	9.9	11.4	13.7	17.0	19.8
10Mins	7.7	10.1	13.0	15.0	17.8	21.8	25.3
20Mins	10.8	14.0	17.6	20.1	23.7	28.8	33.2
30Mins	12.8	16.6	20.7	23.5	27.5	33.3	38.2
1Hr	16.9	21.7	26.7	30.1	34.9	41.9	47.6
2Hrs	22.0	28.2	34.2	38.2	44.0	52.2	59.0
3Hrs	25.8	32.7	39.3	43.8	50.1	59.4	66.9
6Hrs	33.7	42.7	50.6	55.7	63.6	74.4	83.4
12Hrs	43.9	55.4	65.4	71.8	81.6	95.3	106.2
24Hrs	56.4	71.5	84.7	93.4	106.6	125.0	139.9
48Hrs	69.6	89.3	107.5	120.0	138.2	164.2	185.8
72Hrs	77.0	98.6	121.0	135.4	157.0	187.2	213.1

3.4.5 Climate change

Climate change is an emerging issue and although its existence is widely accepted the effects are unclear and unquantifiable at the present time. These effects may impact on the operation, functionality, performance and durability of the catchment drainage infrastructure beyond what can be reasonably predicted with the current available knowledge. Climate change impacts were not investigated in this study as discussed and agreed with SoK.

3.5 Model configuration

3.5.1 Model features

A MikeURBAN hydraulic model was configured to simulate existing stormwater network infrastructure within the Horseshoe Lake catchment. The pipes less than or equal to 0.3m diameter is removed from the model as agreed with SoK. The model consists of 1207 sub-catchments, 5570 manholes (including catch pits and junction pits), and 4822 pipes.

Overland flow network

The MikeURBAN model is linked with a two-dimensional ground surface, where surface flows may enter the pipe network, or any overflow from the pits spills onto the two-dimensional ground surface. The model grid used for this study is 8 m. This is used to generate flood hazard maps, which are discussed in Section 4.

Boundary conditions

MikeURBAN model has downstream channels which discharges stormwater outside downstream model area. These channels were assigned with Mike URBAN outlets.

It was agreed with the CoB that sea level rises due to the influence of climate change would be excluded from this study as the catchment is not connected directly to the sea.

4. Flood Mapping

4.1 Catchment Hydrology

4.1.1 Catchment runoff

A range of storm events were simulated in order to identify the critical duration that resulted in peak flood depths within the road network. The 1-hour and 6-hour durations were identified as critical for the upstream and downstream of the catchment respectively. The maximum flood levels extracted from these two durations were used for assessment and presentation of results for the 20-, 50- and 100-year ARI design events.

4.2 Flood Mapping

The flood hazard mapping during the critical duration 20- 50- and 100-year ARI storm event indicates the key areas of performance constraints within the stormwater network. It is important to highlight that flood simulation accounts for complete routing of stormwater within the catchment (both within piped networks and as overland flow paths).

The existing land use scenario shows current situation of the catchment. The 20-, 50-, and 100-year ARI flood maps for the existing land used are presented in Appendix D – Figure D1, Figure D2, and Figure D3 respectively.

The future land use scenarios represent the future situation with proposed land used in the local planning strategy with the existing drainage infrastructure. The 20-, 50-, and 100-year ARI flood maps for the existing land used are presented in Appendix E – Figure E1, Figure E2, and Figure E3 respectively.

4.3 Flooding issued identified to priorities improvement

Flood hazard areas are zones within a catchment whereby stormwater has the potential to be hazardous to property or people. Generally the flood hazard areas are comprised of overland flow or ponding areas. Overland flow is stormwater flow travelling along surface drainage paths to reach the receiving environment.

Overland flow can occur as a result of limited capacity within the stormwater soakage and piped networks, forcing stormwater to exit the network. Where there is an operational and safe overland flow path, the capacity of the drainage network can be balanced with overland flow path capacity such that the overall conveyance capacity meets Level of Service requirements.

Flood prone areas differ from flood hazard areas and are defined as zones where flooding could occur due to failure of stormwater systems. A typical example is a basin area located at a topographic low without a natural outlet.

Based on information provided from the SoK, flooding depth exceeding 200 mm within the road corridors is considered to be a flood hazard. Advice from the SoK is that the level of service is only required during the critical duration 20-year ARI storm event. Flood assessments were therefore based on this design rainfall event

The Appendix F table includes descriptions of the ranges of water depths and magnitude of effect at each location. Results were extracted from both 20 year ARI and 100 year ARI rainfall events under existing and future land development scenarios. Comments on the 100 year ARI event column record changes observed between the 20 year ARI future development event and the 100 year ARI event. The results have been summarised in the last two columns of the table, risk to property of a 100 year ARI event and potential number of lots affected. The risk to lots in 100 year ARI event indicates how likely lots in the location are affected by flooding in a 100 year

ARI event. High risk indicates water levels above 1m, medium risk between 0.5 to 1m and low risk less than 0.5m. The potential number of lots affected category indicates the number of lots likely to be affected by the flood waters.

4.4 Flow Monitoring Guidance

4.4.1 Flow monitoring

Stream gauging involves obtaining a continuous record of stage, making periodic discharge measurements, establishing and maintaining a relation between the stage and discharge, and applying the stage-discharge relation to the stage record to obtain a continuous record of discharge.

Stream gauging generally involves 3 steps.

1. Measuring stream stage;
2. Discharge measurement;
3. Developing a stage and discharge relation (Stage discharge curve).

Once the stage and discharge curve is developed at the stream monitoring location, the discharge of stream at a particular time can be calculated by measuring stage at that time.

Measuring stream stage

This requires obtaining a continuous record of stage or the height of the water surface at a location along a stream. Stream gauges measure stage and consist of a structure in which instruments used to measure, store, and transmit the stream-stage information are housed. Stage, sometimes called gauge height, can be measured using a variety of methods.

The Stream gauges can be measured with a stilling well in the stream bank. This method uses two underwater pipes allowing the water surface in the stilling well to be at the same elevation as the water surface in the river. The stage is then measured inside the stilling well using a float or a pressure, optic, or acoustic sensor. The measured stage value is stored in an electronic data recorder on a regular interval, usually every 15 minutes.

Routine survey of permanent elevation benchmarks near the stream gauge is required to maintain accuracy, and to ensure that stage is being measured above a constant reference elevation.

The discharge measurement

The discharge measurement is required to develop stage discharge relationship. In general, river discharge is computed by multiplying the area of water in a channel cross section by the average velocity of the water in that cross section:

Discharge = Area x Velocity.

A mechanical current-meter can be used for measuring discharge. To calculate stream discharge the stream channel cross section should be divided into vertical subsections. The area of each subsection should be obtained by measuring the width and depth of the subsection. The water velocity of each sub sections can be determined using a current meter. The discharge in each subsection can be computed by multiplying the subsection area by the measured velocity. The total discharge can then be computed by summing the discharge of each subsection.

The most common current meter used is the “Price AA” current meter. The Price AA current meter has a wheel of six metal cups that revolve around a vertical axis. An electronic signal is transmitted by the meter on each revolution allowing the revolutions to be counted and timed.

Because the rate at which the cups revolve is directly related to the velocity of the water, the timed revolutions are used to determine the water velocity. The Price AA meter is designed to be attached to a wading rod for measuring in shallow waters or to be mounted just above a weight suspended from a cable and reel system for measuring in fast or deep water. In shallow water, the “Pygmy Price” current meter should be used.

The stage-discharge relation

A stage discharge relationship for each monitoring location should be developed using measured stage and discharge records as detailed in the above two sections. Discharge should be plotted on Log scale x-Axis and discharge should be plotted in Y-axis without any scaling. The stage-discharge relation depends upon the shape, size, slope, and roughness of the channel at the stream gauge and is different for every stream gauge.

The developed stage discharge relationship then can be used to convert measured discharge readings to discharge. However due to erosion, cross section of a stream at gauge locations can change with time. This requires update of rating curve mainly after major events.

4.4.2 Indicative locations

Indicative flow monitoring locations for the major streams are provided in Appendix G Figure G1. However these locations should further be investigated for the appropriateness in accordance with the Department of Water – Water Monitoring Guidelines for Better Urban Water Management Strategies / Plans. Refer Section 3.2 of the above guide lines for more information.

5. Conclusions

This study investigated existing stormwater network constraints and flood mapping within the Kalamunda region using MikeURBAN hydraulic modelling. The key outcomes and recommendations from this study are summarised below

5.1 Gap Analysis

GIS data for the existing stormwater network within the Kalamunda region were obtained from SoK and compiled in a GIS database. Review of the GIS data identified a number of data gaps. These gaps included:

- Missing pit and pipe diameters;
- Missing pipe inverts;
- Missing pit lid elevations;
- Missing topographic data of basins.

Assumptions were made where information was not available.

5.2 Modelling results

A MikeURBAN hydraulic model was configured for the Kalamunda region, and simulated during the critical duration 20-, 50- and 100-year ARI design events. Flood hazard maps were generated for each event to indicate the flood extent and depth within the Kalamunda region. Based on information provided from the SoK, flooding depth exceeding 200 mm within the road corridors was considered to be a flood hazard.

The results indicated that the key flooding locations within the catchment. The Appendix F table includes descriptions of the ranges of water depths and magnitude of effect at each location.

5.3 Recommendations

The results of this study shows broader picture of overall performance of the catchment flooding issues and key locations. GHD recommends the following;

- Collect missing drainage network data and update the model as required,
- Install flow gauges at key flow locations of the major streams within the catchment (Refer Appendix G);
- Carryout remedial option assessment for the key flooding areas. This should be carried out at local scale in the order of priority.

Appendices

This document is in draft form. The contents, including any opinions, conclusions or recommendations contained in, or which may be implied from, this draft document must not be relied upon. GHD reserves the right, at any time, without notice, to modify or retract any part or all of the draft document. To the maximum extent permitted by law, GHD disclaims any responsibility or liability arising from or in connection with this draft document.

Appendix A - GIS Figures

Figure A1 Study Area

Figure A2 Topography

Figure A3 Flow Paths

Figure A4 Soil Type

Figure A5 Land Use

Figure A6 Gap Analysis

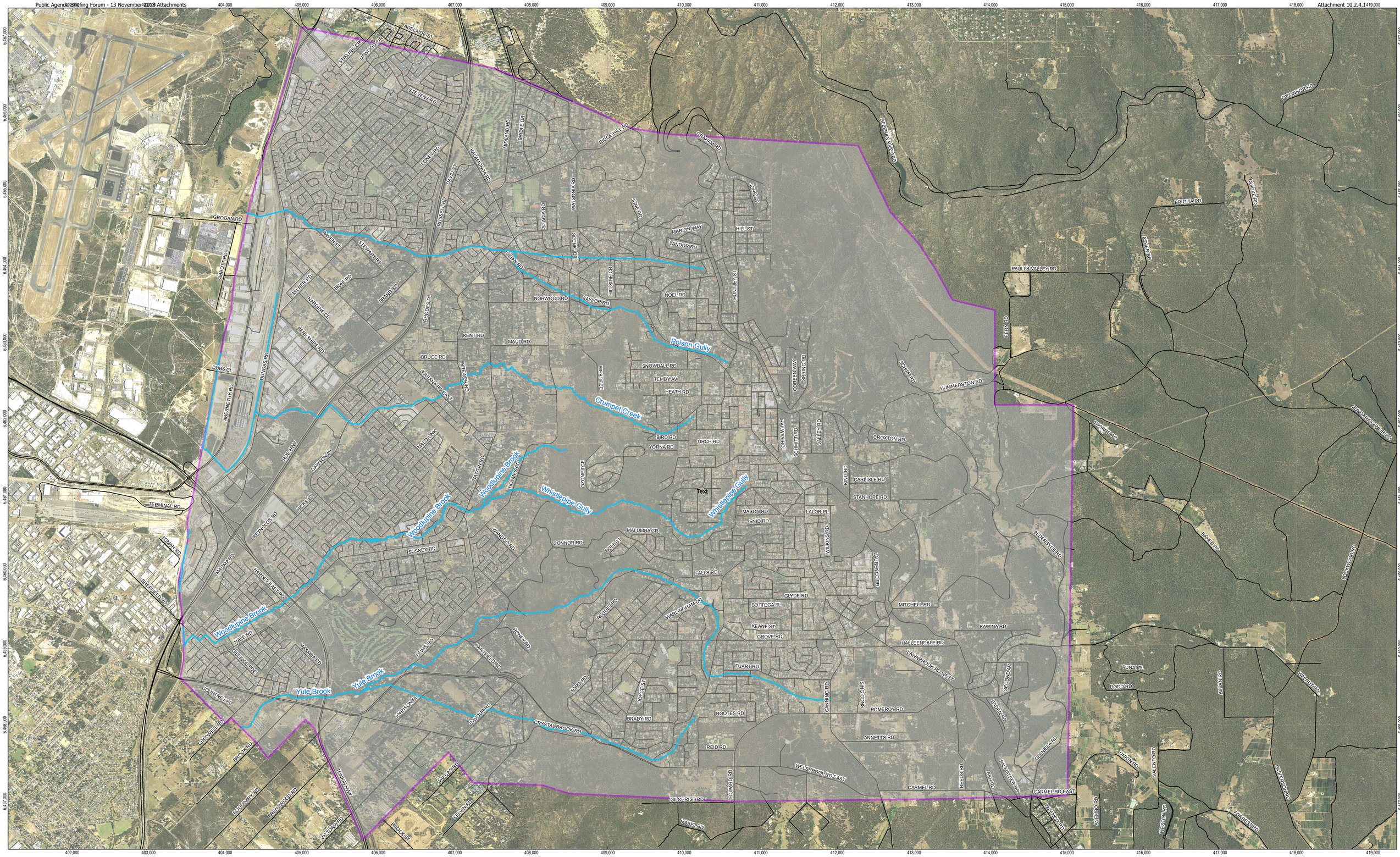
Figure A7 Gap Analysis – pipe downstream invert

Figure A8 Gap Analysis – pipe upstream invert

Figure A9 Gap Analysis – pit diameter

Figure A10 Model catchments

Figure A11 Existing drainage network



Paper Size A1

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

LEGEND

Study Area

Streams

Shire of Kalamunda

Kalamunda Region Flood Study

Study Area

Job Number	61-31574
Revision	0
Date	04 Apr 2016

Figure A1

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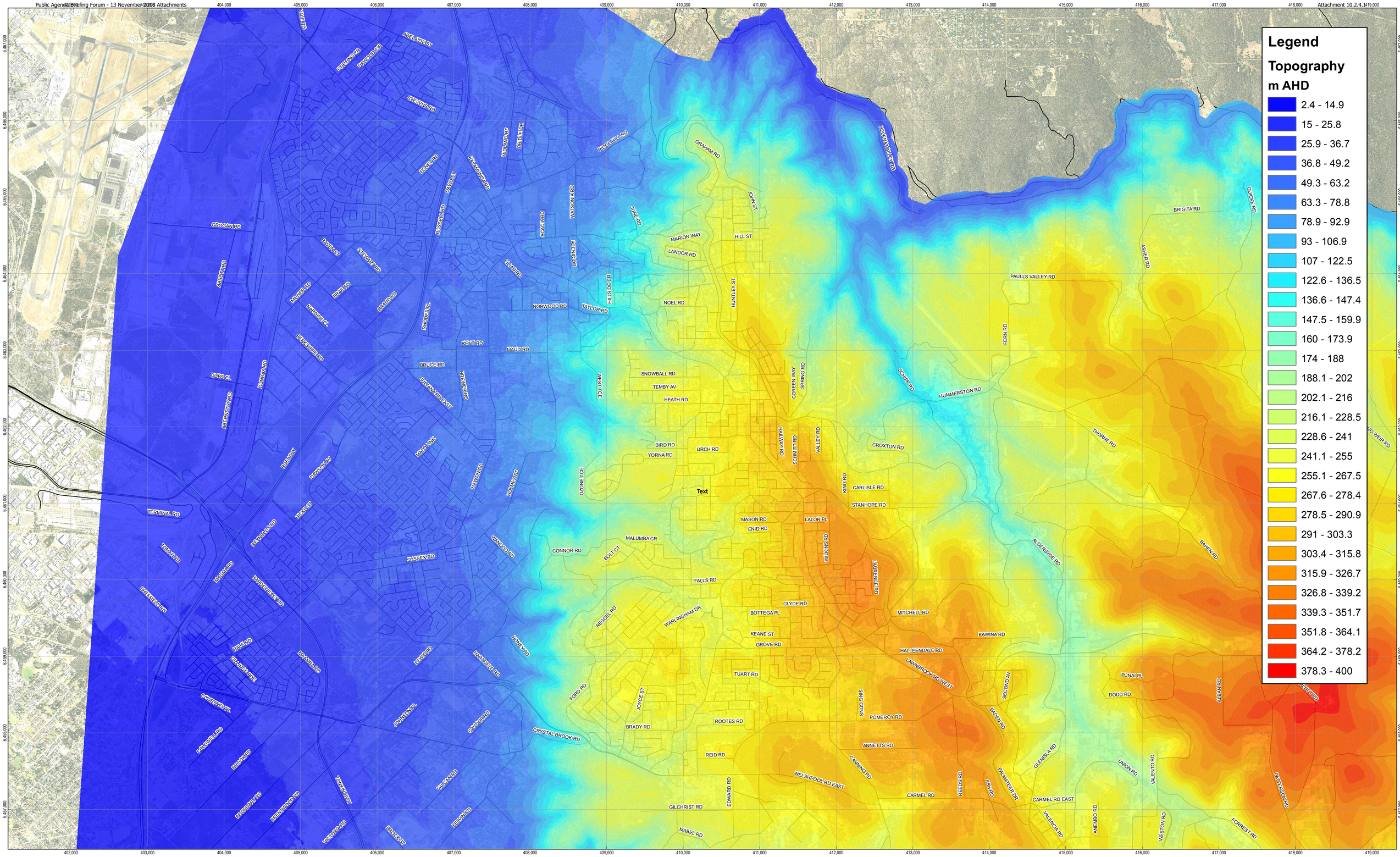
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STEVENS RD
GROGAN RD
ABBOTT RD
MILNER RD
BRAE RD
BRAND RD
NARBUNG CL
BERKSHIRE RD
DURS CL
DUNDAS RD
ABERNETHY RD
RIDE HWY
TERMINAL RD
TOMAH RD
MAGMA RD
SHEFFIELD RD
HASSEY WEST RD
HALE RD
CHAMPION DR
CHAPMAN PL
GOLDFIELD RD
BROOKER
BERRIGAN CR
BRENTWOOD RD
VICTORIA RD
BERRY ST
KELMIT RD
MABEL RD
GILCHRIST RD
WELSHPOOL RD EAST
CARMEL RD
CARMEL RD EAST
REEDS RD
ASH RD
PALMATEER DR
EDWARD RD
CANNING RD
GLENISLA RD
VALENTO RD
UNION RD
ANEMBO RD
VALENCIA RD
WESTON RD
FORREST RD
PATTERSON RD
ALBANY RD
BAYEN RD
ALDERSYDE RD
CROXTON RD
THORNE RD
HUMMERSTON RD
Scarp RD
PAULLS VALLEY RD
FERN RD
ASHER RD
BRIGITA RD
QUICKE RD
HELENA VALLEY RD
GRAHAM RD
JOHN ST
HILL ST
MARION WAY
LANDOR RD
JUNE RD
RIDGE HILL RD
MIDLAND RD
BRIDLE DR
KALAMUNDA RD
DAVID ST
BUSSELL RD
ESNEY RD
WATSON RD
ACACIA RD
SORENSON DR
HILLSIDE CR
HUNTLEY ST
NOEL RD
NORWOOD RD
TAYLOR RD
MILAN RD
KENT RD
MAUD RD
BRUCE RD
SUNNYVALE RD EAST
BREWER RD
WEST TCE
SNOWBALL RD
TEMBY AV
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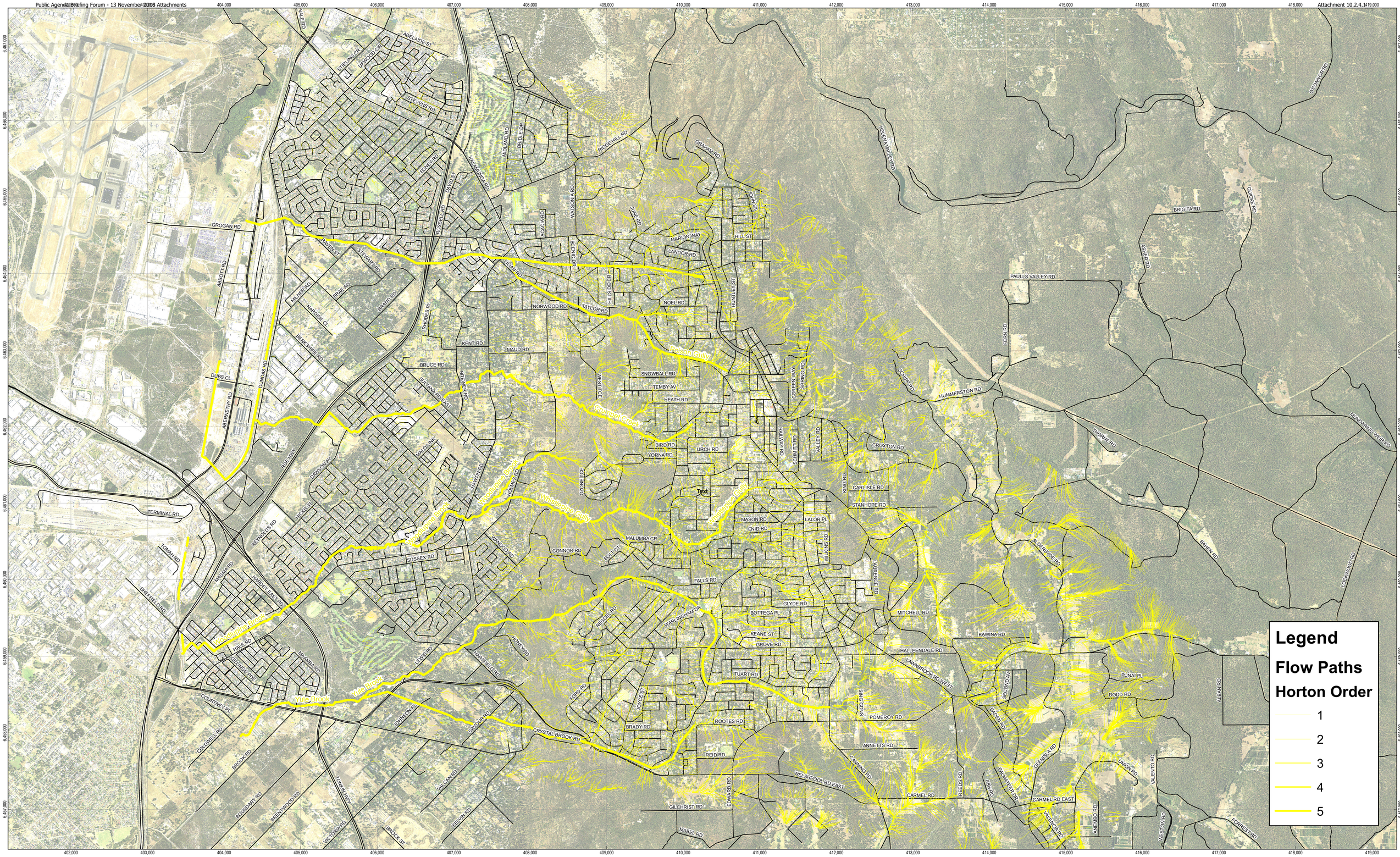

Shire of Kalamunda

Kalamunda Region Flood Study

Flow Paths

Job Number	61-31574
Revision	0
Date	04 Apr 2016

Figure A3

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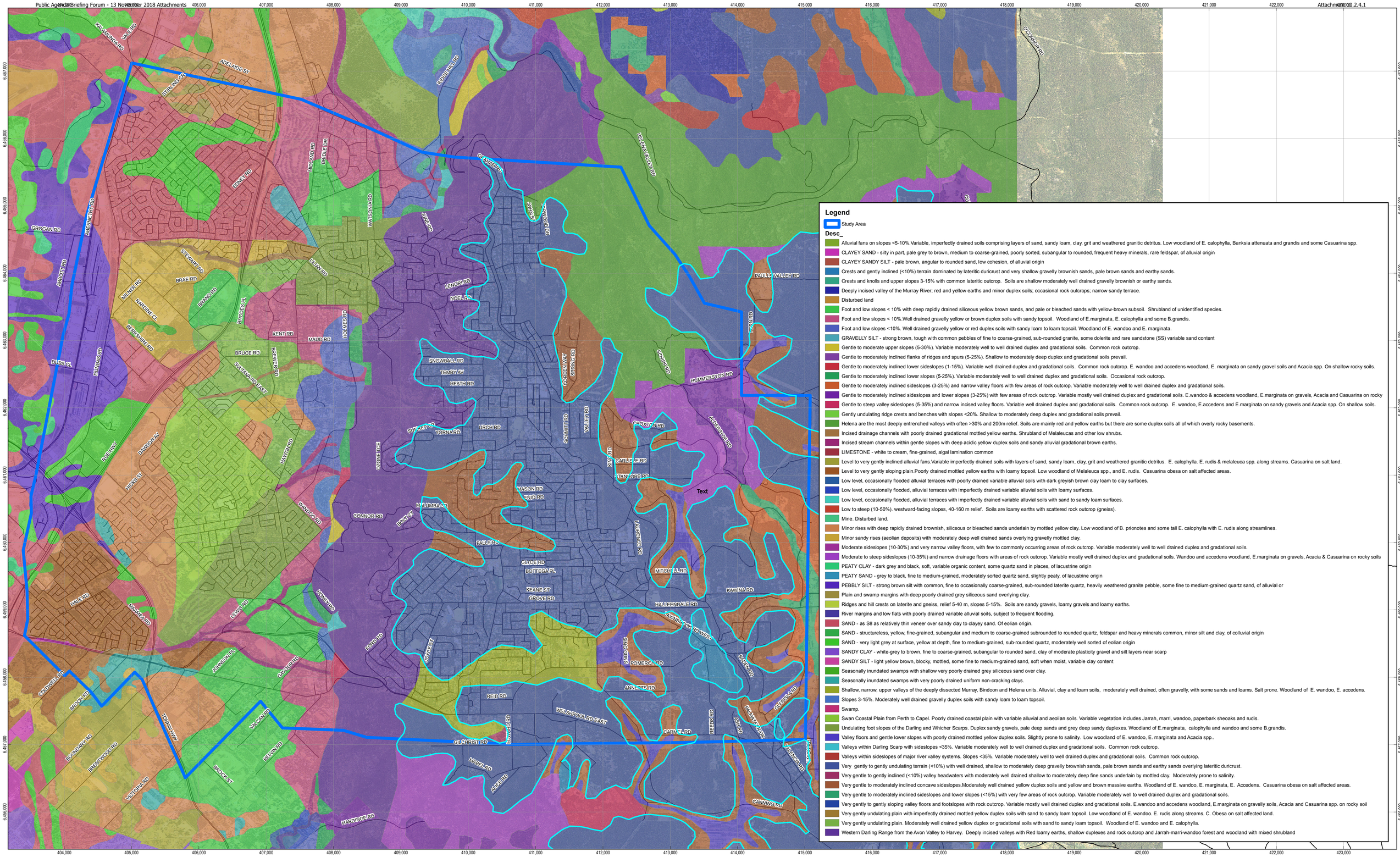

Legend

Study Area

Desc_

- Alluvial fans on slopes <5-10%.Variable, imperfectly drained soils comprising layers of sand, sandy loam, clay, grit and weathered granitic detritus. Low woodland of E. calophylla, Banksia attenuata and grandis and some Casuarina spp.
- CLAYEY SAND - silty in part, pale grey to brown, medium to coarse-grained, poorly sorted, subangular to rounded, frequent heavy minerals, rare feldspar, of alluvial origin
- CLAYEY SANDY SILT - pale brown, angular to rounded sand, low cohesion, of alluvial origin
- Crests and gently inclined (<10%) terrain dominated by lateritic duricrust and very shallow gravelly brownish sands, pale brown sands and earthy sands.
- Crests and knolls and upper slopes 3-15% with common lateritic outcrop. Soils are shallow moderately well drained gravelly brownish or earthy sands.
- Deeply incised valley of the Murray River; red and yellow earths and minor duplex soils; occasional rock outcrops; narrow sandy terrace.
- Disturbed land
- Foot and low slopes < 10% with deep rapidly drained siliceous yellow brown sands, and pale or bleached sands with yellow-brown subsoil. Shrubland of unidentified species.
- Foot and low slopes < 10%.Well drained gravelly yellow or brown duplex soils with sandy topsoil. Woodland of E.marginata, E. calophylla and some B.grandis.
- Foot and low slopes <10%. Well drained gravelly yellow or red duplex soils with sandy loam to loam topsoil. Woodland of E. wandoo and E. marginata.
- GRAVELLY SILT - strong brown, tough with common pebbles of fine to coarse-grained, sub-rounded granite, some dolerite and rare sandstone (SS) variable sand content
- Gentle to moderate upper slopes (5-30%). Variable moderately well to well drained duplex and gradational soils. Common rock outcrop.
- Gentle to moderately inclined flanks of ridges and spurs (5-25%). Shallow to moderately deep duplex and gradational soils prevail.
- Gentle to moderately inclined lower sideslopes (1-15%). Variable well drained duplex and gradational soils. Common rock outcrop. E. wandoo and accedens woodland, E. marginata on sandy gravel soils and Acacia spp. On shallow rocky soils.
- Gentle to moderately inclined lower slopes (5-25%). Variable moderately well to well drained duplex and gradational soils. Occasional rock outcrop.
- Gentle to moderately inclined sideslopes (3-25%) and narrow valley floors with few areas of rock outcrop. Variable moderately well to well drained duplex and gradational soils.
- Gentle to moderately inclined sideslopes and lower slopes (3-25%) with few areas of rock outcrop. Variable mostly well drained duplex and gradational soils. E.wandoo & accedens woodland, E.marginata on gravels, Acacia and Casuarina on rocky
- Gentle to steep valley sideslopes (5-35%) and narrow incised valley floors. Variable well drained duplex and gradational soils. Common rock outcrop. E. wandoo, E.accedens and E.marginata on sandy gravels and Acacia spp. On shallow soils.
- Gently undulating ridge crests and benches with slopes <20%. Shallow to moderately deep duplex and gradational soils prevail.
- Helena are the most deeply entrenched valleys with often >30% and 200m relief. Soils are mainly red and yellow earths but there are some duplex soils all of which overly rocky basements.
- Incised drainage channels with poorly drained gradational mottled yellow earths. Shrubland of Melaleucas and other low shrubs.
- Incised stream channels within gentle slopes with deep acidic yellow duplex soils and sandy alluvial gradational brown earths.
- LIMESTONE - white to cream, fine-grained, algal lamination common
- Level to very gently inclined alluvial fans.Variable imperfectly drained soils with layers of sand, sandy loam, clay, grit and weathered granitic detritus. E. calophylla. E. rudis & melaleuca spp. along streams. Casuarina on salt land.
- Level to very gently sloping plain.Poorly drained mottled yellow earths with loamy topsoil. Low woodland of Melaleuca spp., and E. rudis. Casuarina obesa on salt affected areas.
- Low level, occasionally flooded alluvial terraces with poorly drained variable alluvial soils with dark greyish brown clay loam to clay surfaces.
- Low level, occasionally flooded, alluvial terraces with imperfectly drained variable alluvial soils with loamy surfaces.
- Low level, occasionally flooded, alluvial terraces with imperfectly drained variable alluvial soils with sand to sandy loam surfaces.
- Low to steep (10-50%). westward-facing slopes, 40-160 m relief. Soils are loamy earths with scattered rock outcrop (gneiss).
- Mine. Disturbed land.
- Minor rises with deep rapidly drained brownish, siliceous or bleached sands underlain by mottled yellow clay. Low woodland of B. prionotes and some tall E. calophylla with E. rudis along streamlines.
- Minor sandy rises (aeolian deposits) with moderately deep well drained sands overlying gravelly mottled clay.
- Moderate sideslopes (10-30%) and very narrow valley floors, with few to commonly occurring areas of rock outcrop. Variable moderately well to well drained duplex and gradational soils.
- Moderate to steep sideslopes (10-35%) and narrow drainage floors with areas of rock outcrop. Variable mostly well drained duplex and gradational soils. Wandoo and accedens woodland, E.marginata on gravels, Acacia & Casuarina on rocky soils
- PEATY CLAY - dark grey and black, soft, variable organic content, some quartz sand in places, of lacustrine origin
- PEATY SAND - grey to black, fine to medium-grained, moderately sorted quartz sand, slightly peaty, of lacustrine origin
- PEBBLY SILT - strong brown silt with common, fine to occasionally coarse-grained, sub-rounded laterite quartz, heavily weathered granite pebble, some fine to medium-grained quartz sand, of alluvial or
- Plain and swamp margins with deep poorly drained grey siliceous sand overlying clay.
- Ridges and hill crests on laterite and gneiss, relief 5-40 m, slopes 5-15%. Soils are sandy gravels, loamy gravels and loamy earths.
- River margins and low flats with poorly drained variable alluvial soils, subject to frequent flooding.
- SAND - as S8 as relatively thin veneer over sandy clay to clayey sand. Of eolian origin.
- SAND - structureless, yellow, fine-grained, subangular and medium to coarse-grained subrounded to rounded quartz, feldspar and heavy minerals common, minor silt and clay, of colluvial origin
- SAND - very light grey at surface, yellow at depth, fine to medium-grained, sub-rounded quartz, moderately well sorted of eolian origin
- SANDY CLAY - white-grey to brown, fine to coarse-grained, subangular to rounded sand, clay of moderate plasticity gravel and silt layers near scarp
- SANDY SILT - light yellow brown, blocky, mottled, some fine to medium-grained sand, soft when moist, variable clay content
- Seasonally inundated swamps with shallow very poorly drained grey siliceous sand over clay.
- Seasonally inundated swamps with very poorly drained uniform non-cracking clays.
- Shallow, narrow, upper valleys of the deeply dissected Murray, Bindoon and Helena units. Alluvial, clay and loam soils, moderately well drained, often gravelly, with some sands and loams. Salt prone. Woodland of E. wandoo, E. accedens.
- Slopes 3-15%. Moderately well drained gravelly duplex soils with sandy loam to loam topsoil.
- Swamp.
- Swan Coastal Plain from Perth to Capel. Poorly drained coastal plain with variable alluvial and aeolian soils. Variable vegetation includes Jarrah, marri, wandoo, paperbark sheoaks and rudis.
- Undulating foot slopes of the Darling and Whicher Scarps. Duplex sandy gravels, pale deep sands and grey deep sandy duplexes. Woodland of E.marginata, calophylla and wandoo and some B.grandis.
- Valley floors and gentle lower slopes with poorly drained mottled yellow duplex soils. Slightly prone to salinity. Low woodland of E. wandoo, E. marginata and Acacia spp..
- Valleys within Darling Scarp with sideslopes <35%. Variable moderately well to well drained duplex and gradational soils. Common rock outcrop.
- Valleys within sideslopes of major river valley systems. Slopes <35%. Variable moderately well to well drained duplex and gradational soils. Common rock outcrop.
- Very gently to gently undulating terrain (<10%) with well drained, shallow to moderately deep gravelly brownish sands, pale brown sands and earthy sands overlying lateritic duricrust.
- Very gentle to gently inclined (<10%) valley headwaters with moderately well drained shallow to moderately deep fine sands underlain by mottled clay. Moderately prone to salinity.
- Very gentle to moderately inclined concave sideslopes.Moderately well drained yellow duplex soils and yellow and brown massive earths. Woodland of E. wandoo, E. marginata, E. Accedens. Casuarina obesa on salt affected areas.
- Very gentle to moderately inclined sideslopes and lower slopes (<15%) with very few areas of rock outcrop. Variable moderately well to well drained duplex and gradational soils.
- Very gently to gently sloping valley floors and footslopes with rock outcrop. Variable mostly well drained duplex and gradational soils. E.wandoo and accedens woodland, E.marginata on gravelly soils, Acacia and Casuarina spp. on rocky soil
- Very gently undulating plain with imperfectly drained mottled yellow duplex soils with sand to sandy loam topsoil. Low woodland of E. wandoo. E. rudis along streams. C. Obesa on salt affected land.
- Very gently undulating plain. Moderately well drained yellow duplex or gradational soils with sand to sandy loam topsoil. Woodland of E. wandoo and E. calophylla.
- Western Darling Range from the Avon Valley to Harvey. Deeply incised valleys with Red loamy earths, shallow duplexes and rock outcrop and Jarrah-marri-wandoo forest and woodland with mixed shrubland

Paper Size A1

0 250 500 1,000 1,500 2,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

Shire of Kalamunda

Kalamunda Region Flood Study

Soil Types

Job Number 61-31574
Revision 0
Date 04 Apr 2016

Figure A4

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

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Shire of Kalamunda
Kalamunda Region Flood Study

Land Use

Job Number	61-31574
Revision	0
Date	04 Apr 2016

Figure A5

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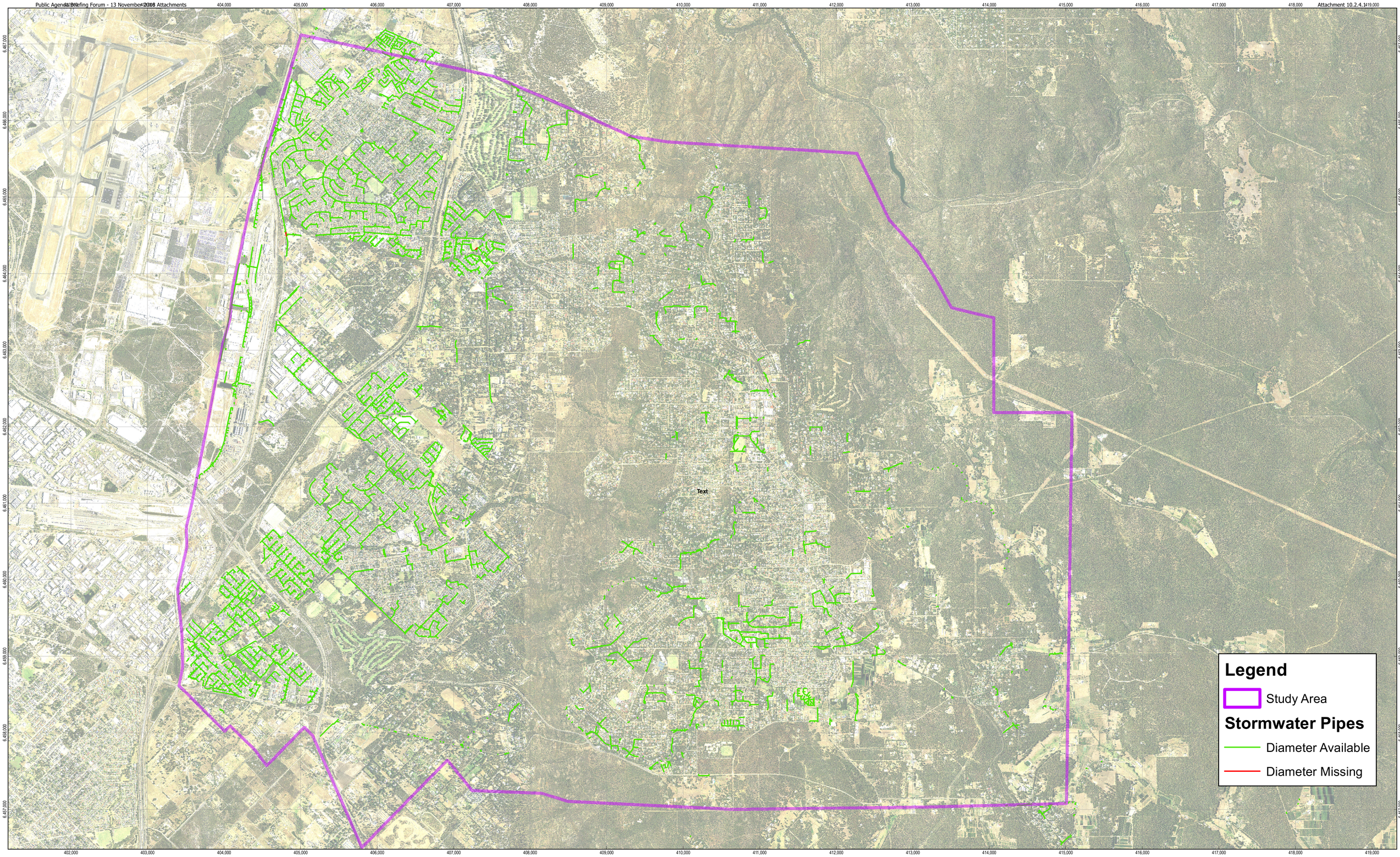

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Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

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Shire of Kalamunda

Kalamunda Region Flood Study

Gap Analysis - pipe diameter

Job Number	61-31574
Revision	0
Date	04 Apr 2016

Figure A6

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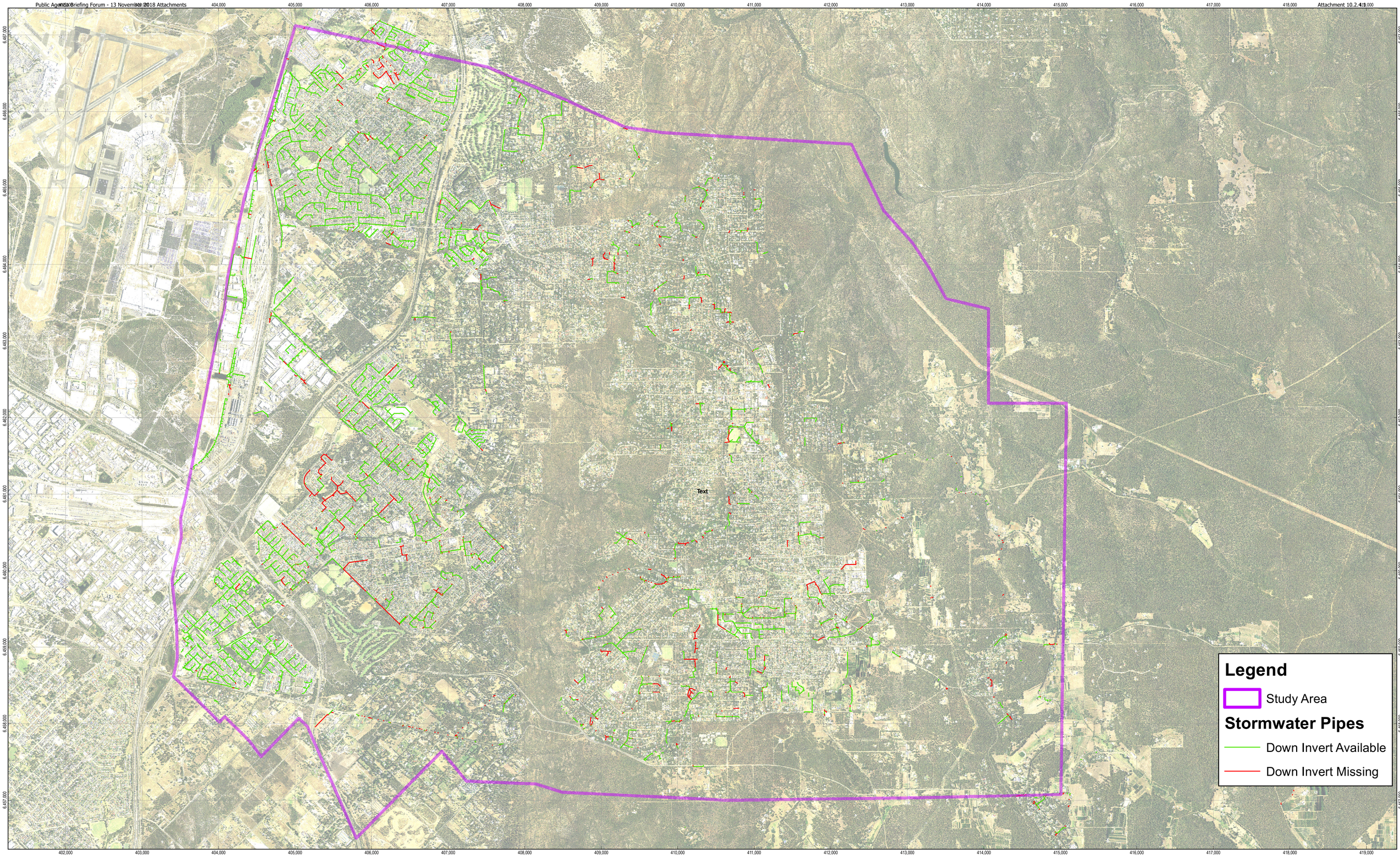

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Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

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Shire of Kalamunda

Kalamunda Region Flood Study

Gap Analysis - downstream invert level

Job Number	61-31574
Revision	0
Date	04 Apr 2016

Figure A7

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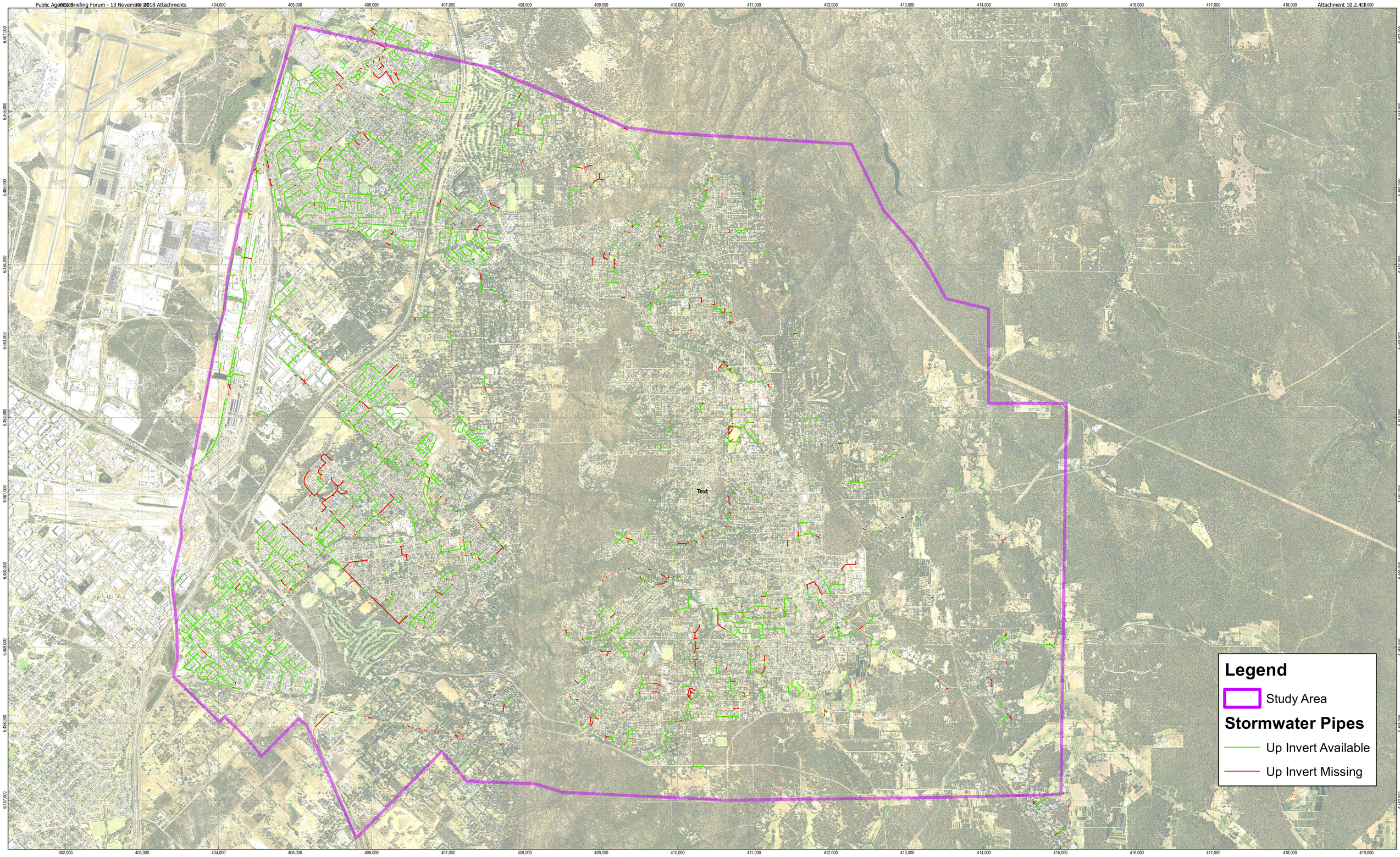

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Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

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Shire of Kalamunda

Kalamunda Region Flood Study

Gap Analysis - up stream invert level

Job Number	61-31574
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Date	04 Apr 2016

Figure A8

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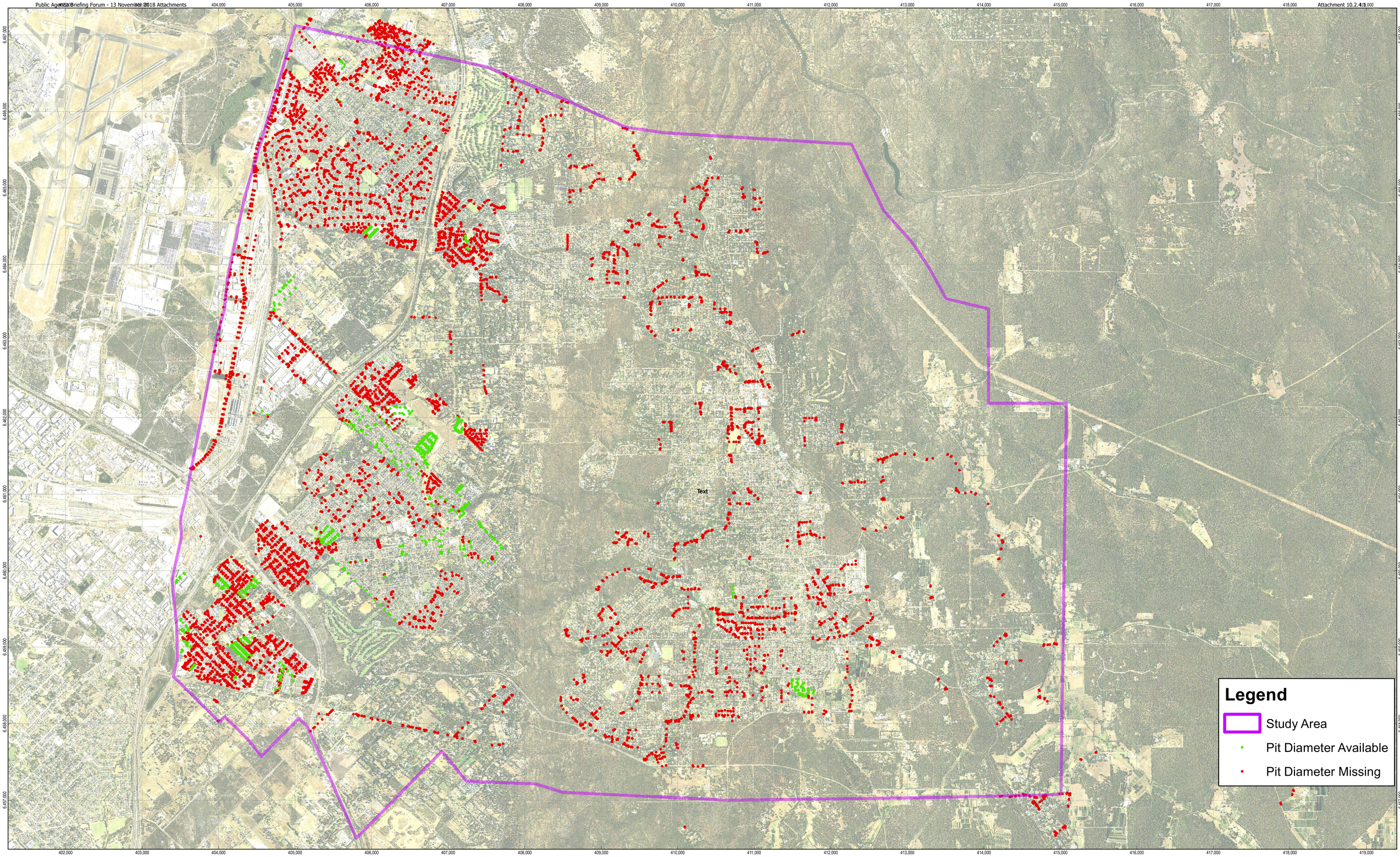

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Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

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Shire of Kalamunda

Kalamunda Region Flood Study

Gap Analysis -pit diameter

Job Number	61-31574
Revision	0
Date	04 Apr 2016

Figure A9

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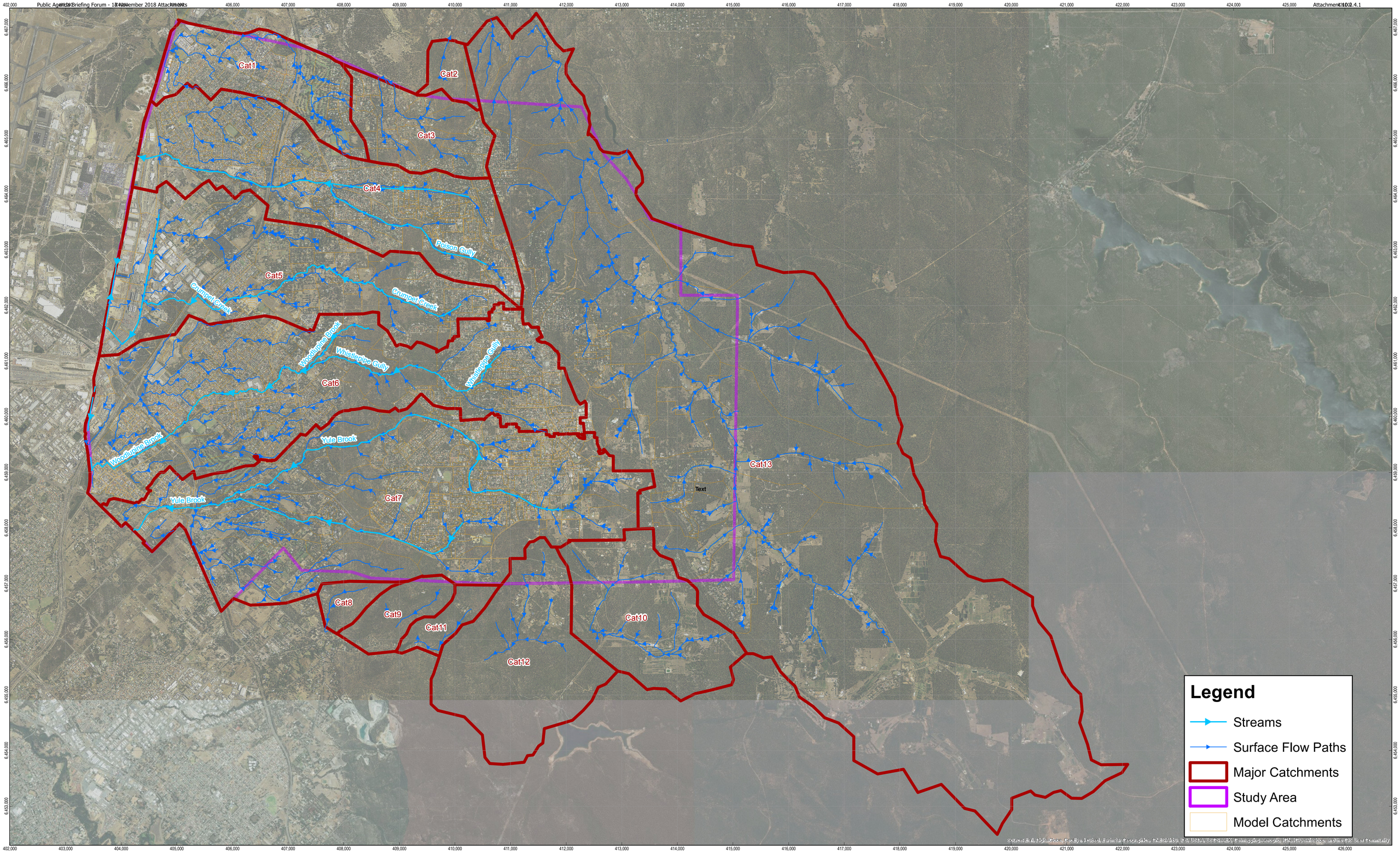

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Metres

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Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

Shire of Kalamunda

Kalamunda Region Flood Study

Model Catchments

Job Number	61-31574
Revision	0
Date	12 May 2016

Figure A10

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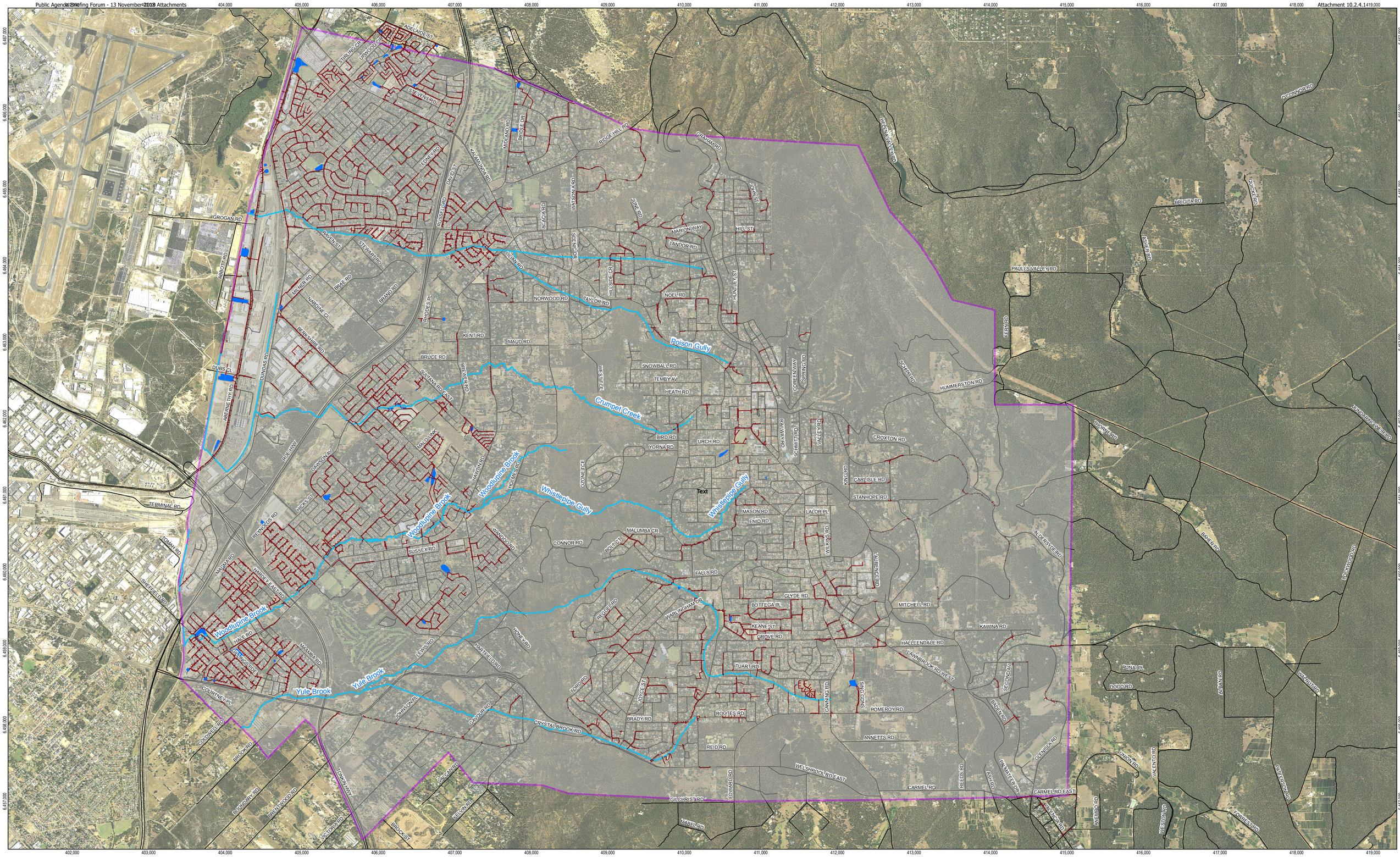

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

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LEGEND

- Streams
- Stormwater Pipes
- Stormwater Pits
- Stormwater Basins
- Study Area

Shire of Kalamunda

Kalamunda Region Flood Study

Existing drainage network

Job Number	61-31574
Revision	0
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Figure A11

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Appendix B – Culvert data along major creeks

Poison Gully - Roe Hwy to Stirk Park						
Location	Culvert Size	Length (m)	I.L. (DS) m AHD*	I.L. (US) m AHD*	Road Level m AHD*	Comments
Myerson Cr	1 x 6.5m W x 2.7m H	19.5	44.0	44.1	48.6	Corrugated steel arched bridge
Maida Vale Rd (east)	1 x 3.0m W x 1.2m H	30.0	48.8	48.7	53	RC Box Culvert
Hawtin Rd	2 x ø1300mm	30.0	50.8	50.9	55.2	RC Pipe
Cootamundra Wy	1 x ø1800mm	25.0	61.3	61.4	65.2	Helcor
Booralie Wy	1 x 1.2m W x 0.9m H	20.0	69.9	70.0	71.6	RC Box Culvert
West Tce	1 x 1.2m W x 0.9m H	14.6	74.2	74.5	76.2	RC Box Culvert
Taylor Rd (lower)	1 x 1.8m W x 1.2m H	11.5	80.1	80.8	82.5	RC Box Culvert
Taylor Rd (central)	1 x 1.8m W x 1.2m H	11.0	83.2	83.7	85.5	RC Box Culvert
Taylor Rd (upper)	1 x 1.8m W x 1.2m H	10.0	88.7	88.8	90.7	RC Box Culvert
Persimmon Pl (north)	2 x ø1050mm	3.7	159.0	159.2	161.5	RC Pipe
Persimmon Pl (south)	1 x ø1800mm	13.0	164.3	164.4	168.3	RC Pipe
Kalamunda Rd	1 x ø1200mm	25.2	208.6	209.5	211.1	RC Pipe
Kalamunda Rd (u/s)	1 x ø1200mm	34.8	209.5	211.5	–	RC Pipe
Lindsay St	1 x ø1250mm	12.0	246.3	246.4	248.3	RC Pipe
Elizabeth St	1 x ø900mm	15.0	248.1	248.4	250.2	RC Pipe

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Crumpet Creek - Dundas Rd to Josephine Cr						
Location	Culvert Size	Length (m)	I.L. (DS) m AHD*	I.L. (US) m AHD*	Road Level m AHD*	Comments
Dundas Rd	2 x ø1200mm	20.0	23.35	23.46	25.4	RC Pipe
U/S Dundas Rd (Lot 1)	2 x ø1200mm	180.4	23.62	25.24	–	RC Pipe
Roe Hwy	2 x ø1800mm	55.0	29.70	29.90	34.4	RC Pipe (Does not include extension for Gateway Project)
US Roe Hwy	1 x 2.4m W x 2.1m H	10.0	32.50	32.51	–	RC Box culvert (new)
Dawson Ave	1 x ø1200mm	22.0	34.64	34.82	36.8	RC Pipe
Dawson Ave - US to Berkshire Rd	1 x ø1050mm	240*	34.97	37.76	–	RC Pipe (*Pipe length measures as 370m approx.)
Berkshire Rd - Dawson Ave to Ilex Wy	1 x ø1050mm	140.0	37.76	39.39	–	RC Pipe
US of Berkshire Rd	1 x ø900mm	18.0	39.64	40.18	41.6	RC Pipe
Sultana Rd	1 x ø1200mm	20.0	46.16	46.26	48.5	RC Pipe
Brewer Rd	2 x ø1350mm	30.0	48.75	48.90	51.3	RC Pipe
Hawtin Rd	1 x ø1350mm &	20.0	54.19	54.39	58.4	RC Pipe
	1 x ø900	20.0	55.32	55.52	58.4	RC Pipe
Holmes Rd	2 x ø600mm	20.0	73.50	74.10	75.9	RC Pipe
Josephine Cr	1 x ø1200mm	20.0	199.00	200.00	202.0	RC Pipe

Yule Brook - Welshpool Rd to Lesmurdie Brook						
Location	Culvert Size	Length (m)	I.L. (DS) m AHD*	I.L. (US) m AHD*	Road Level m AHD*	Comments
Welshpool Rd	2 x 1.8m W x 1.5m H	76.0	13.85	14.08	16.8	RC Box Culvert
			13.78	14.09		
Bruce Rd	2 x ø1200mm	10.0	16.50	16.50	19.0	RC Pipe
Tonkin Hwy	4 x ø1500mm	36.0	19.57	19.76	22.6	RC Pipe
Lewis Rd	1 x ø1050mm	30.0	30.50	31.00	33.0	RC Pipe
Hartfield Rd	1 x ø1500mm	18.0	39.50	40.00	42.0	RC Pipe

Crystal Brook - Yule Brook to Silverdale Rd						
Location	Culvert Size	Length (m)	I.L. (DS) m AHD*	I.L. (US) m AHD*	Road Level m AHD*	Comments
Welshpool Rd East	2 x 1.28m W x 1.2m H	49.0	28.90	29.10	31.0	RC Box Culvert
Johnson Pl	3 x ø600mm	34.0	34.80	35.00	37.4	RC Pipe
Gavour Rd	1 x ø1800mm	48.0	48.00	49.90	52.0	RC Pipe
Fontano Rd	4 x 1.28m W x 1.2m H	14.0	60.50	61.00	63.2	RC Box Culvert
Welshpool Rd East	1 x ø1200mm	133.0	161.00	177.00	164.0 to 180.0	RC Pipe
Gladys Rd	1 x ø1050mm	26.0	198.00	199.00	201.0	RC Pipe
Lesmurdie Rd	1 x ø1200mm	35.0	213.00	215.50	217.0	RC Pipe
Silverdale Rd	1 x 1.26m W x 0.9m H	27.0	227.50	227.80	229.5	RC Box Culvert

Lesmurdie Brook - Yule Brook to L122 Sing Gdns						
Location	Culvert Size	Length (m)	I.L. (DS) m AHD*	I.L. (US) m AHD*	Road Level m AHD*	Comments
Palm Tce	3 x ø1500mm	31.0	64.00	65.00	67.0	RC Pipe
Falls Rd	1 x 3.0m W x1.8m H	20.0	211.00	212.00	215.0	RC Box Culvert
Kimbarlee Wy	1 x ø1200mm	34.0	228.50	229.00	231.0	RC Pipe
Grove Rd	2 x ø600mm	29.0	248.00	248.50	251.0	RC Pipe
Lesmurdie Rd	1 x ø1200mm	36.0	254.50	255.00	256.5	RC Pipe
Winjana Rd	2 x ø600mm	30.0	258.00	258.10	260.0	RC Pipe
Yalyunga Rd	2 x ø600mm	26.0	261.00	261.50	262.5	RC Pipe
L128 Christina Pl	2 x ø375mm	13.7	270.00	270.25	271.5	RC Pipe
L28 Canning Rd	2 x ø375mm	11.6	274.50	275.00	276.5	RC Pipe
Canning Rd	2 x 0.9m W x 0.6m H	20.0	275.50	275.60	277.0	RC Box Culvert
L122 Sing Gdns	1 x ø450mm	10.0	281.50	282.00	282.5	RC Pipe

Woodlupine Brook - Roe Hwy to Hale Rd						
Location	Culvert Size	Length (m)	I.L. (DS) m AHD*	I.L. (US) m AHD*	Road Level m AHD*	Comments
Roe Hwy	3 x 1.26m W x 0.9m H	71.0	7.55	7.77	9.4	RC Box Culvert
William Rd South CB	1 x ø1500mm	41.0	7.95	7.99	–	Helcor Pipe
Welshpool Rd	1 x ø1500mm	63.0	7.99	8.19	20.0	RC Pipe
	1 x ø1350mm	66.0	9.53	9.94	20.0	RC Pipe
Railway Culvert	6 x 1.8m W x 1.8m H	21.0	10.78	10.86	–	RC Box Culvert
Sheffield Rd	2 x ø1350mm	57.9	11.00	11.50	14.0	RC Pipe
POS adjacent to Lenihan Cnr	2 x ø1500mm	60.0	11.50	11.60	–	RC Pipe
DS Hardey Rd	2 x ø1500mm	22.0	19.18 (19.19)	19.42	–	RC Pipe
Hardey Rd	2 x ø1500mm	22.0	19.43	19.49 (19.50)	22.2	RC Pipe
Tonkin Hwy	4 x ø1500mm	45.0	20.14	20.22	24.2	RC Pipe (Note 2 x ø450 culverts linking original brook omitted)
Reynolds Rd	2 x 1.8m W x 1.2m H	22.0	23.04	23.08	25.6	RC Box Culvert
Perth International Tourist Caravan Park	2 x 1.8m W x 1.2m H	6.0	23.82	23.83	26.8	RC Box Culvert
DS Cypress Rd	1 x 0.9m W x 1.2m H	32.0	25.26	25.36	–	RC Box Culvert
	2 x 1.8m W x 1.2m H	32.0	25.26	25.36	–	RC Box Culvert
Cypress Rd	2 x ø1350mm	28.0	25.34	25.60	27.5	RC Pipe
			25.38	26.15		
Dawson Ave	2 x ø1350mm	29.0	29.39	29.68	32.0	RC Pipe
			29.36	29.70		
DS Strelitzia Ave	2 x ø1050mm	5.0	34.66	34.64	–	RC Pipe
			34.66	34.68		
Strelitzia Ave	2 x ø1350mm	27.0	35.00	35.32	38.5	RC Pipe
			34.99	35.33		
Hale Rd	2 x ø900mm	14.0	44.40	44.67	48.6	RC Pipe
			44.39	44.69		

Whistlepipe Gully - Holmes Rd to Orange Valley Rd						
Location	Culvert Size	Length (m)	I.L. (DS) m AHD*	I.L. (US) m AHD*	Road Level m AHD*	Comments
Holmes Rd	1 x ø1200mm	29.0	55.80	56.00	58.4	RC Pipe
Lewis Rd (Near L50)	1 x ø1050mm	10.0	72.50	73.00	75.0	RC Pipe
Near Panoramic Tce	1 x ø900mm	30.0	92.60	93.20	95.4	RC Pipe
Orange Valley Rd	2 x ø900mm	11.0	208.30	208.50	211.0	RC Pipe

Appendix C – Kalamunda Local Planning Strategy Map

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Local Planning Strategy - Key Planning Elements

KENNETH ROAD AND BERLE WAY SHOPPING CENTRES

•Improved urban design outcomes through the preparation of townscape Improvement Plans.

TRANSPORT INITIATIVE

Investigation of potential rail line option linking Perth Airport to eastern suburbs.

URBAN GROWTH

•Residential infill in existing older urban area of High Wycombe/Maida Vale through increased residential densities in selected areas.

KALAMUNDA DISTRICT CENTRE

•Encourage economic development of the town centre by encouraging a range of commercial uses and the introduction of residential land uses into the centre.
•Improved urban design outcomes through the preparation of Townscape Improvement Plans.
•Promotion of the town centre and surrounds as a tourist centre.
•Maintain 'Village' character in the town centre.

EMPLOYMENT/ECONOMIC OPPORTUNITIES

•Development of Forrestfield/High Wycombe as a key strategic industrial area.
•Access Park Industrial Area, Forrestfield Industrial Area, Forrestfield Intermodal Container Facility.

URBAN INVESTIGATION AREA *

FOOTHILLS INVESTIGATION AREA *

TOURIST ATTRACTIONS

•Commencement of Bibbulmun Walking Track.

INVESTIGATION AREA *

URBAN GROWTH

•Residential infill in existing older urban area of Forrestfield through increased residential densities in selected areas.

KALAMUNDA DURE SCHEME AREA

•Residential infill in Kalamunda where connection to sewer is available.

ENVIRONMENT

•Protection of Middle Helena Water Catchment Area.

URBAN GROWTH

•Residential infill in existing older urban area of High Wycombe/Maida Vale through increased residential densities in selected areas.

FORRESTFIELD DISTRICT CENTRE

•Improved urban design outcomes through the preparation of Townscape Improvement Plans for the District Centre.
•Develop concept of Forrestfield as a designated Activity Centre through the preparation of a Structure Plan.

TOURIST ATTRACTIONS

•Perth Hills Wine Region.
•National Parks and Reserves.

INDUSTRIAL DEVELOPMENT INVESTIGATION AREA *

EDINBURGH ROAD SHOPPING CENTRE

•Improved urban design outcomes through the preparation of Townscape Improvement Plans for the Shopping Centre.

URBAN INVESTIGATION AREA *

INVESTIGATION AREA *

That in investigating the future potential of this area, high regard will be given to the issue of bush fire risk and management.

PICKERING BROOK TOWNSITE INVESTIGATION AREA *

SUSTAINABLE PLANNING APPROACH

SOCIAL	ECONOMIC	ENVIRONMENT
• Increased housing opportunities for aged accommodation. • Increased local employment opportunities through planned industrial areas. • Development of bush fire hazard assessment. • Provide well located quality community facilities. • Provide for a range of passive and active recreation facilities.	• Increase local employment opportunities. • Take advantage of growing employment base at Perth airport. • Promotion of tourist based activities. • Support ongoing horticultural activities in hills orchard areas.	• Protection of biodiversity and natural environment. • Protection of water catchment areas.

Legend

- POTENTIAL FUTURE SEWERAGE
- INVESTIGATION AREAS
- PROPOSED INDUSTRIAL DEVELOPMENT AREAS
- PROPOSED RESIDENTIAL INFILL AREAS
- URBAN DEVELOPMENT AREAS

*** An exact boundary for the investigation has not yet been determined.**

MAIDA VALE · HIGH WYCOMBE · GOOSEBERRY HILL · PIESSE BROOK · PAULLS · KALAMUNDA · HACKETTS GULLY · FORRESTFIELD · WALLISTON · RESERVOIR · BICKLEY · WATTLE GROVE · CANNING LOCATION 311 · LESMURDIE · CARMEL

U2 · U4 · U6 · U7 · U9

MAIDA VALE RD · KALAMUNDA RD · ROE HWY · BERKSHIRE RD · HOLMES RD · HAWTIN RD · CANNING RD · LEWIS RD · WANDOO RD · HALE RD · HARTFIELD RD · TONKIN HWY · BROOK RD · WELSHPOOL RD East

Shire of Kalamunda: Local Planning Strategy - Key Planning Elements

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Author: K. Ito

Map Produced: 2/01/2013

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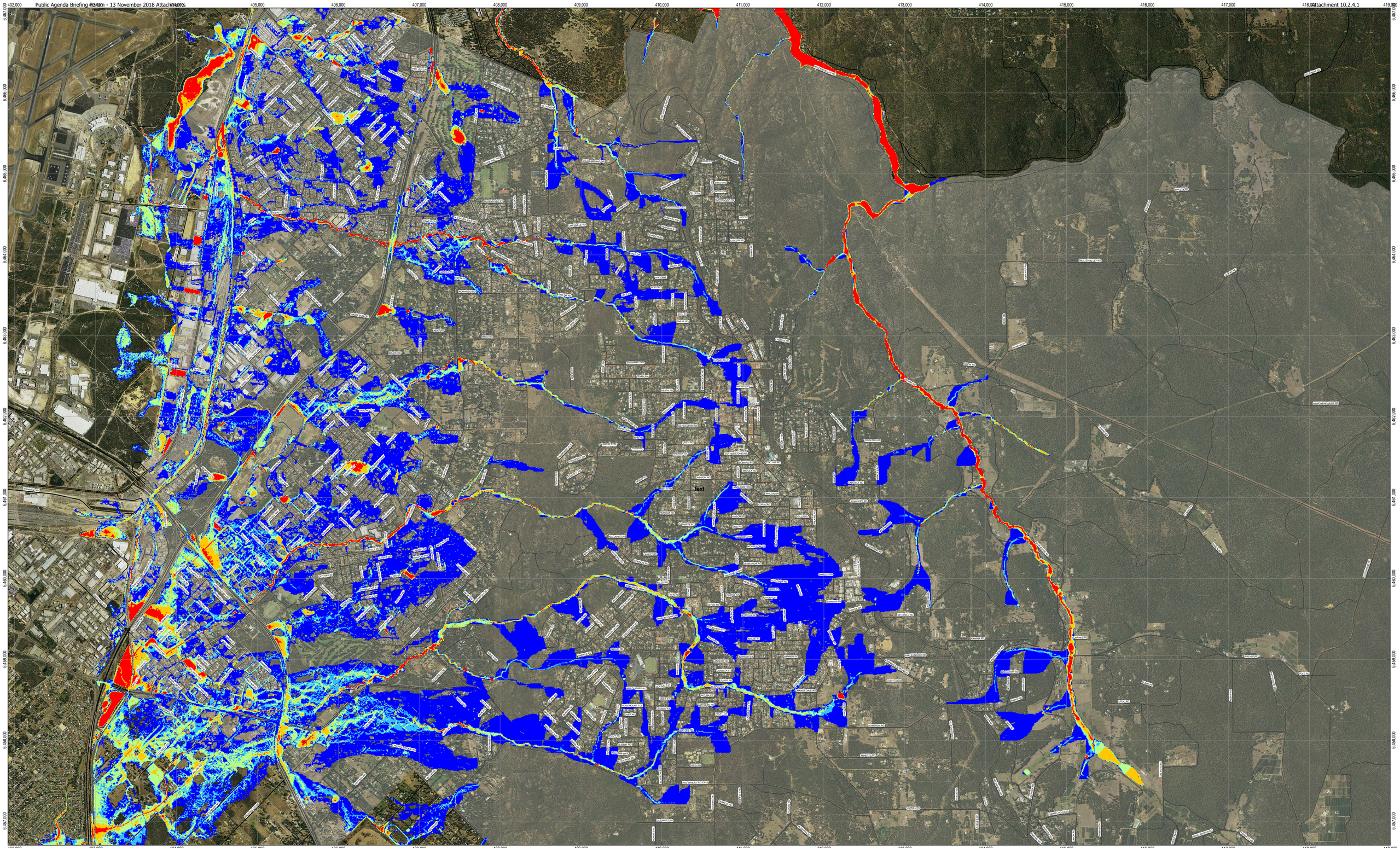
shire of kalamunda

Appendix D – Existing Land Use Flood Maps

Figure D1 Existing Land Use Flood Risk – 20-year ARI

Figure D2 Existing Land Use Flood Risk – 50-year ARI

Figure D3 Existing Land Use Flood Risk – 100-year ARI



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LEGEND

Flood Depth
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- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- > 1.0

Shire of Kalamunda
Kalamunda Region Flood Study

Job Number 61-31574
Revision 0
Date 04 Apr 2016

Existing Land Use Flood Risk - 20-year ARI Flood Depth

Figure D1

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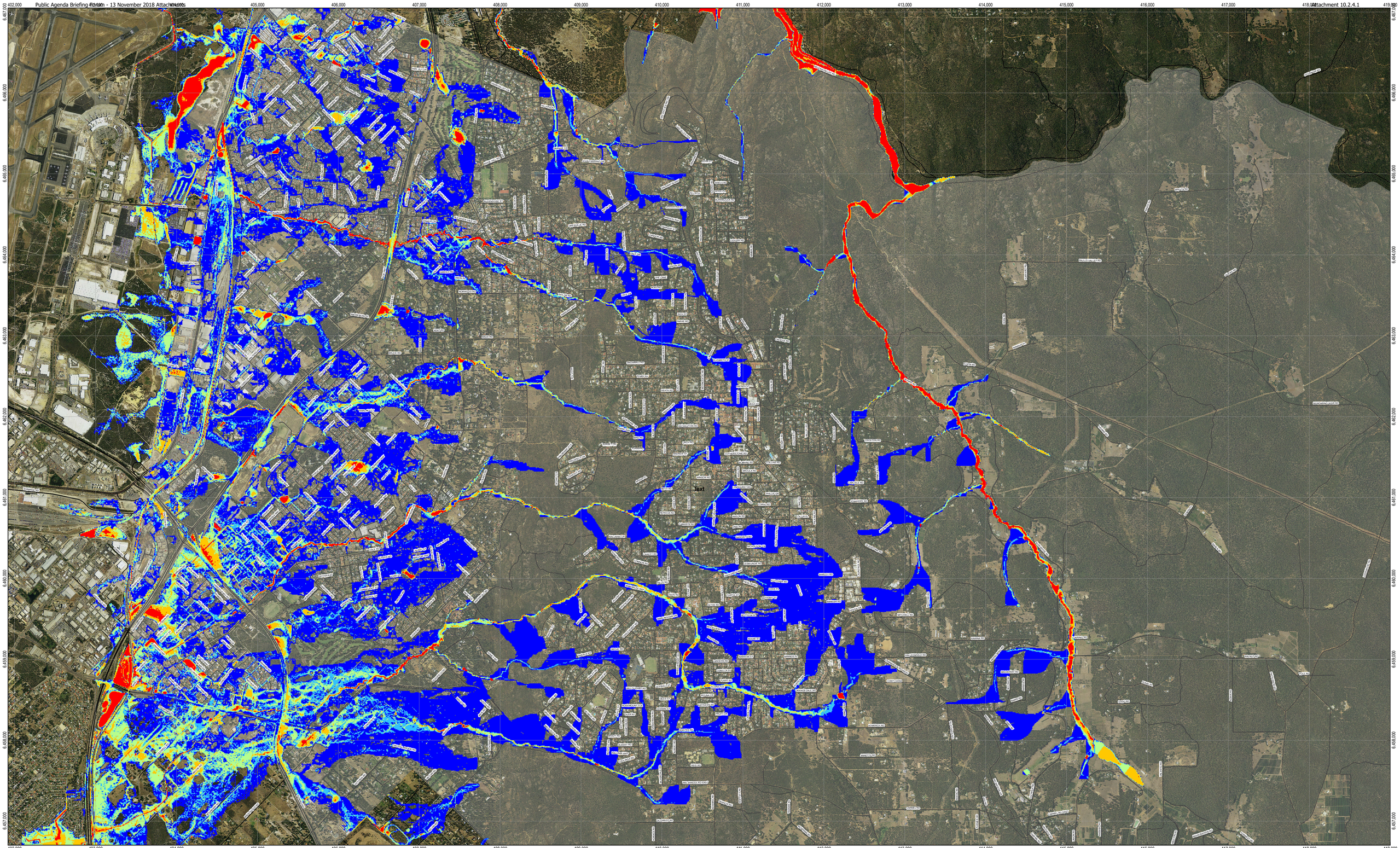

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Metres

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Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

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LEGEND

Flood Depth
<VALUE>

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- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- > 1.0

Shire of Kalamunda
Kalamunda Region Flood Study

Job Number 61-31574
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Date 04 Apr 2016

Existing Land Use Flood Risk - 50-year ARI Flood Depth

Figure D2

G:\61\31574\GIS\Maps\Working\ReportMaps\PreDev50Yr.mxd

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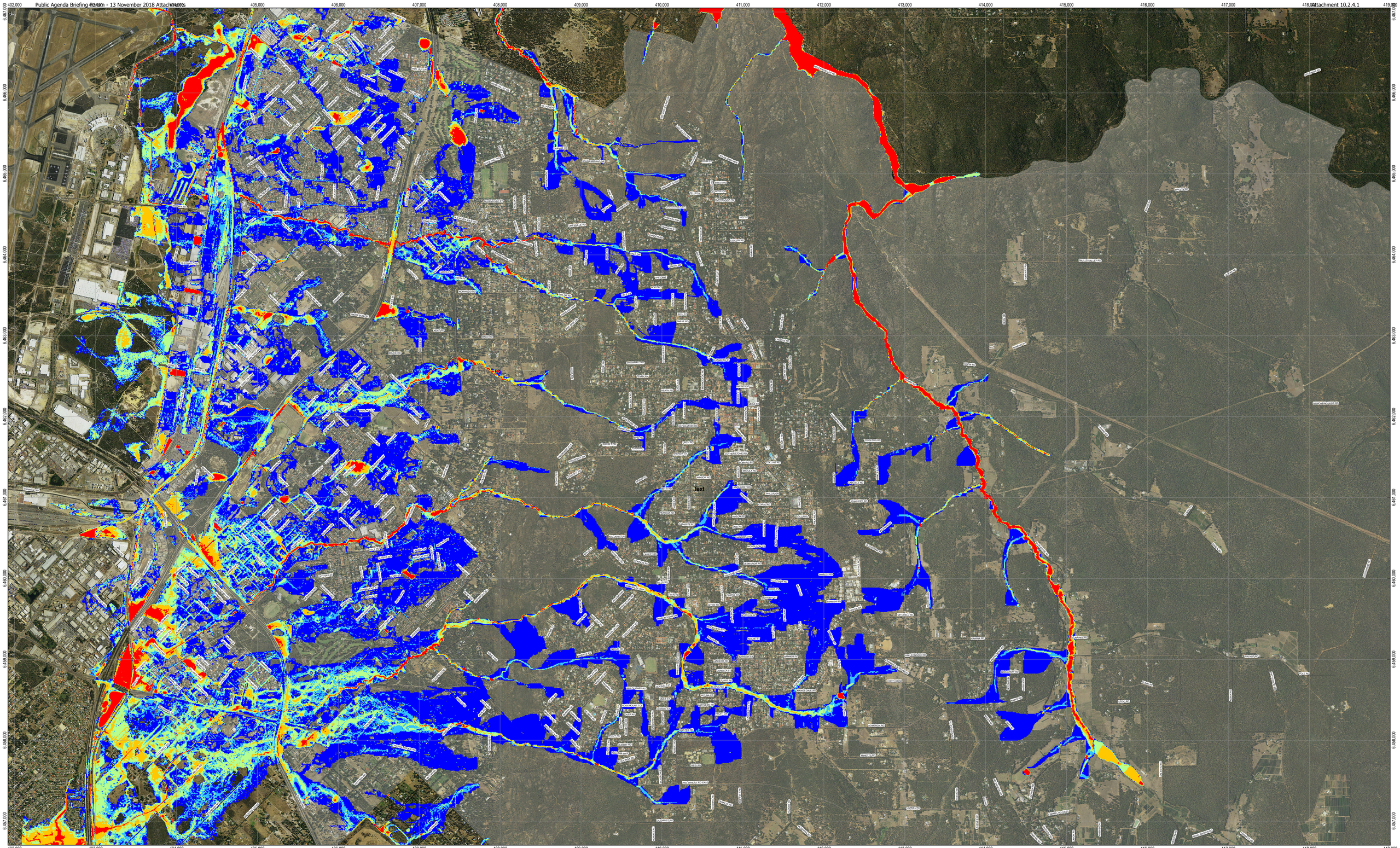

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Grid: GDA 1994 MGA Zone 50

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LEGEND

Flood Depth
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- 0.2 - 0.5
- 0.5 - 1
- > 1.0

Shire of Kalamunda
Kalamunda Region Flood Study

Job Number 61-31574
Revision 0
Date 04 Apr 2016

Existing Land Use Flood Risk - 100-year ARI Flood Depth

Figure D3

G:\61\31574\GIS\Maps\Working\ReportMaps\PreDev100Yr.mxd

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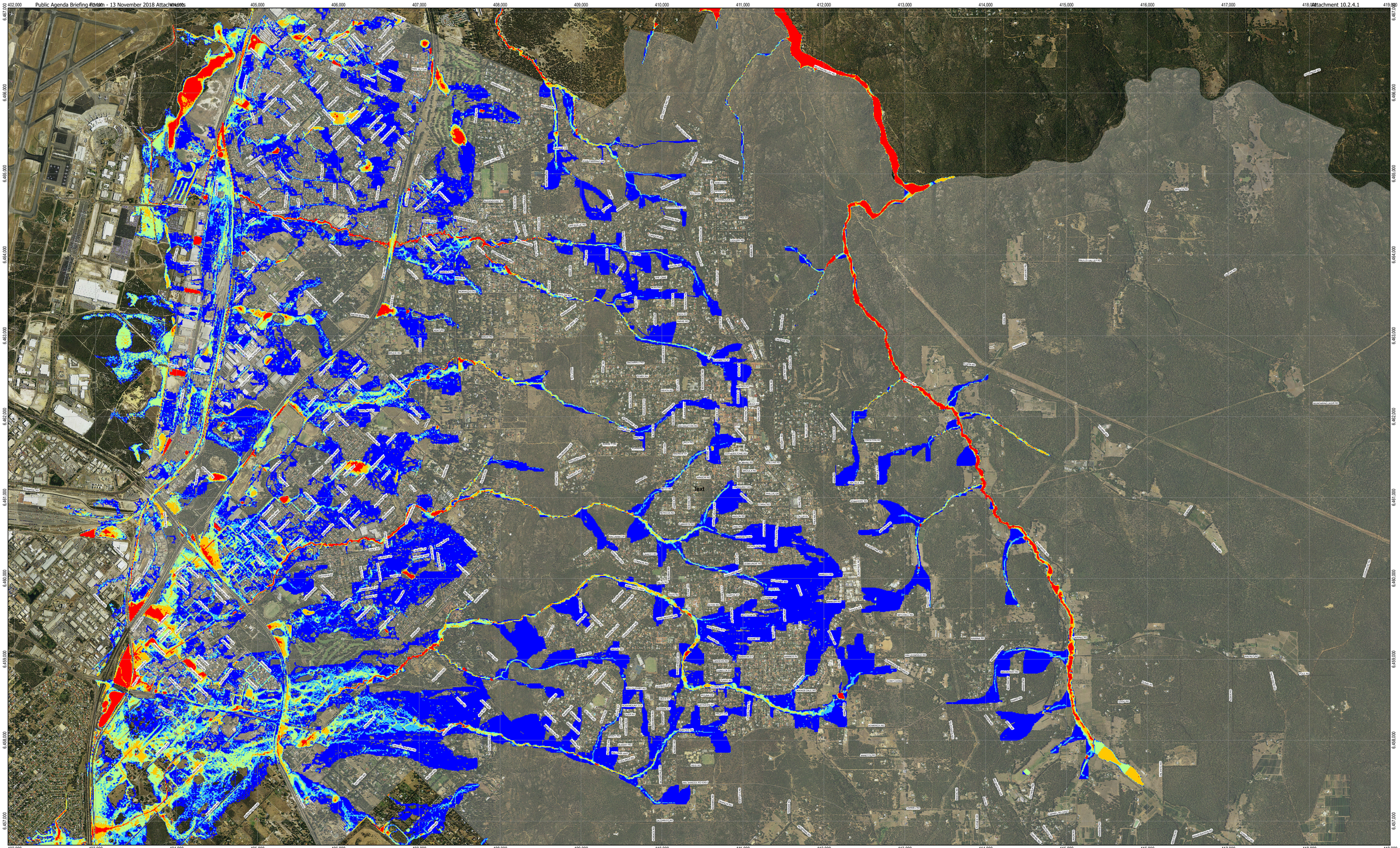
Appendix E – Future Land Use Flood Maps

Figure E1 Future Land Use Flood Risk – 20-year ARI

Figure E2 Future Land Use Flood Risk – 50-year ARI

Figure E3 Future Land Use Flood Risk – 100-year ARI



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LEGEND

Flood Depth
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- 0.2 - 0.5
- 0.5 - 1
- > 1.0

Shire of Kalamunda
Kalamunda Region Flood Study

Job Number 61-31574
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Future Land Use Flood Risk - 20-year ARI Flood Depth

Figure E1

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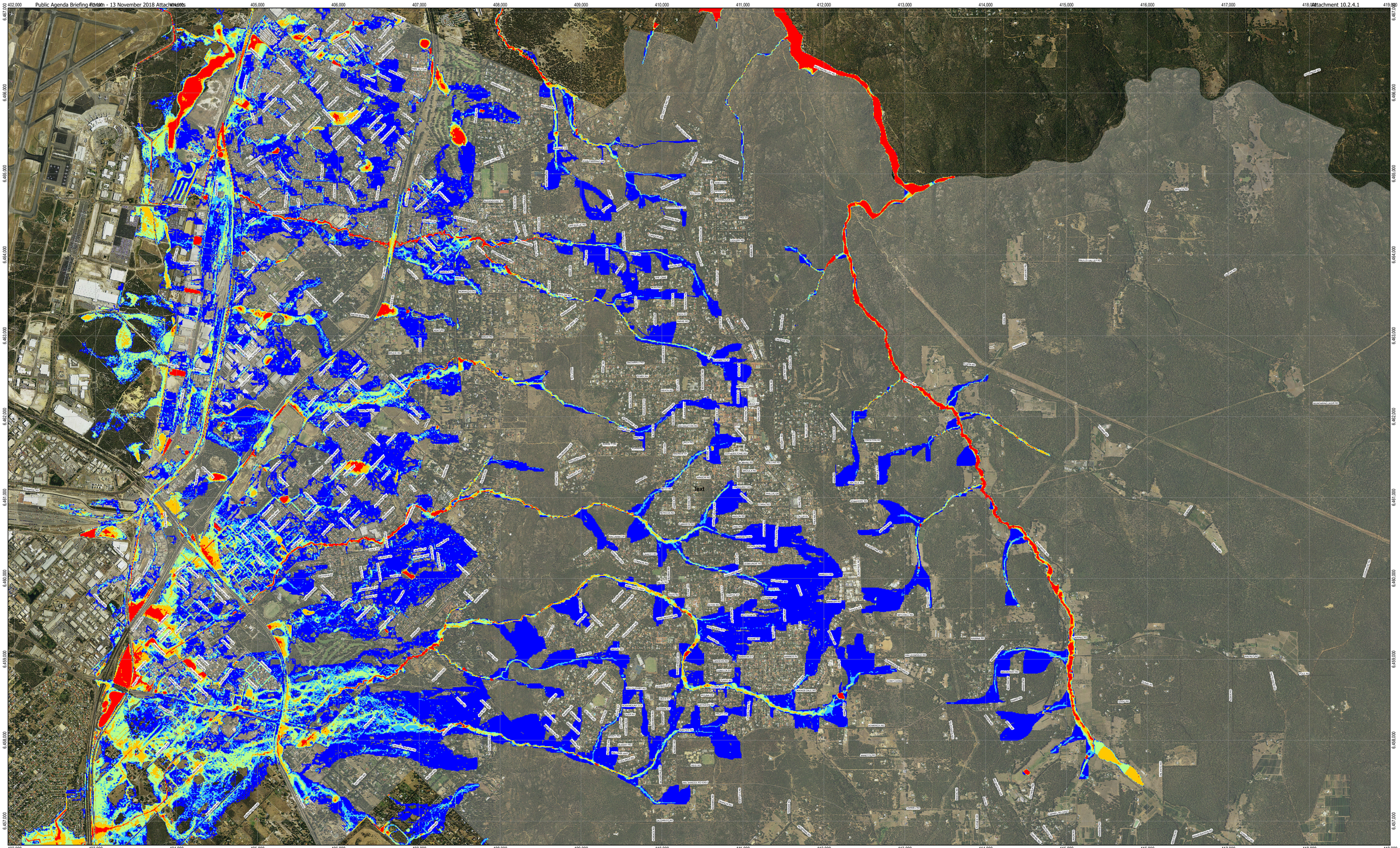

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LEGEND

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- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- > 1.0

Shire of Kalamunda
Kalamunda Region Flood Study

Job Number 61-31574
Revision 0
Date 04 Apr 2016

Future Land Use Flood Risk - 50-year ARI Flood Depth

Figure E2

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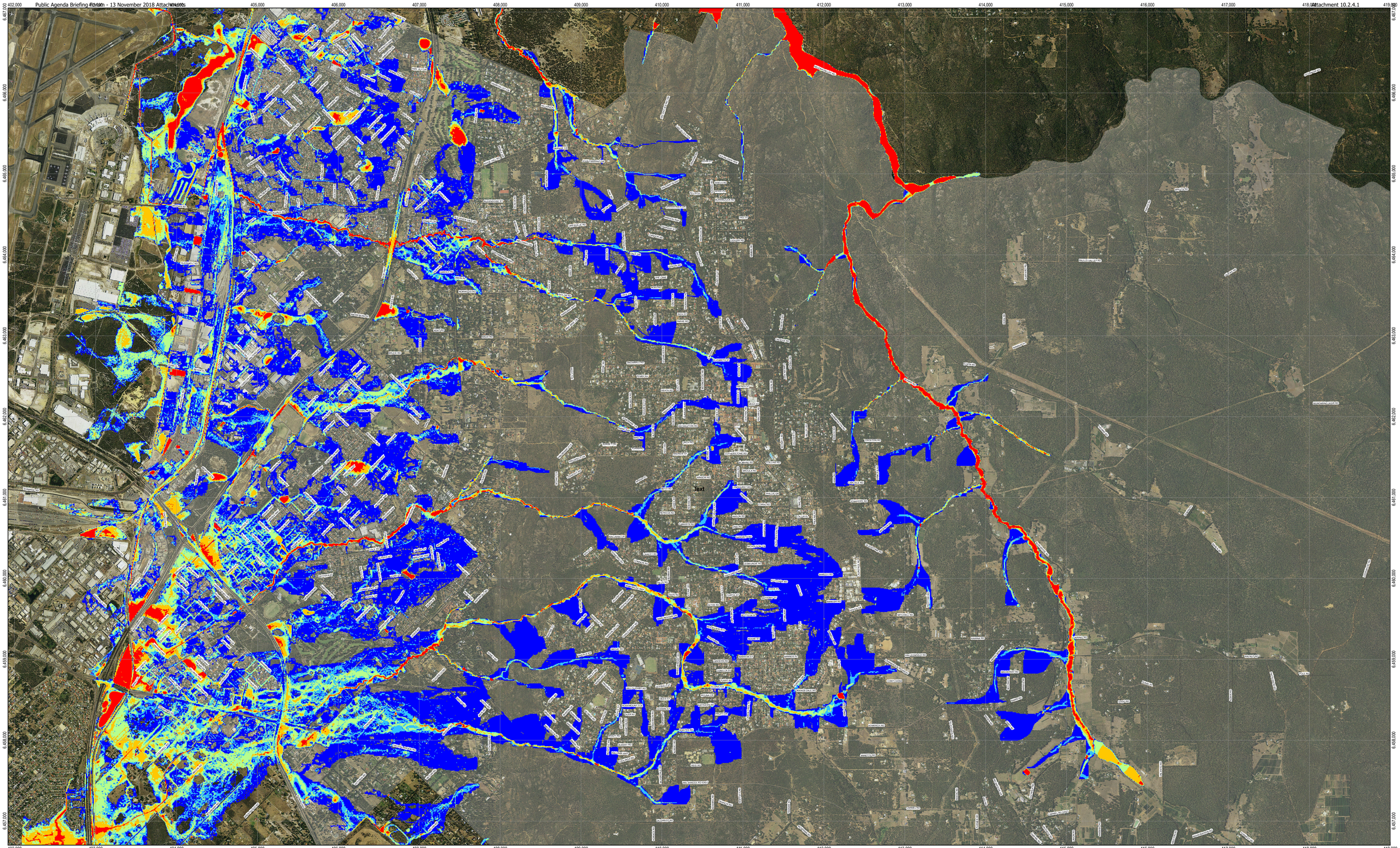

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LEGEND

Flood Depth
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- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- > 1.0

Shire of Kalamunda
Kalamunda Region Flood Study

Future Land Use Flood Risk - 100-year ARI Flood Depth

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Revision 0
Date 04 Apr 2016

Figure E3

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Appendix F – Flooding issues identified to prioritise remediation

Flooding issues identified to prioritise improvement

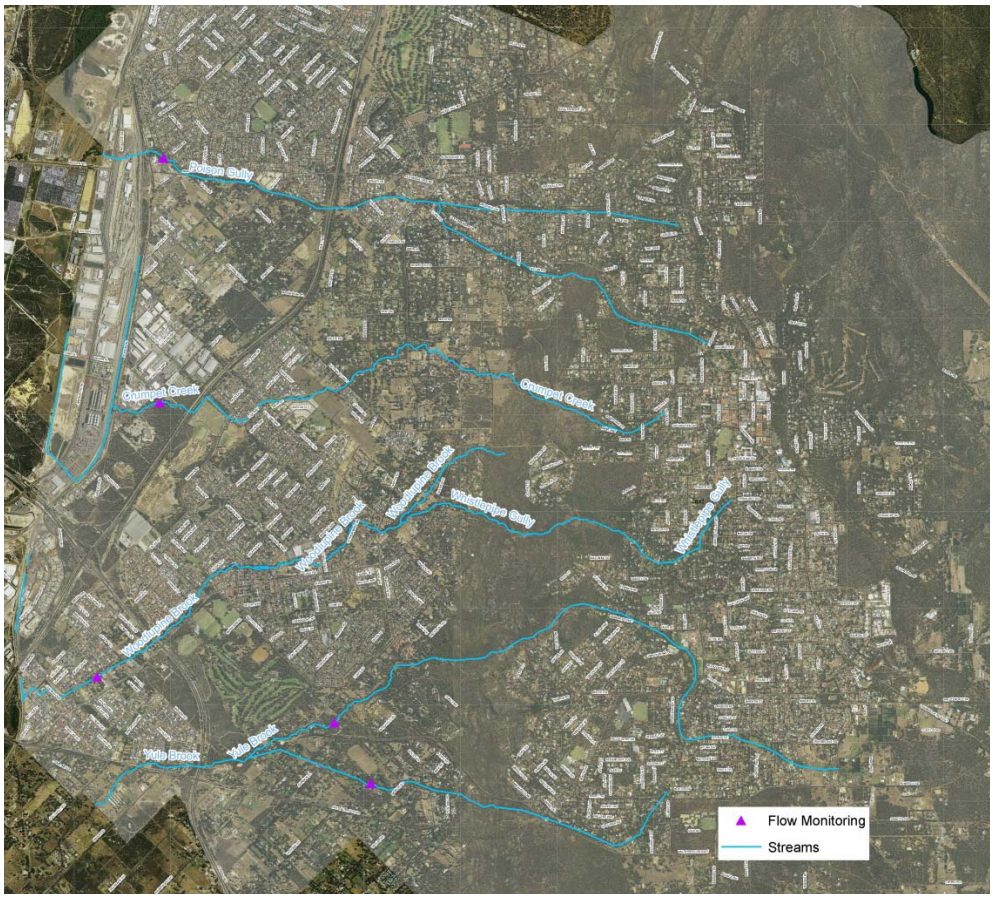
Catchment (Refer Figure A10)	Location	Existing Development 20-year ARI	Future development 20-year ARI	Comments on 100 year event	Prioritity of flood remediation	Potential number of properties affected
Cat4	Corner of Dundas Rd and Wittenoom Rd	Significant area flooded from 0.2m to above 1m	Significant area flooded from 0.2m to above 1m	No significant changes in flood area but minor expansion of depths above 1m	High	6 to 10
Cat4	Corner of Wycombe Rd and Kiandra Wy	Significant area flooded from 0.1m to 1m	Significant area flooded from 0.1m to 1m	No significant changes in flood area but significant increase of depths above 1m	High	6 to 10
Cat4	Corner of Markham Rd and Cyril Rd	Significant area flooded from 0.2m to 1m	Significant area flooded from 0.5m to above 1m	No significant changes in flood area but large increase of depths above 1m	High	6 to 10
Cat4	Corner of Cyril Rd and Swan Rd	Significant area flooded from 0.2m to 1m	Significant area flooded from 0.2m to 1m	Small increase in flood area and medium increase of depth above 1m	High	6 to 10
Cat4	Tia Ave and Edney Rd	Large area flooded from 0.2m to above 1m	Large area flooded from 0.2m to above 1m	No significant changes in flood area or depths	High	11 to 20
Cat5	Rhodes Pl	Minor area flooded from 0.2m to above 1m	Minor area flooded from 0.2m to above 1m	Large increase in flood area and large expansion of depth above 1m	High	1 to 5
Cat5	Corner of Abernathy Rd and Beyer Pl	Significant area flooded from 0.2m to 1m	Significant area flooded from 0.2m to 1m	No significant change in flood area but large expansion of depth to above 1m	High	6 to 10
Cat5	Corner of Harrison Rd and Berkshire Rd	Significant area flooded from 0.2m to 1m	Significant area flooded from 0.2m to above 1m	Medium increase in flood area and medium expansion of depth to above 1m	High	6 to 10
Cat6	Bougainvillea Av, Mallee Wy and and Akebea Av	Large area flooded from 0.2m to above 1m	Large area flooded from 0.2m to above 1m	No significant change in flood area but small expansion of depth to above 1m	High	11 to 20
Cat6	Area encompassing Delta St, Burnett St and Thorogood Av	Large area flooded from 0.1m to 1m	Large area flooded from 0.1m to 1m	Medium increase in flood area and medium expansion of depth to above 1m	High	11 to 20
Cat6	Nutmeg Pl, Chervi Bend and William St	Large area flooded from 0.1m to 1m	Large area flooded from 0.1m to above 1m	Large increase in flood area and large expansion of depth to above 1m	High	11 to 20
Cat1	Corner of Kalamunda and Abernathy roads	Minor area flooded from 0.1m to 1m	Significant area flooded from 0.1m to above 1m	No significant change in flood area or depths	High	6 to 10
Cat1	Corner of Adelaide St and Larwood Cres	Minor area flooded from 0.5 to above 1m	Minor area flooded from 0.5 to above 1m	No significant change in flood area or depths	High	1 to 5
Cat1	Corner of Kalamunda Rd and Stirling Cres	Minor area flooded from 0.1m to above 1m	Minor area flooded from 0.1m to above 1m	No significant change in flood area or depths	High	1 to 5
Cat1	Roe Hwy adjacent to Hill View Golf Course	Significant area of road flooded from 0.2m to above 1m	Significant area of road flooded from 0.2m to above 1m	No significant changes in flood area or depths	High risk to traffic	N/A
Cat1	Abernathy Rd between Kalamunda Rd and Dundas Rd	Significant area of road flooded from 0.5m to above 1m	Significant area of road flooded from 0.5m to above 1m	No significant changes in flooded area but significant expansion of depths above 1m	High risk to traffic	N/A
Cat7	Intersection of Tonkin Hwy and Welshpool Rd	Minor road area flooded from 0.1m to 1m	Significant road area flooded from 0.1m to 1m	No significant change in flood area but small expansion of depth to 1m	Medium risk to traffic	N/A

Catchment (Refer Figure A10)	Location	Existing Development 20-year ARI	Future development 20-year ARI	Comments on 100 year event	Prioritity of flood remediation	Potential number of properties affected
Cat1	Foxton Blvd between Elmore Way and Manor Garden	Significant area flooded from 0.1m to 0.5m	Significant area flooded from 0.1m to 1m	No significant change in flood area but significant expansion of depth to 1m	Medium	6 to 10
Cat1	Blancoa St	Significant area flooded from 0.2m to 1m	Significant area flooded from 0.2m to 1m	Small increase in flooded area and no significant change to depths	Medium	6 to 10
Cat1	Intersetion of Citriadora Ave and Buttercup Cres	Minor area flooded from 0.1m to 0.5m	Minor area flooded from 0.1m to 0.5m	Small increase in flooded area and small expansion of depth to 1m	Medium	1 to 5
Cat1	Between Abernathy Rd and Aurora Ent	Significant area flooded from 0.2m to 0.5m	Significant area flooded from 0.2m to 1m	No significant changes in flood area or depths	Medium	6 to 10
Cat4	Eagle Ct	Minor area flooded from 0.2m to 1m	Minor area flooded from 0.2m to 1m	No significant changes in flood area or depths	Medium	1 to 5
Cat1	Corner of Cyril Rd and Kalamunda Rd	Significant area flooded from 0.1m to 1m	Significant area flooded from 0.1m to 1m	No significant change in flood area or depths	Medium	6 to 10
Cat4	Swan Rd adjacent to Range View Park	Significant area flooded from 0.1m to 1m	Significant area flooded from 0.1m to 1m	Small increase flood area and no significant change in depth	Medium	6 to 10
Cat4	Roe Hwy near Maida Vaile Rd	Large area flooded from 0.2m to 1m	Large area flooded from 0.2m to 1m	No significant changes in flood area but large expansion of depths to 1m	Medium	11 to 20
Cat5	Corner of Ilex Wy and Caluna Wy	Minor area flooded from 0.2m to 1m	Minor area flooded from 0.2m to 1m	No significant change in flood area but large expansion of depth to 1m	Medium	1 to 5
Cat5	Mandon St	Significant area flooded from 0.1m to 0.5m	Significant area flooded from 0.1m to 0.5m	Large increase in flood area and large expansion of depth to 1m	Medium	6 to 10
Cat5	Around Kent Rd Between Brewer Rd and Hawtin Rd	Minor area flooded from 0.1m to 0.5m	Minor area flooded from 0.1m to 0.5m	No significant change in flood area but small expansion of depth to 1m	Medium	1 to 5
Cat6	Area encompassing Hicks St, Reynolds Rd, Cypress Rd and Marble Pl	Extreme area flooded from 0.1m to 0.5m	Extreme area flooded from 0.1m to 0.5m	Small increase in flood area and large expansion of depth to 1m	Medium	20+
Cat6	Area bounded by Kalari Dr and Kooya Wy	Extreme area flooded from 0.1m to 0.5m	Extreme area flooded from 0.1m to 1m	No significant change in flood area but small expansion of depth to 1m	Medium	20+
Cat1	Hamilton Rd between Margery Rd and Western Pl	Minor area flooded from 0.1m to 0.5m	Minor area flooded from 0.1m to 0.5m	No significant change in flood area or depths	Low	1 to 5
Cat1	Chipping Dr	Minor area flooded from 0.1m to 0.5m	Minor area flooded from 0.1m to 0.5m	Small increase in flooded area and no significant change to depths	Low	1 to 5
Cat4	Wren Ct	Minor area flooded from 0.1m to 0.2m	Minor area flooded from 0.1m to 0.2m	Small increase in flooded area and no singificant changes in depth	Low	1 to 5
Cat4	Perrin Wy	Minor area flooded from 0.1m to 0.5m	Minor area flooded from 0.1m to 0.5m	No significant changes to flood area but small increase in depth to 0.5m	Low	1 to 5
Cat4	Emerald Ct	Minor area flooded from 0.1m to 0.5m	Minor area flooded from 0.1m to 0.5m	No significant change in flood area or depths	Low	1 to 5

Catchment (Refer Figure A10)	Location	Existing Development 20-year ARI	Future development 20-year ARI	Comments on 100 year event	Prioritity of flood remediation	Potential number of properties affected
Cat4	Cootamundra Wy	Minor area flooded from 0.1m to 0.5m	Minor area flooded from 0.1m to 0.5m	No significant change in flood area but large expansion of depth to 0.5m	Low	1 to 5
Cat5	Maya Cr	Minor area flooded from 0.1m to 0.5m	Minor area flooded from 0.1m to 0.5m	Medium increase in flood area and Medium expansion of depth to 0.5m	Low	1 to 5
Cat6	Area bordered by Mics Mews, Magma Rd ad Silica Rd	Large area flooded from 0.1m to 0.5m	Large area flooded from 0.1m to 0.5m	Small increase in flood area and no significant change in depth	Low	11 to 20
Cat6	Intersection of Anderson Rd and Hale Rd	Minor area flooded from 0.1m to 0.5m	Minor area flooded from 0.1m to 0.5m	Small increase in flood area and medium expansion of depth to 0.5m	Low	1 to 5
Cat6	Corner of Arthur Rd and Dilabert Ln	Significant area flooded from 0.1m to 0.5m	Significant area flooded from 0.1m to 0.5m	No significant change in flood area but small expansion of depth to 0.5m	Low	6 to 10
Cat6	Intersection of Dorchester Rd and Durham Wy	Significant area flooded from 0.1m to 0.5m	Significant area flooded from 0.1m to 0.5m	Small increase in flood area and small expansion of depth to 0.5m	Low	6 to 10
Cat7	Intersection of Welshpool Rd and Coldwell Rd	Significant road area flooded from 0.1m to 0.5m	Significant road area flooded from 0.1m to 0.5m	No significant changes in flood area or depths	Low	6 to 10
Cat7	Johnson Pl	Minor area flooded from 0.1m to 0.5m	Minor area flooded from 0.1m to 0.5m	No significant change in flood area but medium expansion of depth to 0.5	Low	1 to 5

Appendix G – Flow monitoring locations

Figure G1 Indicative flow monitoring locations



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