WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

335 Barrabool Road,
61-63 Cityview Drive,
65 Cityview Drive,
67 Cityview Drive,
Wandana Heights

Proposed Subdivision – Surface Water Management Strategy

Final Report

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1. INTRODUCTION

Water Technology has been engaged through St Quentin to prepare a Surface Water Management Strategy (SWMS) for Villawood for a proposed residential subdivision at 335 Barrabool Road, 61-63 Cityview Drive, 65 Cityview Drive and 67 Cityview Drive, Wandana Heights.

Water Technology understands the proposal involves sub-division of the site for private sale and residential construction on each new title.

This report focuses on surface stormwater quantity to mitigate any potential downstream impacts due to the proposed subdivision. The report provides an introduction to the site, the proposed plan for subdivision and the proposed strategy for managing stormwater.

Discussions with relevant drainage authorities, Corangamite Catchment Authority and the City of Greater Geelong Council (CoGG), have been conducted to inform the strategy within this report.

Water Technology has also sourced drainage information from VicRoads (the responsible authority for management of the Geelong Ring Road which bounds the property to the west); This too has informed this report.

It should be noted that analysis of water quality was not within the scope of this study and will be addressed in a separate report.

2. SITE OVERVIEW

The subject site is located in Wandana Heights and is bordered by the Geelong Ring Road to the west, Barrabool Road to the north and Cityview Drive to the east. The site is located on a hilltop with sections of the site consisting of undulating and steep terrain. The steep terrain may limit opportunities for on-site storage.

Currently the site consists predominately of cleared agricultural land. Drewan Park borders the site to the east and a Barwon Water asset is located in the centre of the site with access via Cityview Drive. The site is currently zoned Farming Zone (FZ) but is likely to be rezoned to General Residential as part of the proposed Section 96A application (combined rezoning and permit application process).

A significant proportion of the site drains to the west with flow passing through a 700 mm diameter VicRoads culvert under the Geelong Ring Road. This flow path goes on to form a tributary of Kardinia Creek which then flows through Highton and outfalls into the Barwon River.

The Kardinia Creek through Highton is largely piped with the Highton Flood Study identifying capacity problems with the local stormwater system through this area. This study demonstrates that the proposed development will not worsen these existing problems in large flood events.

A smaller proportion of the development site flows to the north-east and south-east draining into the City of Geelong pipe network. Figure 2-1 demonstrates how both the western and eastern catchments ultimately drain into the former Kardinia Creek alignment (now piped) through Highton.

A general catchment plan for the site is shown in Figure 2-5. Key flow paths from the site include to the west towards the culvert under the Ring Road and some small flow paths to the north-east and south-east. Much of the eastern portion of the site drains towards Cityview Drive as sheet flow.

The residential catchments to the east of the site are drained by the existing council pipe network. It is expected that any overland flow generated from this catchment would be low and significantly impeded by property fences/gardens etc.

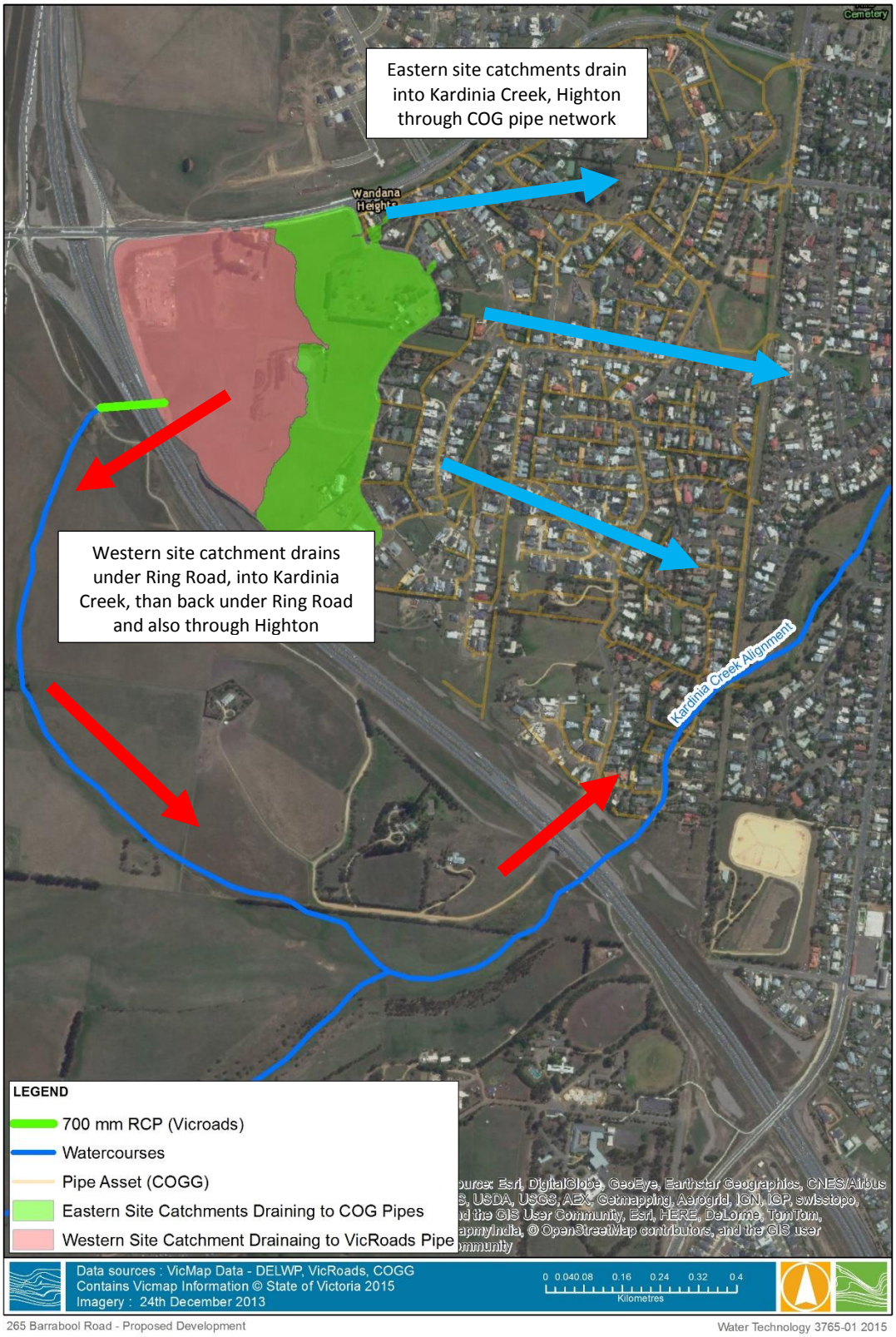

Figure 2-1 **Study area demonstrating that all site catchments ultimately drain into Highton and the former Kardinia Creek alignment**

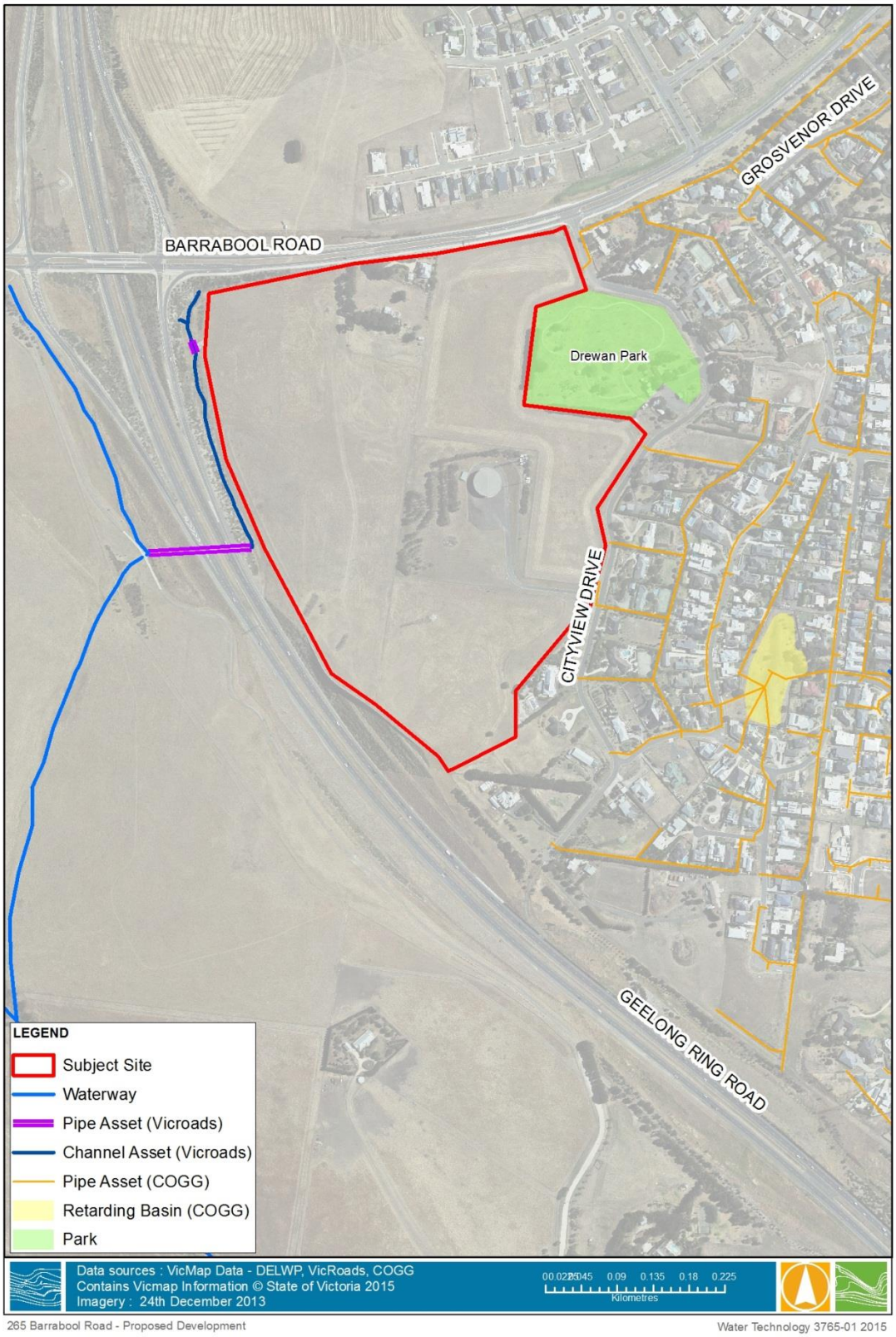

Figure 2-2 Subject Site locality plan

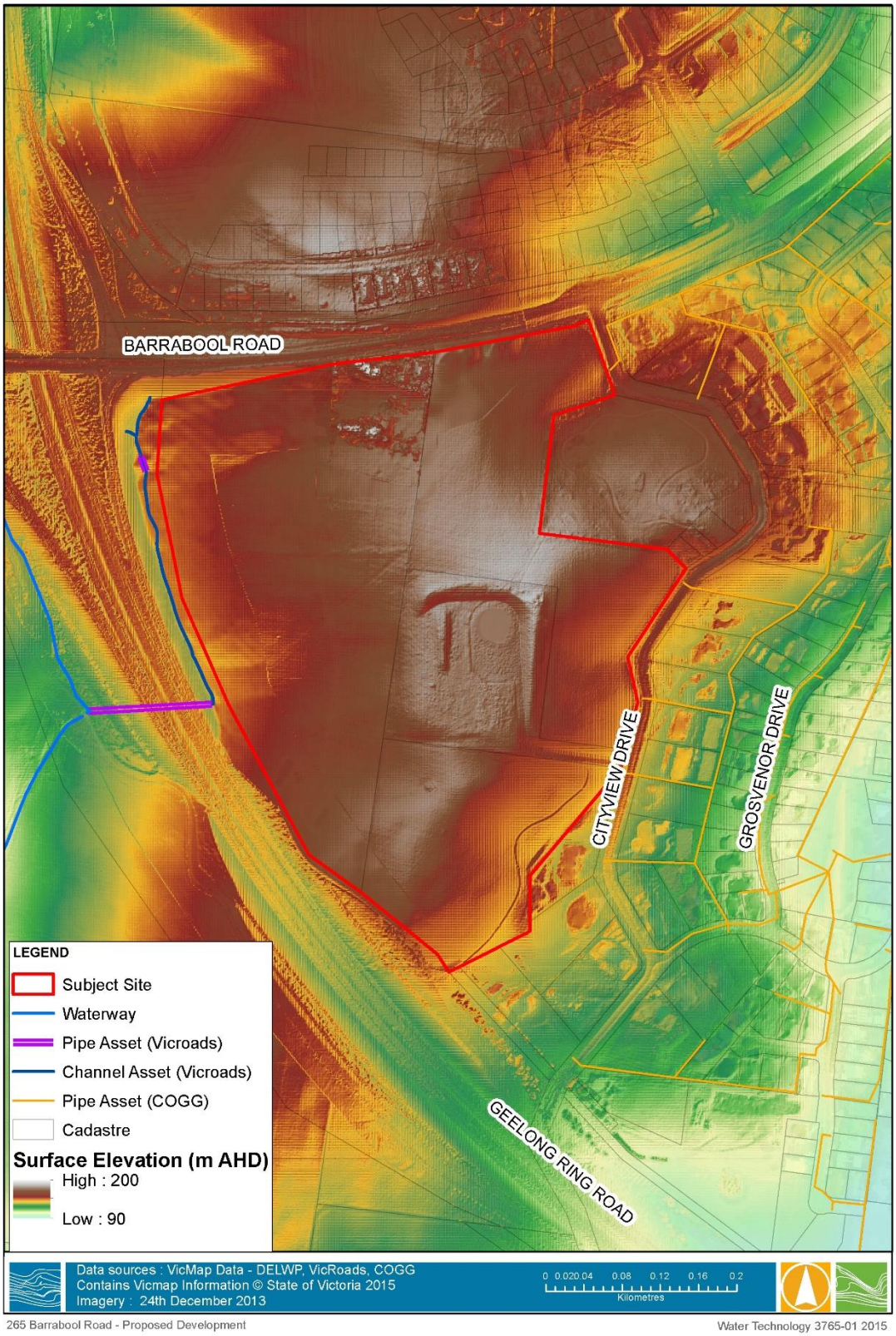

Figure 2-3 Site elevations

Figure 2-4 Drainage assets around the subject site

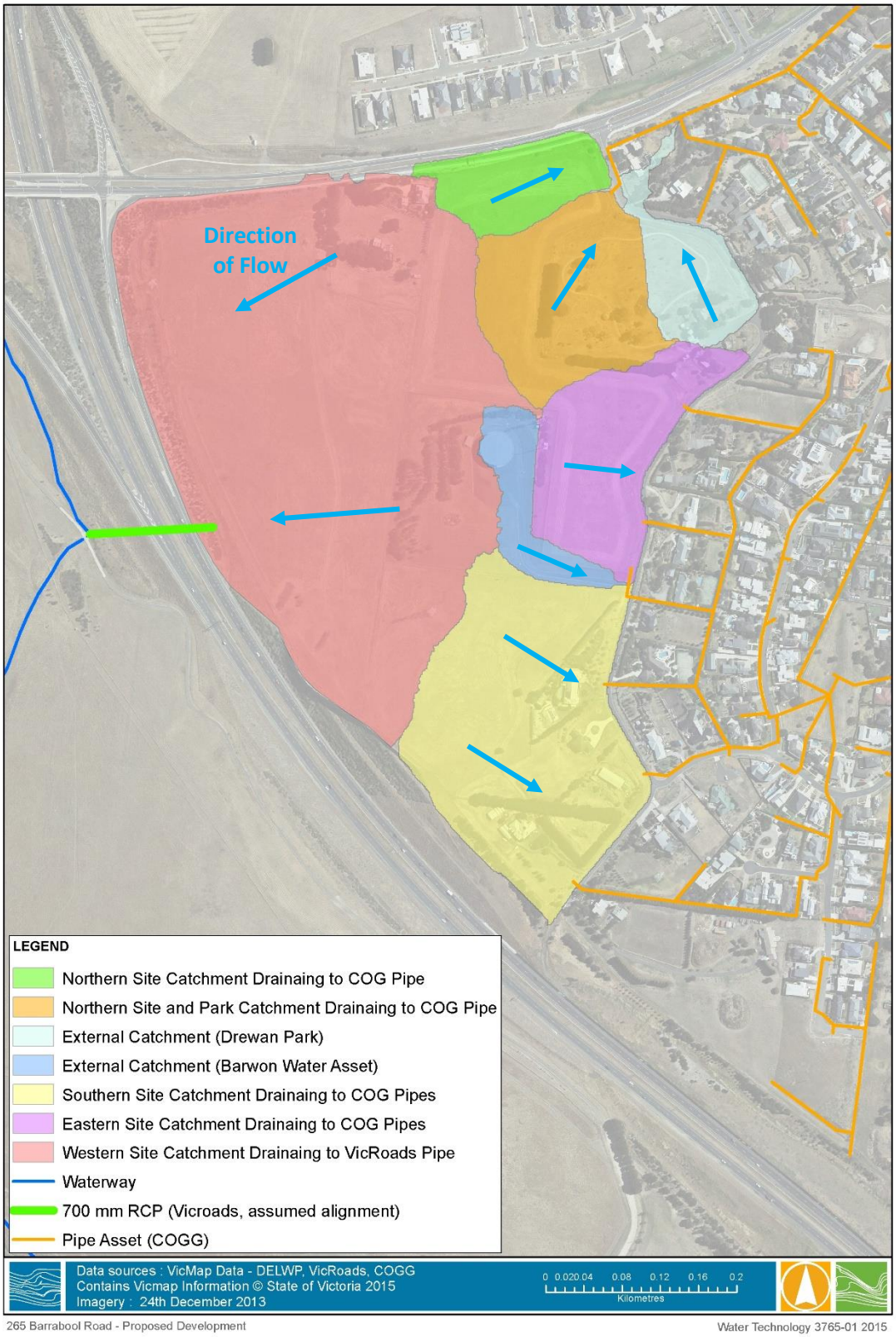

Figure 2-5 Catchment Plan

3. SITE ANALYSIS

3.1 Study Hydrology

The hydrologic analysis of the site to date has been undertaken using a TUFLOW Rainfall-on-Grid model and a RORB model. The TUFLOW model was used initially to define key flow paths across the site, given the site is located on top of a hill and flow paths are not obvious. The RORB model was then developed based on the key flow paths identified in the TUFLOW model. The RORB model was calibrated to the VicRoads Rational Method as per City of Great Geelong guidelines.

The calibrated RORB model was then run for the 1% and 10% AEP events for the full range of event durations. Existing conditions were run first to determine the flooding mechanisms across the site. Details of the RORB model setup and parameters are provided in Appendix A.

3.1.1 Existing Conditions

The pre-developed conditions model represents the site undeveloped currently with the main discharge points being a 700 mm diameter RCP culvert under the Geelong Ring Road to the west, a flow path to the north-east draining towards a CoGG pipe and a number of small flow paths in the south-east of the site flowing towards private properties on Cityview Drive. Much of the eastern half of the site drains as sheet flow onto Cityview Drive and into the Council drainage network. Currently the site is undeveloped and consists of pastured agricultural land.

The flood behaviour of the site under existing conditions is outlined below:

- Site Flows:
    - The western portion of the site forms the largest on-site catchment and flows to the west discharging towards a 700 mm diameter RCP under the Geelong Ring Road. A natural storage exists on the upstream side of the culvert and fills in large events. The total flow entering the natural storage is 0.79 m^3/s (790 l/s) in the 1% AEP event, and 0.26 m^3/s (260 l/s) in the 10% AEP event;
    - A portion of the site slopes to the north and north-east towards Wandana Drive and Barrabool Road and produces a small flow path with a peak of 0.18 m^3/s (180 l/s) in the 1% AEP event, and 0.05 m^3/s (50 l/s) in the 10% AEP event;
    - A portion of the site slopes to the east and south-east towards Cityview Drive and produces several very small flow paths and sheet flow. It is difficult to provide peak flows for individual flow paths through this area due to the small sub-catchment areas and very low flows however a notable flow path exists further downstream near the end of Cityview Drive. That location has been termed South-East outlet (upper) in this report and peak flows of 0.07 m^3/s (70 l/s) occur in the 1% AEP event, and 0.02 m^3/s (20 l/s) in the 10% AEP event. Further downstream additional flow is received from a flow path which drains the southern edge of the subject site and parts of the Ring Road reserve. That location has been termed South-East outlet (lower) in this study and peak flows of 0.21 m^3/s (210 l/s) occur in the 1% AEP event, and 0.08 m^3/s (80 l/s) in the 10% AEP event.
- The low lying area between the Geelong Ring Road and the site acts as a ‘defacto’ retarding basin with outflows restricted by the 700 mm diameter RCP pipe.

The peak 1% AEP existing flows leaving the site are shown in Figure 3-1 for the critical duration event in each catchment. Peak flows for the other durations are shown in Table 3-1.

The peak 10% AEP existing flows leaving the site are shown in Figure 3-2 for the critical duration event in each catchments. Peak flows for the other durations are shown in Table 3-2.

Figure 3-1 Existing 100 year ARI Event Peak Flows

Figure 3-2 Existing 10 year ARI Event Peak Flows

Figure 3-3 Existing 2 year ARI Event Peak Flows

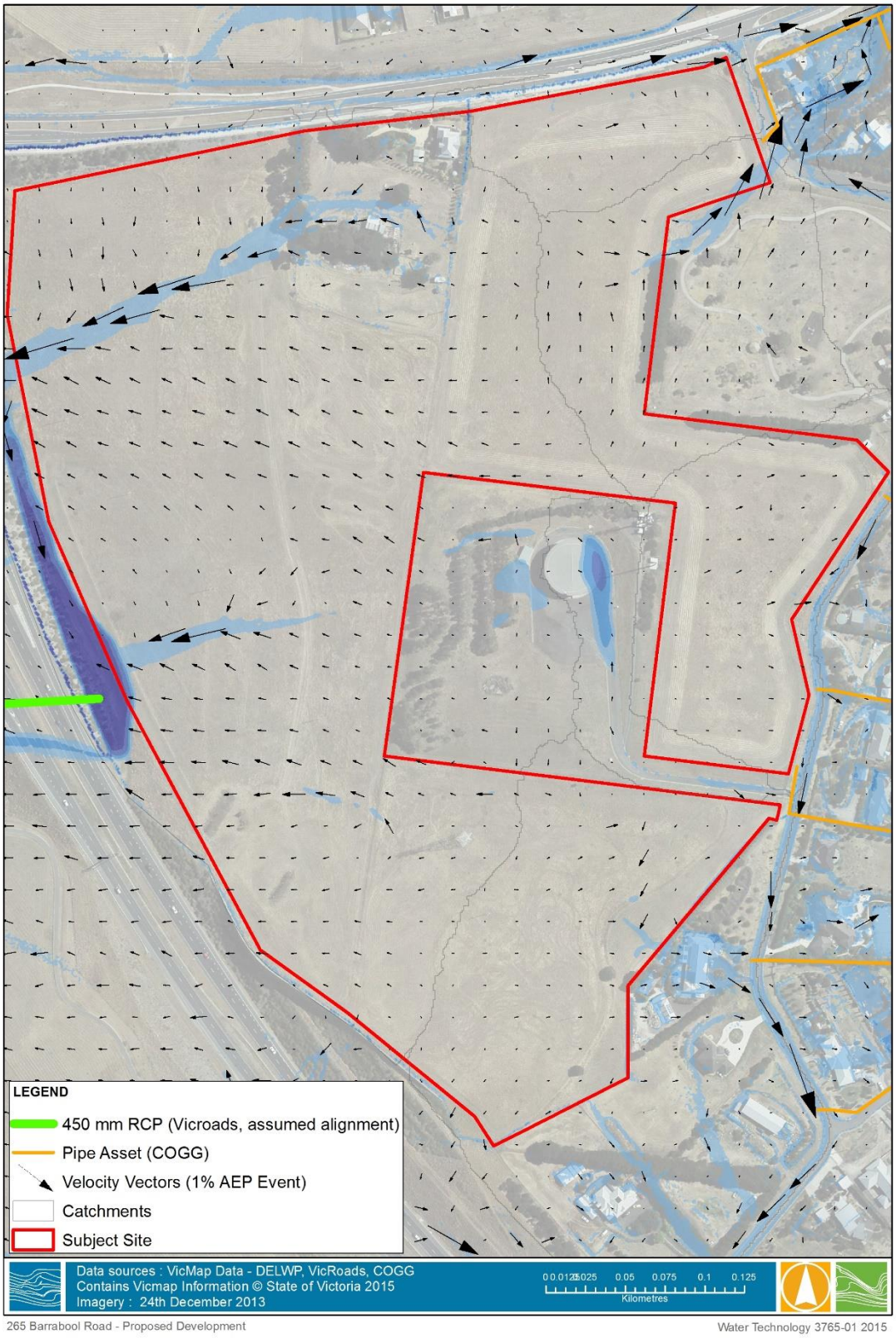

Figure 3-4 100 year ARI velocity vectors demonstrating key flow paths

Table 3-1 Peak 100 year ARI Flows Leaving the Site under Existing Conditions

Duration	Western catchments (m^3/s)	North-east catchments (m^3/s)	South-east catchments (m^3/s)
10m	0.208	0.075	0.277
15m	0.374	0.136	0.351
20m	0.500	0.176	0.378
25m	0.583	0.203	0.403
30m	0.653	0.212	0.375
45m	0.758	0.235	0.353
1h	**0.795**	0.249	0.424
1.5h	0.761	0.245	**0.425**
2h	0.760	**0.254**	0.416
3h	0.651	0.189	0.270
4.5h	0.710	0.208	0.292
6h	0.649	0.190	0.235
9h	0.657	0.176	0.219
12h	0.568	0.146	0.194

Table 3-2 Peak 10 year ARI Flows Leaving the Site under Existing Conditions

Duration	Western catchments (m^3/s)	North-east catchments (m^3/s)	South-east catchments (m^3/s)
10m	0.021	0.004	0.057
15m	0.027	0.006	0.063
20m	0.050	0.013	0.075
25m	0.081	0.024	0.091
30m	0.109	0.033	0.089
45m	0.168	0.051	0.107
1h	0.193	0.056	0.124
1.5h	0.198	0.055	0.138
2h	0.208	0.059	**0.146**
3h	0.203	0.055	0.090
4.5h	0.188	0.056	0.113
6h	0.217	0.056	0.099
9h	**0.260**	**0.070**	0.101
12h	0.233	0.058	0.088

Table 3-3 Peak 2 year ARI Flows Leaving the Site under Existing Conditions

Duration	Western catchments (m^3/s)	North-east catchments (m^3/s)	South-east catchments (m^3/s)
10m	0.009	0.002	0.027
15m	0.012	0.002	0.031
20m	0.014	0.003	0.032
25m	0.016	0.003	0.032
30m	0.018	0.003	0.034
45m	0.023	0.005	0.036
1h	0.045	0.012	0.039
1.5h	0.062	0.017	0.035
2h	0.066	0.018	0.042
3h	0.076	0.019	0.039
4.5h	0.075	0.019	0.039
6h	0.077	0.020	0.038
9h	**0.125**	**0.033**	**0.056**
12h	0.107	0.028	0.046

3.1.2 Developed Conditions

Developed conditions were modelled in the RORB model based on the current layout plans. Appendix A contains additional information regarding the parameters used in the developed RORB model. Minor flows (<= 20% AEP) will drain through the development drainage network whilst major flows (>= 1% AEP) are to be catered for along the road network.

In unmitigated conditions in the western catchment, peak 100 year ARI flows entering the natural storage area have increased from 0.80 m^3/s to 1.46 m^3/s following development of the site. In the north-east, peak flows leaving the site have increased from 0.25 m^3/s to 0.33 m^3/s. Flows from the south-east catchments have increased from 0.42 m^3/s to 0.83 m^3/s.

The layout design has three significant locations which are the preferred locations for retardation works. These have been termed the western Retarding Basins, north-east Retardation Storage and south-east Retarding Basins.

3.1.3 Mitigated Conditions – Western Catchment

Three retarding basins are proposed for the western catchment area to retard 2, 10 and 100 year ARI development flows leaving the western boundary of the site back to existing conditions. The system ensures that total design flows flowing into the natural storage area adjacent to the Geelong Ring Road are retarded back to existing conditions.

The two minor retarding basins will receive minor flows from the development drainage network. Major flows will enter the minor basins as overland runoff from the low point in the roads, adjacent to the respective basins.

The major basin will not spill in any event up to and including the 100 year ARI event while the minor basin will spill in events greater than the 2 year ARI event. The two minor basin are designed to retard the 2 year ARI event while the major basin is designed for the 100 year event. The combination of basins also adequately retards the 10 year ARI event flows to below existing conditions.

The concept designs for the three Western catchment basin are as follows:

Western Minor Retarding Basin "A" – designed for 2 year ARI event

- Basin base level = 132.4 m AHD
- Basin Depth = 0.80 metres (below spillway level)
- Capacity at spillway level = 895 m^3 (excluding freeboard)
- Outlet Pipe = 1 x 300 mm RCP with 100 mm orifice plate with invert at 132.4 metres AHD
- 30 metre wide spillway at 133.1 m AHD for events greater than 2 yr ARI event.
- 100 Year ARI flood depth = 0.86 m
- 100 Year ARI flood volume = 986 m^2

Western Minor Retarding Basin "B" – designed for 2 year ARI event

- Basin base level = 134.2 m AHD
- Basin Depth = 0.40 metres (below spillway level)
- Capacity at spillway level = 380 m^3 (excluding freeboard)
- Outlet Pipe = 1 x 300 mm RCP with 100 mm orifice plate with invert at 134.2 metres AHD
- 20 metre wide spillway at 134.6 metres depth for events greater than 2 yr ARI event.
- 100 Year ARI flood depth = 0.46 m
- 100 Year ARI flood volume = 446 m^2

Western Major Retarding Basin – designed for 100 year ARI event

- Basin base level = 131.0 m AHD
- Basin Depth = 0.70 metres
- Capacity = 2,134 m^3 (excluding freeboard)
- Outlet Pipe = 1 x 600 mm RCP with invert at 131.0 metres AHD
- 100 Year ARI flood depth = 0.70 m
- 100 Year ARI flood volume = 2,134 m^2

Batters are 1:6 at all three basins. The impact of the retarding basins on peak flows across the range of modelled events is shown in Figure 3-8, Figure 3-10 and Figure 3-12 below.

An orifice plate has been recommended to be fitted to the outlet pipe in the two minor basins due to the very low outlet flows required to retard to existing conditions. A diagram of a typical orifice plate is shown in Figure 3-5. It is recommended that a regular maintenance schedule be implemented and a grill considered (for ease of maintenance) due to the higher risk of blockage.

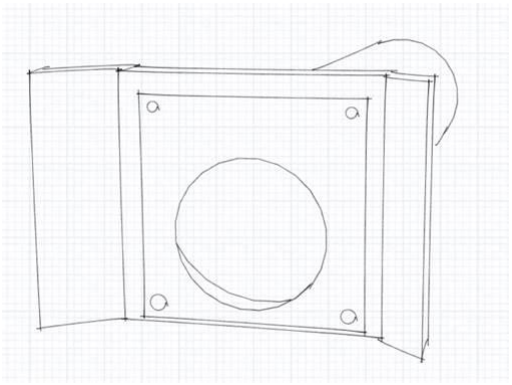

Figure 3-5 Sketch of a typical orifice plate

It should be noted that the basin design was based on proposed levels and a conceptual stage-storage volume calculated based on 1 in 6 batter slopes to the natural surface. The stage-storage relationships for the three Western basins are shown in Table 3-4, Table 3-5 and Table 3-6. The final shape and configuration of the retarding basin will be confirmed in the functional design stage.

The proposed location of the three retarding basins is shown in Figure 3-6.

Table 3-4 Proposed Western Minor Basin A Stage – Storage Relationship

Depth	Stage (m AHD)	Flood Storage (m^3)	Comments
0	132.40	0	Normal water level
0.1	132.50	84	
0.2	132.60	175	
0.3	132.70	274	
0.4	132.80	380	
0.5	132.90	496	
0.6	133.00	620	
0.7	133.10	753	
0.8	133.20	895	Spillway level

Table 3-5 Proposed Western Minor Basin B Stage – Storage Relationship

Depth	Stage (m AHD)	Flood Storage (m^3)	Comments
0	134.20	0	Normal water level
0.1	134.30	84	
0.2	134.40	175	
0.3	134.50	274	
0.4	134.60	380	Spillway Level

Table 3-6 Proposed Western Major Basin Stage – Storage Relationship

Depth	Stage (m AHD)	Flood Storage (m^3)	Comments
0	131.00	0	Normal water level
0.1	131.10	258	
0.2	131.20	530	
0.3	131.30	819	
0.4	131.40	1,123	
0.5	131.50	1,443	
0.6	131.60	1,780	
0.7	131.70	2,134	

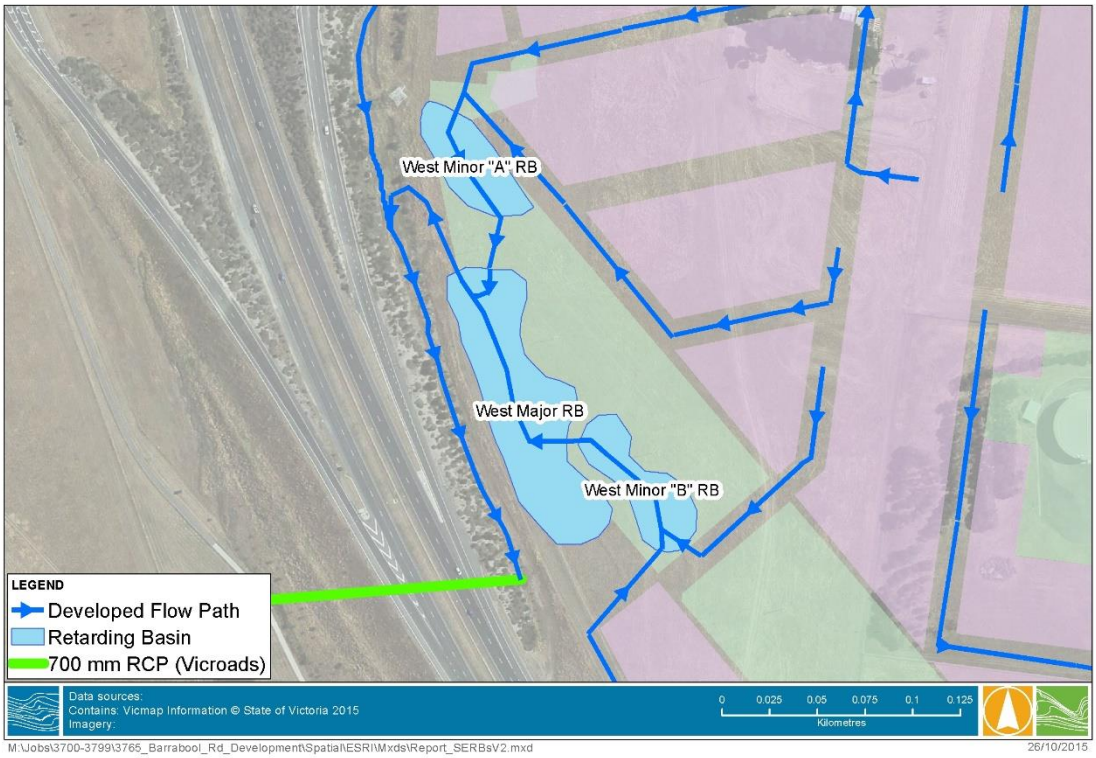

Figure 3-6 Western catchment developed flow paths and retarding basins

3.1.4 Mitigated Conditions – North-East Catchment

Retardation storage is proposed in the north-east of the site adjacent to the corner of Barrabool Road and Cityview Drive to retard 2, 10 and 100 year ARI development flows leaving the north-east of the site to below existing conditions. The storage is located within a series of Biofilta tanks which have an internal depth of 1.6 metres with the top 1.45 metres of each cell available for detention storage.

The detention tanks will receive both minor and major flows from the development drainage network.

The concept designs for the north-east catchment retardation storage are as follows:

- Available Detention Depth = 1.45 metres
- Detention Capacity = 191.4 m^3
- Four Outlet Pipes:
  - 1 x 50 mm outlet at 0 metres depth (for 2 year event)
  - 1 x 70 mm outlet at 0.95 metres depth (for 10 year event)
  - 2 x 250 outlets at 1.15 m depth (for 100 year event)
- 50 mm outlet invert at 134.55 metres AHD
- 100 Year ARI flood depth = 1.41 m
- 100 Year ARI flood volume = 185 m^3
- Detention storage tanks with detailed design by Biofilta Pty Ltd.

The 2 hour duration storm was found to be critical for flood storage in the proposed storage, with a storage volume of 185 m^3 required in the 1% AEP event. The impact of the retarding storage on peak flows across the range of modelled events is shown in Figure 3-8, Figure 3-10 and Figure 3-12 below.

The final layout and configuration of the retarding storage will be confirmed by Biofilta Pty Ltd.

Alternative Detention Option - Off-Site Detention at Scenic Road Retarding Basin

An alternative proposal for detention of the north-east catchment has been discussed whereby the Scenic Road Retarding Basin at the corner of Scenic Road and Barrabool Road could be used to retard the north-east catchment runoff as opposed to on-site measures. The proposal was deemed worthy of consideration given the close proximity of the basin and that the catchment RORB modelling (see Section 4) indicates it has available capacity in the 100 year ARI event. The proposal would involve:

- Upgrading the capacity of the drainage line between the north-east corner of the development site to the Scenic Rd retarding basin to ensure the site flows can be adequately conveyed to the basin (as well as additional flow from adjoining sub-catchments). Currently an overland drainage path exists along this drainage alignment but consists of an ill-defined channel with very limited capacity. Hydraulic modelling from the Highton Flood Study indicates that much of the flow runoff under existing conditions flows down Barrabool Road. An upgrade to this drainage line would improve flood risk along the roadway by ensuring flow is conveyed safely within a channel and pipe system of appropriate capacity. The map below demonstrates the 1% AEP flood map through this area under existing conditions and the alignment of the proposed upgraded drainage line is marked.

- The proposal could also involve modifications to the Scenic Drive Retarding Basin including increasing the capacity by the additional volume in the 100 year ARI event (an increase of less than 1%). Additional modification works could include optimising the outlets of the basin. Given the basin does not appear to be using its full storage capacity in the 100 year ARI event, modifying the RB outlet to ensure more of its capacity is utilised could significantly improve downstream flood conditions.

Given the significant drainage upgrade works that would be required as well as the extensive engagement with stakeholders that would be needed including nearby landholders and Council it is recommended that on-site detention be the preferred option. The current proposal for the north-east catchment which includes the Biofilta system offers a cost-effective solution which adequately addresses the challenges of the catchment which are namely limited space for detention works and the significant gradient of the catchment.

If the off-site detention option is to be pursued, further analysis would be required to better understand the nature of the flows along the drainage line between the development site and the retarding basin as well as what modifications what need to be made to the basin.

3.1.5 Mitigated Conditions – South-East Catchment

Two retarding basins are proposed for the south-eastern catchment area to retard 2, 10 and 100 year ARI development flows leaving the southern and south-eastern boundaries of the site. The system ensures that total design flows flowing from the south-eastern catchments into an open channel adjacent to the Geelong Ring Road are retarded to below existing conditions.

The minor retarding basin will receive minor flows from the development drainage network. Major flows will enter the minor basin as overland runoff from the low point in the road, adjacent to the basin.

The major basin will not spill in any event up to and including the 100 year ARI event while the minor basin will spill in events greater than the 2 year ARI event. The minor basin is designed to retard the 2 year ARI event while the major basin is designed to retard the 10 and 100 year ARI events.

The concept designs for the two south-eastern catchment basins are as follows:

South-eastern Minor Retarding Basin – designed for 2 year ARI event

- Basin base level = 144.55 m AHD
- Basin Depth = 0.35 metres

- Capacity at spillway level = 232 m^3 (excluding freeboard)
- Outlet Pipe = 1 x 300 mm RCP with invert at 144.55 metres AHD
- The major storage is split into two separate basins connected by a 300 mm RCP balance pipe which ensures they effectively operate as a single basin.
- 5 metre wide spillway at 144.9 m AHD for events greater than 2 yr ARI event.
- 100 Year ARI flood depth = 0.50 m
- 100 Year ARI flood volume = 250 m^3

South-eastern Major Retarding Basins – designed for 10 and 100 year ARI events

- Basin base level = 137.24 m AHD
- Basin Depth = 0.71 metres
- Capacity = 1,290 m^3 (excluding freeboard)
- Outlet Pipe 1 = 1 x 300 mm RCP with 50 mm orifice plate with invert at 137.24 metres AHD
- Outlet Pipe 2 = 3 x 300 mm RCP with invert at 137.64 metres AHD
- The major storage is split into two separate basins connected by a 450 mm RCP balance pipe which ensures they effectively operate as a single basin.
- 100 Year ARI flood depth = 0.71 m
- 100 Year ARI flood volume = 1,290 m^3

For the south-east catchment two retarding basins are proposed within the open space near the outlet of the south-east catchment area to retard 2, 10 and 100 year ARI development flows leaving the east and south-east of the site back to existing conditions. The major storage is split into two separate basins to be clear of transmission power lines and are connected by a 450mm balance pipe which ensures effectively function as a single storage. The minor storage is also split into two separate basins for the same reason with a 450mm balance pipe connecting them.

Peak flows have been reported at two locations - the southern end of Cityview Drive and the South-East Catchment Outlet. The south-east outlet location includes flows from the minor catchments located at the south of the site and adjacent to the Geelong Ring Road. Under existing conditions a greater proportion of the south-east catchment flows directly to the south into the drain adjacent to the Ring Road compared with under developed conditions where more flow is directed towards the retarding basin and then along the flow path at the southern end of Cityview Drive. This explains why the result show an increase in flow at the end of City View Drive under developed conditions however the ultimate peak flow from the south-east catchment is less than under existing conditions.

The stage-storage relationships for the basins are shown in Table 3-7 and Table 3-8 while the proposed locations of the basins are shown in Figure 3-7.

The impact of the retarding basins on peak flows across the range of modelled events is shown in Figure 3-8, Figure 3-10 and Figure 3-12.

Table 3-7 Proposed South-East Minor Basin Stage – Storage Relationship

Depth	Stage (m AHD)	Flood Storage (m^3)	Comments
0	144.55	0	Normal water level
0.1	144.65	59	
0.2	144.75	124	
0.3	144.85	194	
0.35	144.90	232	Spillway Level

Table 3-8 Proposed South-East Major Basin Stage – Storage Relationship

Depth	Stage (m AHD)	Flood Storage (m^3)	Comments
0	137.24	0	Normal water level
0.1	137.34	134	
0.2	137.44	279	
0.3	137.54	437	
0.4	137.64	607	
0.5	137.74	790	
0.6	137.84	986	
0.7	137.94	1,290	

Figure 3-7 South-east catchment flow paths and retarding basins

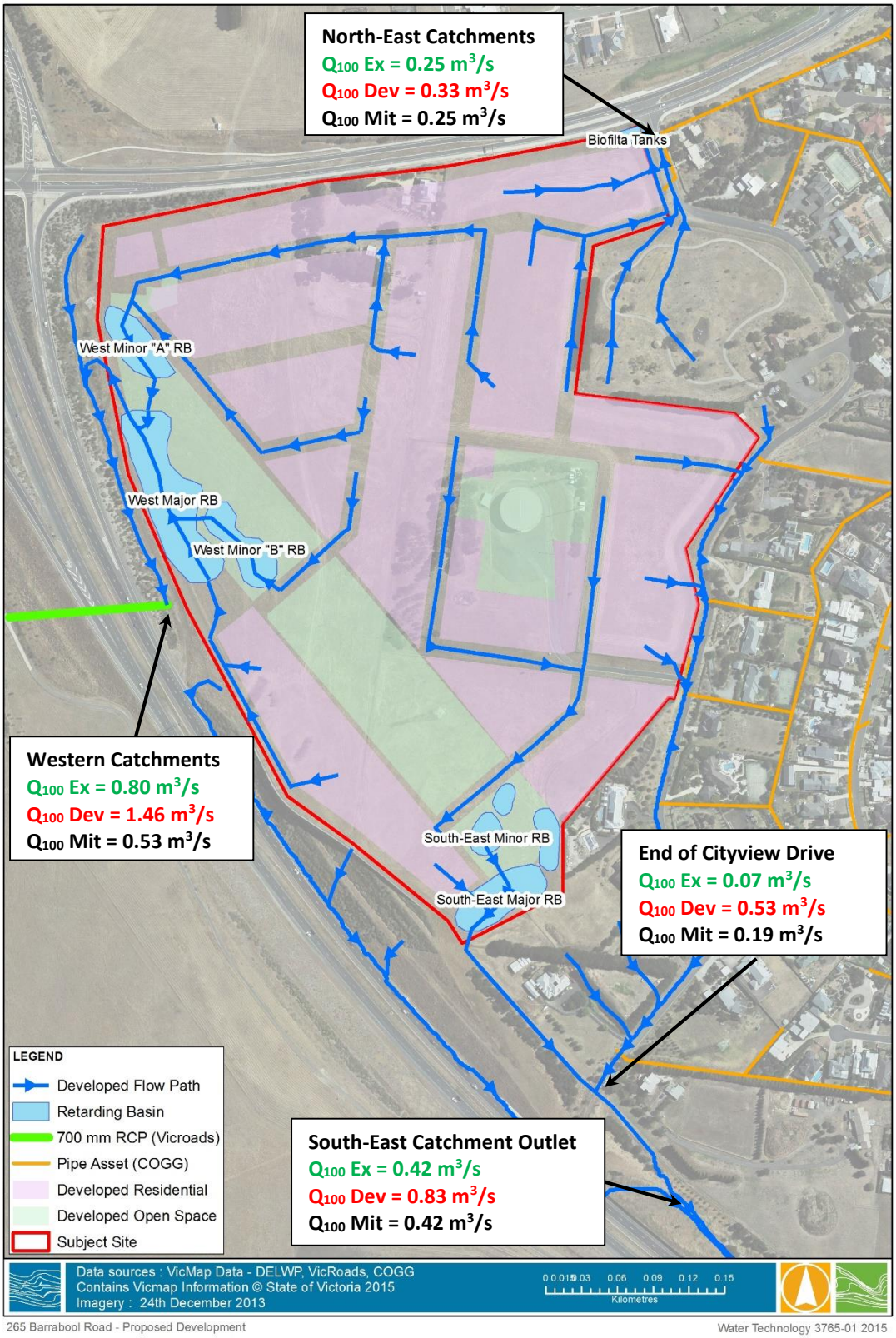

Figure 3-8 Existing, Developed and Mitigated Peak 100 year ARI Flows

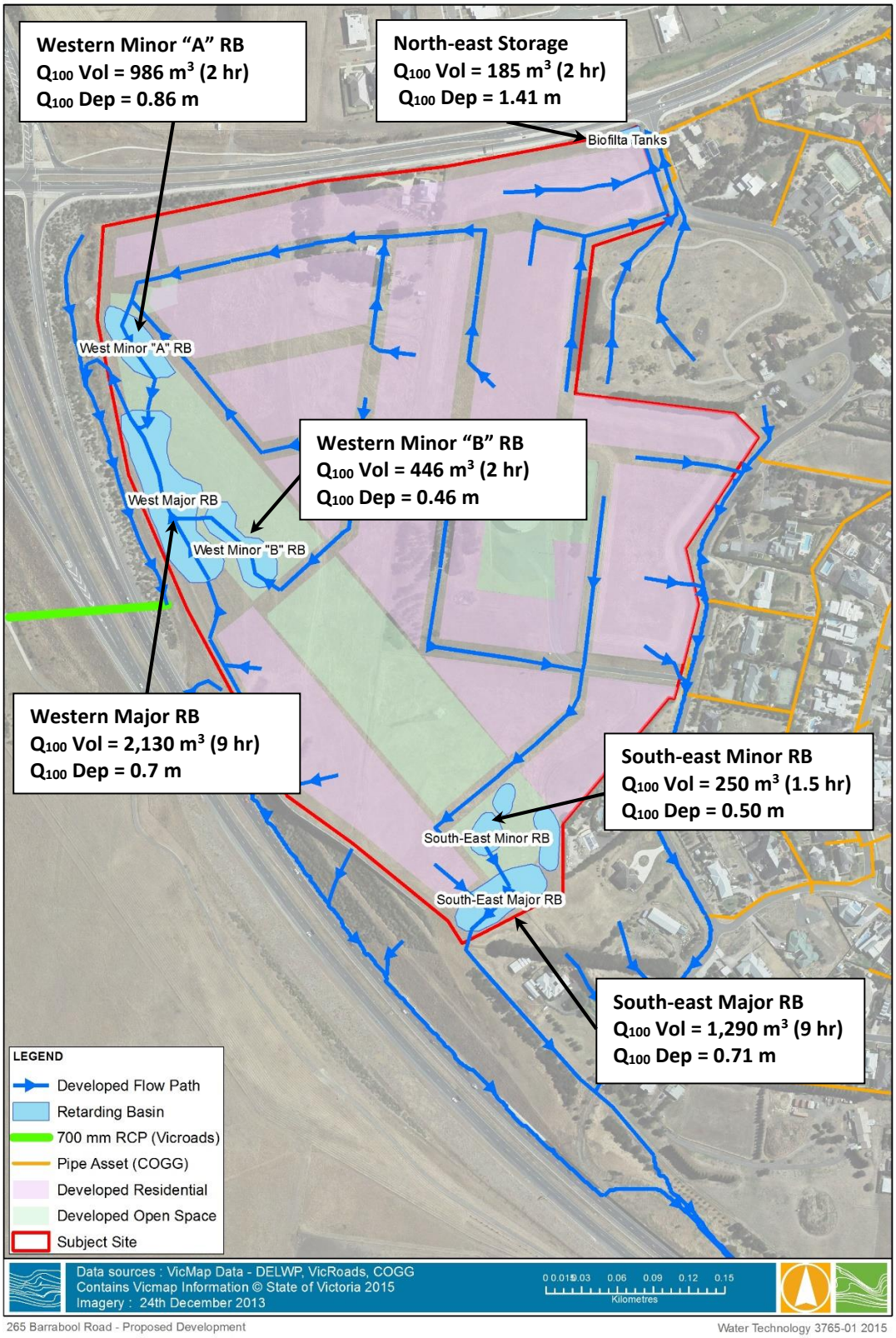

Figure 3-9 100 year ARI Retarding Basin Volumes and Depths

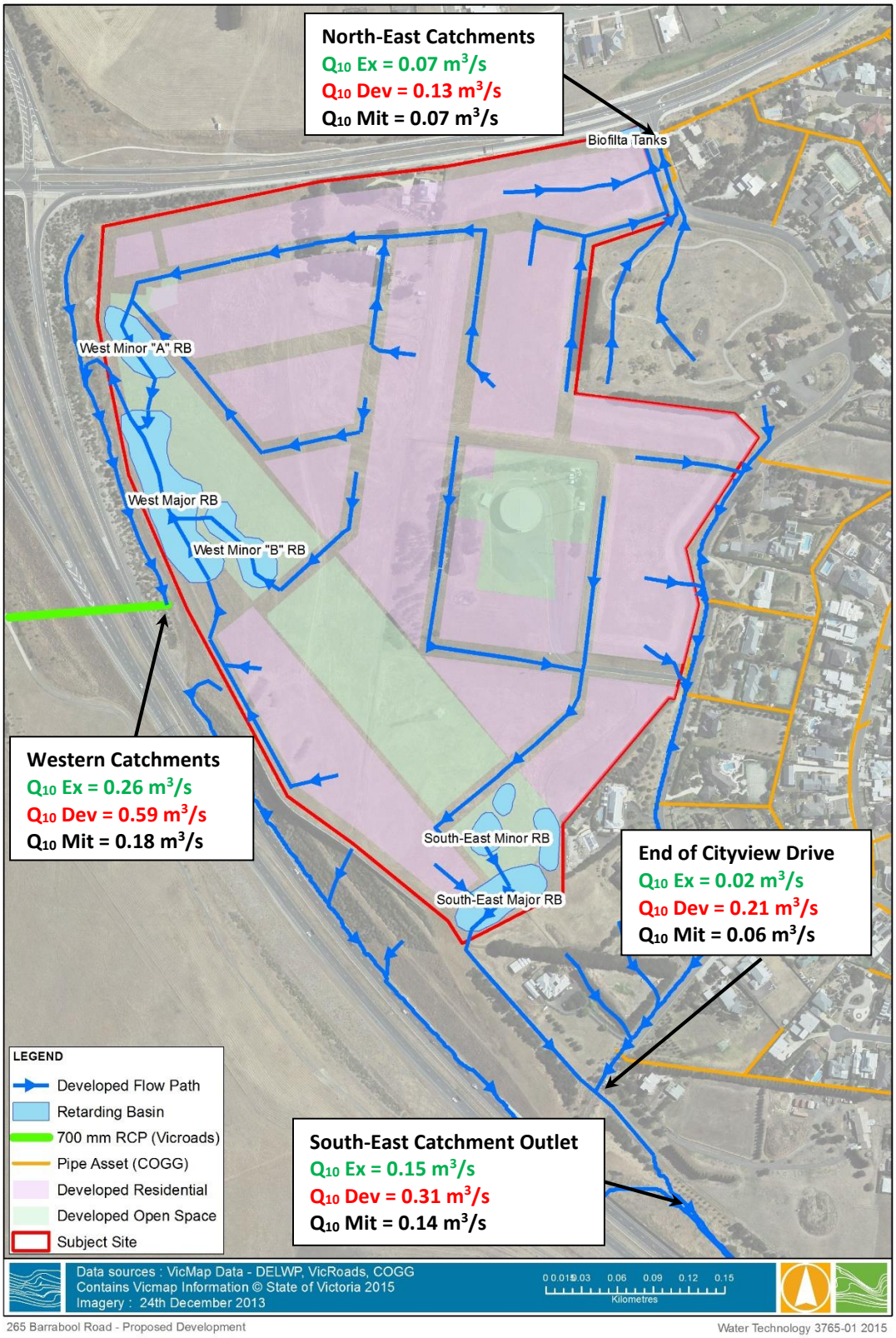

Figure 3-10 Existing, Developed and Mitigated Peak 10 year ARI Flows

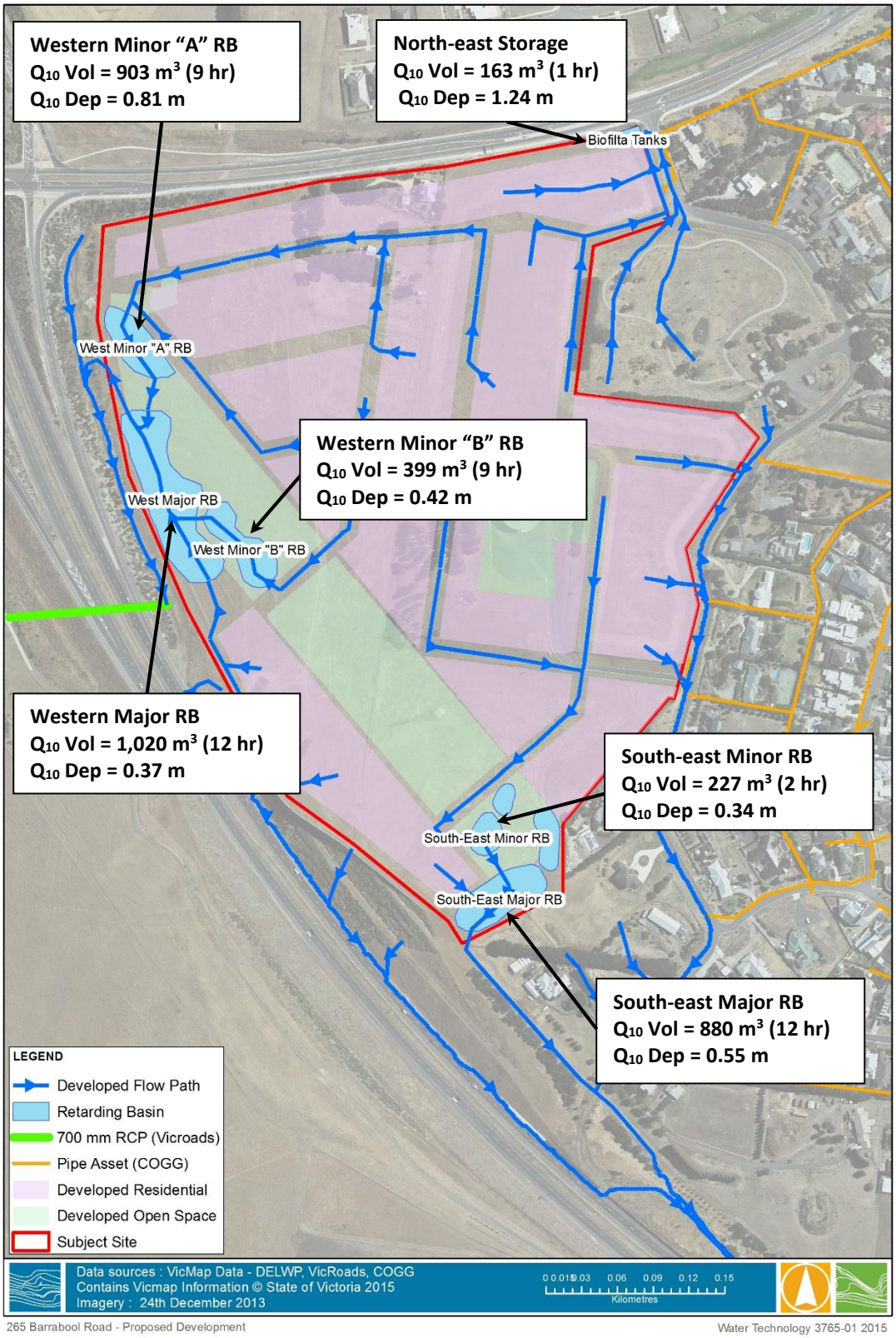

Figure 3-11 10 year ARI Retarding Basin Volumes and Depths

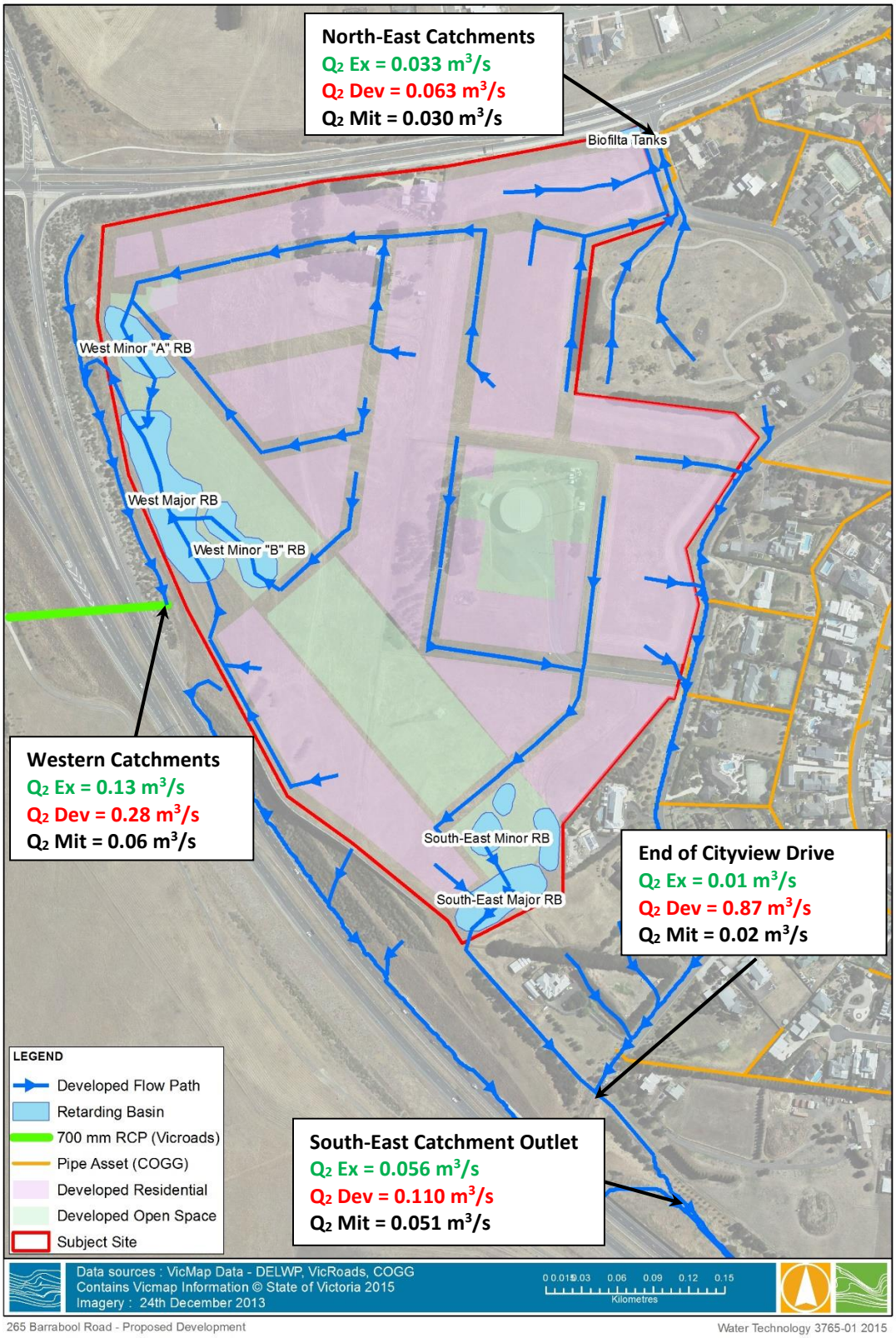

Figure 3-12 Existing, Developed and Mitigated Peak 2 year ARI Flows

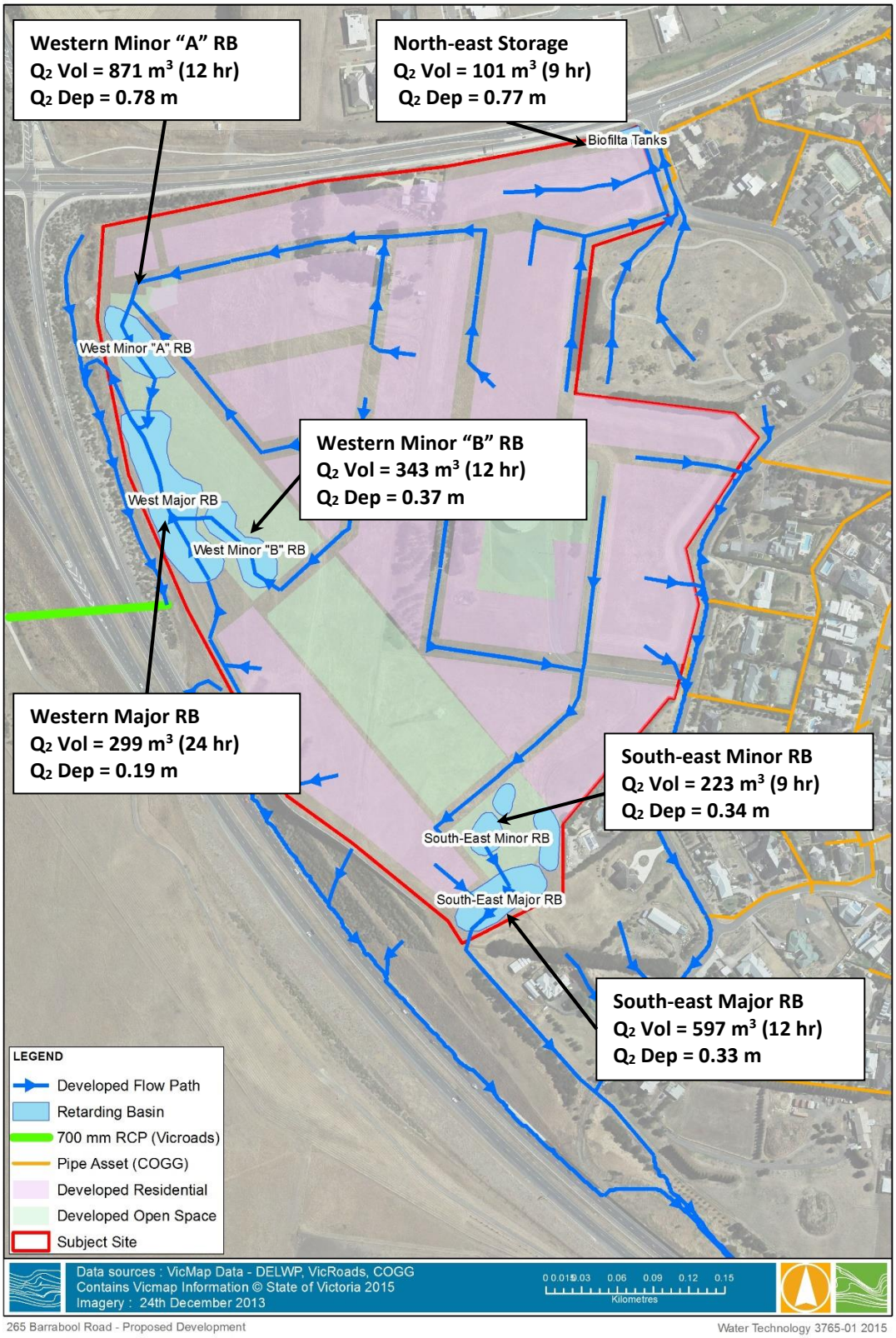

Figure 3-13 2 year ARI Retarding Basin Volumes and Depths

Table 3-9 100 Year ARI Peak Flows Leaving the Site - Developed Conditions with the Proposed Retardation Works

Duration	Western catchments (m^3/s)	North-east catchments (m^3/s)	South-east catchments (m^3/s)
10min	0.240	0.048	0.263
15min	0.322	0.098	0.323
20min	0.346	0.155	0.352
25min	0.357	0.186	0.378
30min	0.321	0.211	0.351
45min	0.305	0.242	0.318
1hr	0.372	**0.253**	0.388
1.5hr	0.395	0.244	0.401
2hr	0.410	0.241	**0.422**
3hr	0.424	0.192	0.313
4.5hr	0.401	0.206	0.327
6hr	0.404	0.182	0.271
9hr	**0.527**	0.175	0.325
12hr	0.466	0.153	0.279

Table 3-10 10 Year ARI Peak Flows Leaving the Site - Developed Conditions with the Proposed Retardation Works

Duration	Western catchments (m^3/s)	North-east catchments (m^3/s)	South-east catchments (m^3/s)
10min	0.043	0.011	0.062
15min	0.048	0.012	0.065
20min	0.065	0.013	0.082
25min	0.076	0.018	0.089
30min	0.078	0.023	0.092
45min	0.092	0.038	0.108
1hr	0.104	0.053	0.116
1.5hr	0.109	0.059	**0.138**
2hr	0.126	0.064	0.137
3hr	0.091	0.054	0.084
4.5hr	0.110	0.047	0.110
6hr	0.118	0.055	0.101
9hr	**0.180**	**0.069**	0.112
12hr	0.174	0.055	0.116

Table 3-11 2 Year ARI Peak Flows Leaving the Site - Developed Conditions with the Proposed Retardation Works

Duration	Western catchments (m^3/s)	North-east catchments (m^3/s)	South-east catchments (m^3/s)
10min	0.021	0.007	0.033
15min	0.025	0.008	0.035
20min	0.025	0.007	0.036
25min	0.025	0.008	0.038
30min	0.025	0.008	0.040
45min	0.026	0.011	0.040
1hr	0.031	0.016	0.041
1.5hr	0.033	0.021	0.038
2hr	0.035	0.023	0.044
3hr	0.036	0.018	0.038
4.5hr	0.034	0.022	0.039
6hr	0.037	0.017	0.038
9hr	**0.057**	**0.030**	0.050
12hr	**0.057**	0.028	**0.051**

3.1.6 Eastern Catchment

Runoff from the eastern catchment which drains directly on Cityview Drive is not detained however the catchment area is considerably smaller under developed conditions and as a result both peak flows and total volumes are less than under pre-developed conditions. Under developed conditions approximately 70% of the catchment (under existing conditions) is directed through the south-east retarding basins.

Table 3-12 compares the peak flows and volumes across the range of modelled events while Figure 3-14 shows the eastern catchment boundary under developed conditions.

Table 3-12 Peak flows and total volumes from the Eastern Catchment under existing and developed conditions

Event	Peak Flow (m^3/s)		Total Volume (m^3)	
	Existing Conditions	Developed Conditions	Existing Conditions	Developed Conditions
2 year	0.074	**0.074**	1,180	**873**
10 year	0.170	**0.165**	2,490	**1,530**
100 year	0.629	**0.470**	6,700	**4,160**

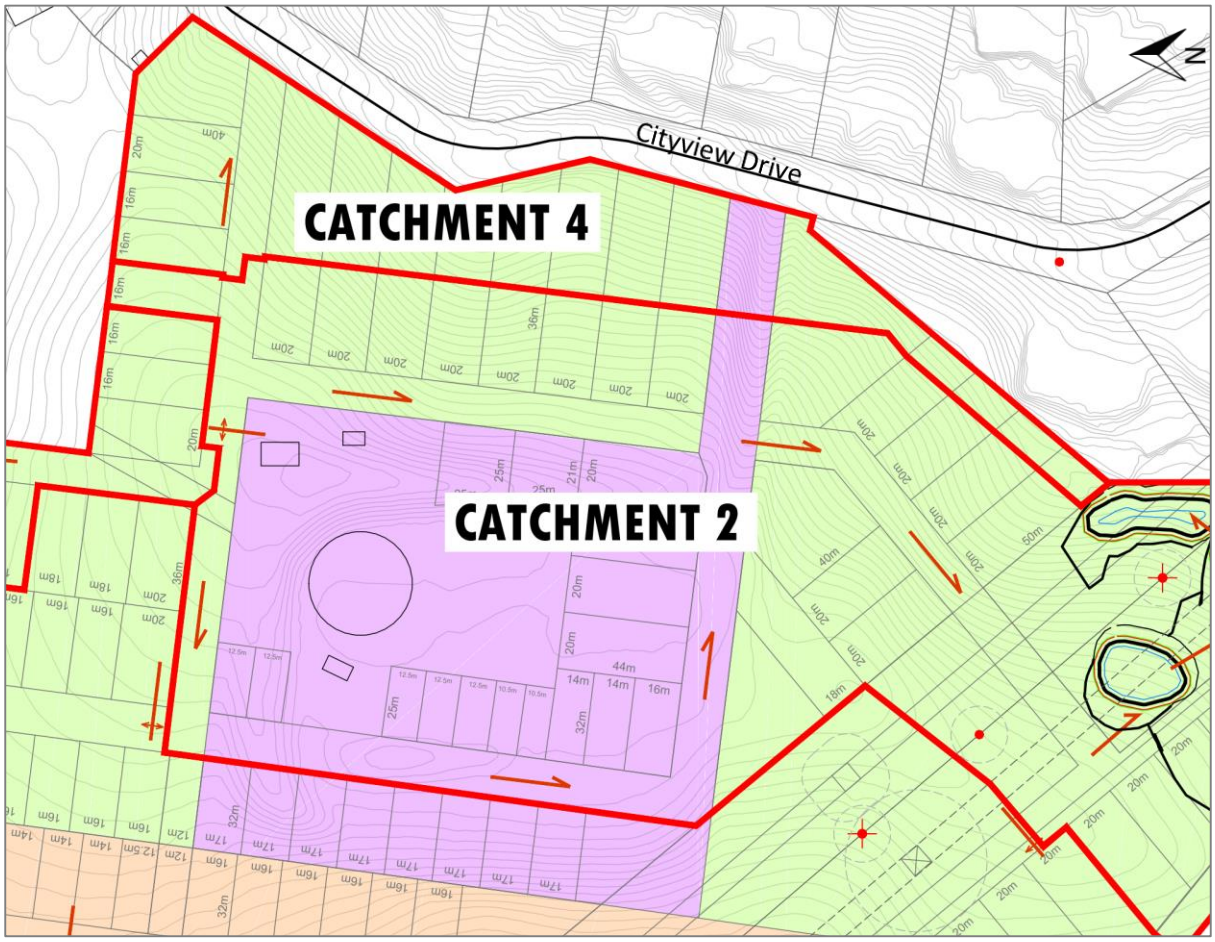

Figure 3-14 Catchment plan showing catchment boundary of Eastern Catchment (Catchment 4)

4. DOWNSTREAM IMPACTS

4.1 Overview

The following section demonstrates the impact of the development site on the broader Kardinia Creek catchment including the key downstream retarding basins. This section aims to directly address the concerns by City of Greater Geelong and Corangamite CMA stated in a letter dated 2 July 2015 from Stuart Thiele, Strategic Planner- City Development which are:

"Increased stormwater runoff from the site is likely to have some impact on the performance of the Thornhill Road retention basin and to result in an increase in flood risk for properties downhill of Thornhill Road. Revised documentation needs to quantify this impact."; and

"There needs to be an indication that the multiple retarding basins in the Kardinia Creek catchment will not be compromised by the proposed works".

Key retarding basins tested within this analysis are shown in Figure 4-1 below as well as the extents of the RORB models used in the analysis.

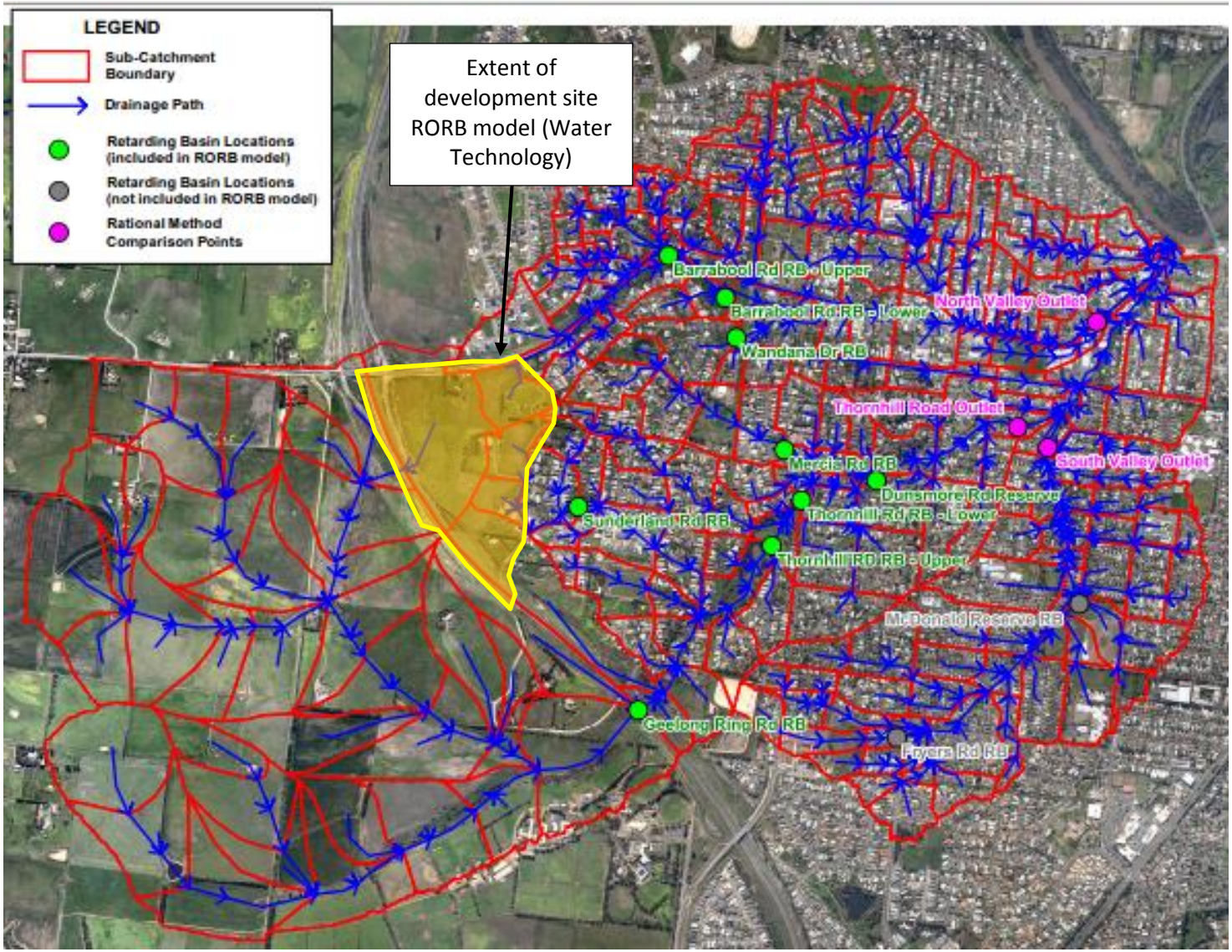

Figure 4-1 Map of Highton RORB model extent extracted from Highton Flood Study report (BMT WBM 2014)

4.2 Method

The existing Highton RORB model provided by City of Greater Geelong was reviewed and modified to reflect existing, current and existing conditions at the subject site. This was achieved by removing the subareas which cover the development site and replacing them with inflow hydrographs from the existing RORB model of the development site developed by Water Technology. The model was then run for the 100 year ARI critical duration events for each retarding basin i.e. the events which led to the greatest storage volume and peak outflow at each retarding basin.

4.3 Results

The results of the analyses are shown in Table 4-1 and Table 4-2 below. It can be seen that at every key retarding basin the mitigated peak flows are either equal to lower than under existing conditions across the range of events. Total volumes for each event passing through the retarding basin are marginally higher under mitigation with differences in the order of a 0.5% increase or less. Table 4-2 demonstrates that the peak storage volume at each key retarding basin is also lower than under existing conditions. It is also interesting to know that based on the Highton Flood Study RORB model none of the retarding basins fill close to capacity in the 1% AEP event with three of the basins filling to less than 50% capacity.

The results demonstrate that as a result of site flows being adequately retarded to below existing conditions the impact on the broader catchment is minimal and flood risk in the vicinity of the retarding basins is less than or equal to that under existing conditions.

Table 4-1 Summary of Results at Key Retarding Basins – 100 year ARI Event

Retarding Basin	Critical Event Storm	100 Year ARI Peak Flow (m^3/s)			100 Year ARI Event Total Volume (m^3)		
		Existing	Developed (unmitigated)	Developed (mitigated)	Existing	Developed (unmitigated)	Developed (mitigated)
Scenic Road RB	2 hr	1.85	1.86	1.85	16,100	16,200	16,200
Geelong Ring Rd RB	12 hr	4.01	4.02	4.01	174,000	176,000	176,000
Thornhill Road Upper RB	12 hr	4.78	4.80	4.78	227,000	230,000	230,000
Thornhill Road Lower RB	12 hr	5.17	5.27	5.16	238,000	240,000	240,000

Table 4-2 Peak Storage Volumes at Key Retarding Basins – 100 year ARI Event

Retarding Basin	Capacity (below spillway level) (m^3)	Peak Storage Volume (m^3)			% Full at Peak (%)		
		Existing	Developed (unmitigated)	Developed (mitigated)	Existing	Developed (unmitigated)	Developed (mitigated)
Scenic Road RB	17,700	6,480	6,630	6,430	37%	37%	36%
Geelong Ring Rd RB	98,670	76,200	77,200	75,400	77%	78%	76%
Thornhill Road Upper RB	88,640	27,100	27,800	27,100	31%	31%	31%

Thornhill Road Lower RB	4,728	865	892	854	18%	19%	18%

The results above clearly demonstrate that all key retardation peak outflows and peak and consequently flood risk is the same or less at all of those locations. There are some slight increase in total volumes which pass through the retarding basins but as site runoff will be appropriately retarded before it leaves the site there is no increase in peak storage volumes or flows at the downstream retarding basins. The analysis has been undertaken for the critical 100 year ARI events at each retarding basin and given that site flows for the 2 and 10 year ARI are also retarded to below existing conditions it is a reasonable to assume the downstream impacts will be the same i.e. no increase in peak flows, peak storage volumes or flood risk as a result of the development site.

5. CONCLUSIONS

A Surface Water Management Strategy has been developed for the proposed residential development at 335 Barrabool Rd, Wandana Heights. The strategy considered works required to manage water quantity and quality for the development. The proposed stormwater works include:

- A system of three retarding basins to retard flows from the western catchments designed for the 100, 10 and 2 year ARI events. The system consists of two minor basins, 895m^3 and 380m^3 in capacity, and a major basin 2,134 m^3 in capacity. The systems consists of two minor basins which each have outlets recommended to consist of a 300 mm diameter RCP with a 100 mm diameter orifice plate as well as spillways for events greater than the 2 year ARI event. The minor basins flow into a major basin which has an outlet consisting of a 600 mm diameter RCP and has been designed to retard 100 year ARI flows. The outlet from the major basin discharges into an open channel which flows into the natural storage depression adjacent to the Geelong Ring Road.

- 191 m^3 of detention storage located within a series of Biofilta water treatment tanks located underground in the tree reserve near the corner of Barrabool Road and Cityview Drive to retard flows from the north-east site catchment. The storage has three staged outlets which are designed to retard flows in the 2, 10 and 100 year ARI events to below existing conditions. The tanks will discharge into the City of Greater Geelong drainage network. The storage will undergo further detailed design as part of a water treatment system designed by Biofilta Pty Ltd.

- A system of two retarding basins to retard flows from the south-eastern catchments designed to retard the 100, 10 and 2 year ARI events. The system consists of a minor basin, 232m^3 in capacity, and a major basin 1,290 m^3 in capacity. The major basin is split into two separate storages connected by a 450 mm balance pipe. The minor basin is split into two separate storages connected by a 300 mm balance pipe. The minor basin outlet is recommended to consist of a 300 mm RCP as well as a spillway for events greater than the 2 year ARI event. The outlets of the major basin are recommended to consist of a 300 mm RCP with a 50 mm orifice plate as well as three 300 mm RCPs. The major basins will discharge into an open channel or pipe which flows to the south-east in a drainage easement located between private property and the Geelong Ring Road.

In addition, an analysis has been undertaken of the impact of the development site flows on downstream flood risk using the broader Highton RORB model. The analysis has determined that:

- The development has no significant impacts downstream of the development with regards to flood risk as a result of all site flows being retarded to below existing conditions. It has been demonstrated that peak flows under mitigated conditions are either the same or lower than under existing conditions at all key retarding basins for the 100 year ARI events.

- Flow volumes at key retarding basins are either the same or marginally increased. The marginal increase in volume presents no increase in flood risk as flood peaks from the development site are delayed and lower in magnitude as a result of the proposed retardation works.

An analysis of water quality was not within the scope of this study and will be addressed in a separate report.

APPENDIX A RORB MODELLING

RORB Modelling

RORB is a non-linear rainfall runoff and streamflow routing model for calculation of flow hydrographs in drainage and stream networks. The model requires catchments to be divided into subareas, connected by a series of conceptual reach storages. Design storm rainfall is input to the centroid of each subarea. Specific losses are then deducted, and the excess rainfall routed through the reach network.

Fraction Impervious Data

The FI values for each sub catchment were applied as recommended in Melbourne Water's MUSIC Guidelines.

Under existing conditions much of the subject site was assigned a fraction impervious (FI) value of 0.1. The Barwon Water asset located within the subject site was also assigned an FI of 0.1.

Under developed conditions, the fraction impervious value across the developed areas of the site was set to 0.6 (based on average lot sizes of 500-800m^2). The fraction impervious value for the open space reserves was set at 0.1 and road reserves at 0.7.

Model Calibration

The existing conditions RORB model was built to allow for reconciliation with the Rational Method. The RORB model was reconciled at the two discharge points shown in Figure A-1, through adjustment of the sub-catchment properties. The VicRoads Rational Method was used as recommended in City of Great Geelong guidelines. A Rational Method reconciliation was not used in the south-east catchment due to the limited number of clearly defined flow paths and also the presence of a number of CoGG pipe assets which divert flow out of the south-catchment as defined in the model.

Table A - 1 Reconciled RORB Flows

	Rational Method (Vicroads) 100 year ARI Peak flow Estimate (m^3/s)	Reconciled RORB Model Flow (m^3/s)
Western outlet (flow into natural storage)	0.76	0.80
North-east outlet	0.20	0.18

Interstation areas were used at the outlets of the three catchments due to differing levels of catchment delineation, which was required to ensure a minimum of 5 subareas being located above each outlet location. Different Kc values for each catchment were adopted based on the model calibration process described above. The adopted Kc for the south-east catchment was determined using the ratios of Kc / D_{av} determined in the two reconciled catchments. An initial loss / runoff coefficient loss model was adopted with an initial loss of 15 mm deemed appropriate for the predominately rural subject site. Runoff coefficients of 0.6 for the 100 year ARI event and 0.35 for the 10 year were adopted as recommended in Melbourne Water Flood Mapping and Mitigation guidelines and technical specifications.

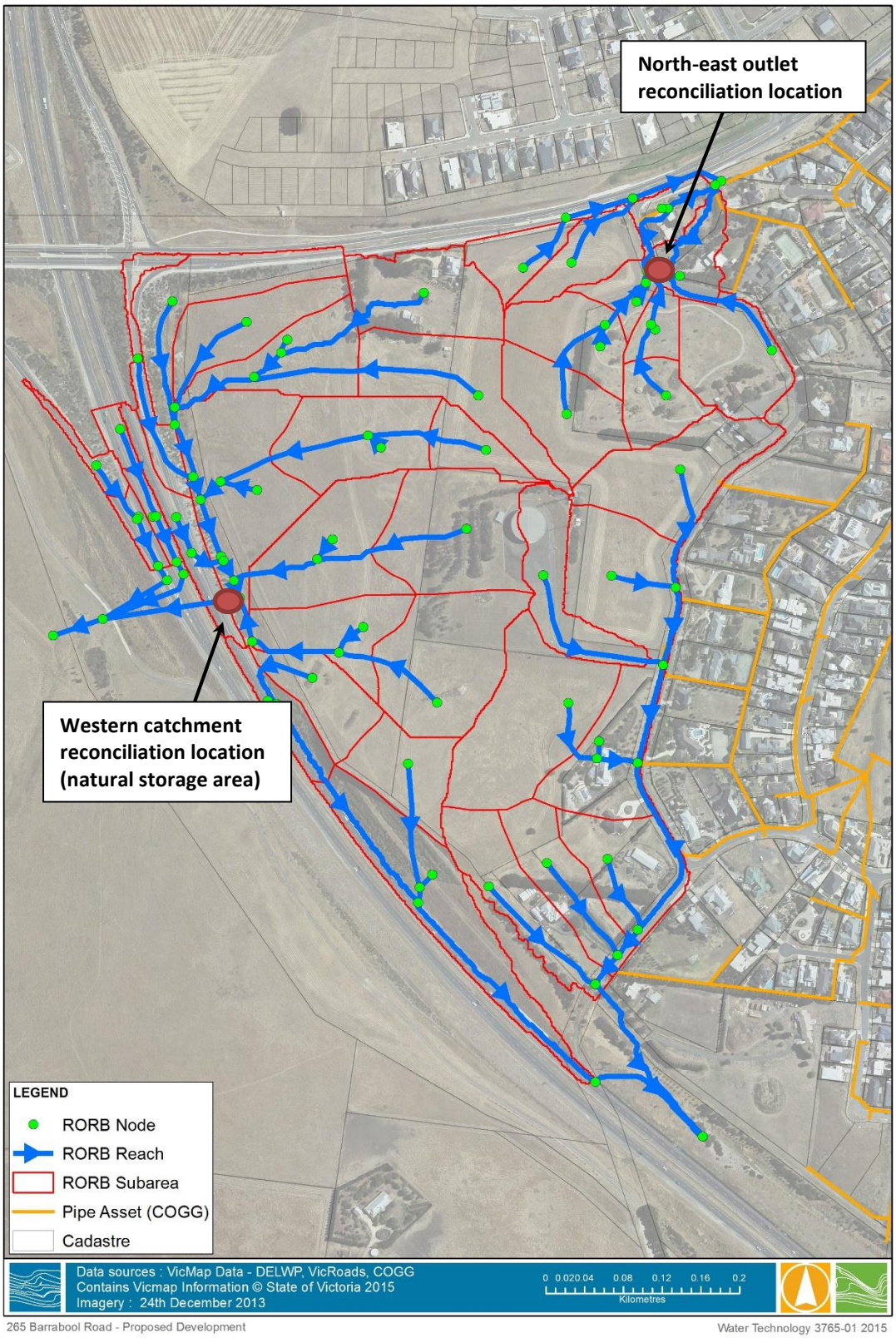

Figure A – 1 Existing conditions RORB model and reconciliation locations