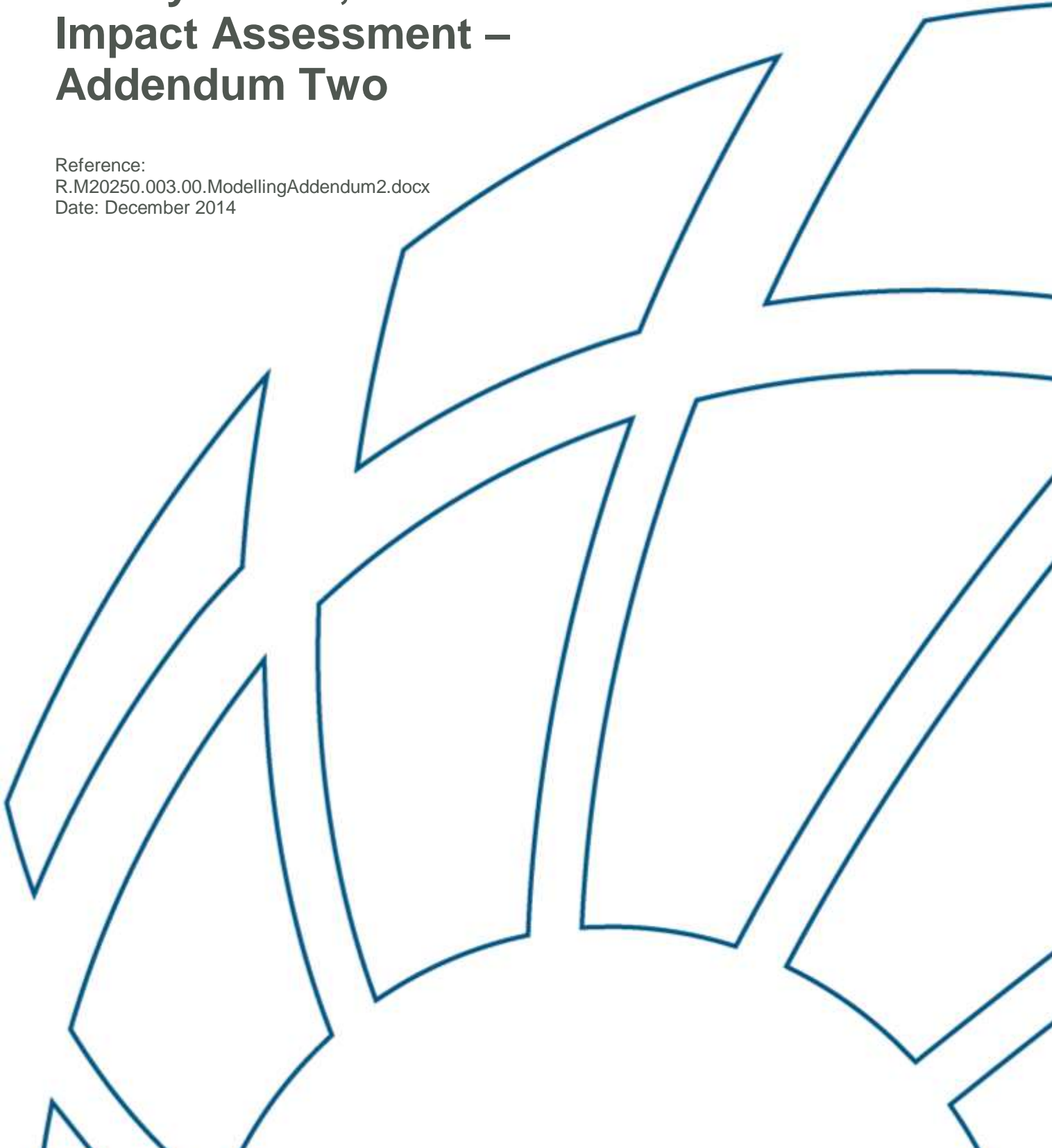




Proposed Development of Caddys Road, Lara – Flood Impact Assessment – Addendum Two

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Date: December 2014



Proposed Development of Caddys Road, Lara – Flood Impact Assessment – Addendum Two

Prepared for: L Bisinella Developments Pty Ltd and TGM Group Pty Ltd

Prepared by: BMT WBM Pty Ltd (Member of the BMT group of companies)



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<p>Synopsis: Report detailing the methodology and finding of hydraulic modelling of the Caddys Road development, Lara, Victoria</p>		

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Introduction

1 Introduction

1.1 Background

L.Bisinella Developments Pty Ltd is proposing the development of a parcel of land (the Site) on Caddys Road, Lara. The Site is bounded by existing development and Flinders Avenue to the south and private property to the north and east. This is shown in Figure 1-1. The Site is contained entirely within the City of Greater Geelong (CoGG) local government area, and is referred to in the Lara Structure Plan 2011 (LSP) as the Caddys Road area. The LSP notes that as part of the rezoning of the Site it would be necessary prepare documentation “to address drainage and stormwater management”.

Flood mapping undertaken by BMT WBM Pty Ltd (BMT WBM) for CoGG shows that much of the Site is currently flood prone in the 1% AEP (annual exceedance probability) flood event. The flooding is a result of overland flow from the catchments to the north and east. The flow passes through the Site as it makes its way to Serendip Creek. Therefore an important consideration in the development of the Site is the management of the conveyance of these floodwaters through the Site as well as additional runoff generated by the development of the Site, as is stated in the LSP. The Site is mostly above the Serendip Creek flood level and hence is not subject to flooding from the creek: a small section along the western boundary of the Site is inundated in a 1% AEP Serendip Creek flood event, but no roads or lots are proposed in this area.

BMT WBM previously prepared a flood impact assessment as a supporting report for the Stormwater Management Plan prepared by TGM Group Pty Ltd (TGM). The flood impact assessment (BMT WBM, 2014) and Stormwater Management Plan were prepared in support of the re-zoning and development application for the subject land.

Although described as Addendum 2, this report is largely a reproduction of previous flood impact assessments (BMT WBM (2014a) and BMT WBM (2014b)) that has been updated to present the modelling results of the assessment of the updated development design. As previously, the purpose of this report is to:

- establish flood levels across the Site for input into the civil design and setting of finished ground levels;
- demonstrate that the proposed interim development can be constructed without causing unacceptable flood impacts on surrounding properties;
- demonstrate that the design satisfies flood hazard and Site egress requirements.

1.2 Proposed Development

Key aspects of the design of the proposed development with regards to flood management are as follows:

- Upgrades to the table drain along the southern side of Windermere Road to help intercept and convey floodwaters from upstream directly to Serendip Creek without passing through the Site.
- A catch drain to intercept and direct overland flow from the north into the Site’s stormwater pipe network.

Introduction

- Court heads along the eastern boundary that are designed to capture overland flow from the east and convey the flow through the Site's drainage system.
- A retarding basin on the western edge of the development that collects all runoff from the Site and overland flow external to the Site which is drained by the Site's stormwater pipe system. This retarding basin discharges via twin $\phi 450$ mm RCP culverts to Serendip Creek.
- Apart from the catch drains and retarding basin, the Site is filled to above the 1% AEP flood event.

Further detailed information on the internal drainage design is provided in TGM's Stormwater Management Plan

1.3 Development Scenarios

The Site will be developed in two stages due to the current land ownership within the Site. Therefore, two development scenarios were analysed:

- Overall - Complete development of the Caddys Road Site
- Interim - Development of the L.Bisinella owned land within the Caddys Road Site

The flood impact assessment for the overall design has previously been presented in BMT WBM (2014), whilst this current report presents the revised interim development design. The interim development design in this report is different to the staged development design previously discussed in BMT WBM (2014a) and BMT WBM (2014b).

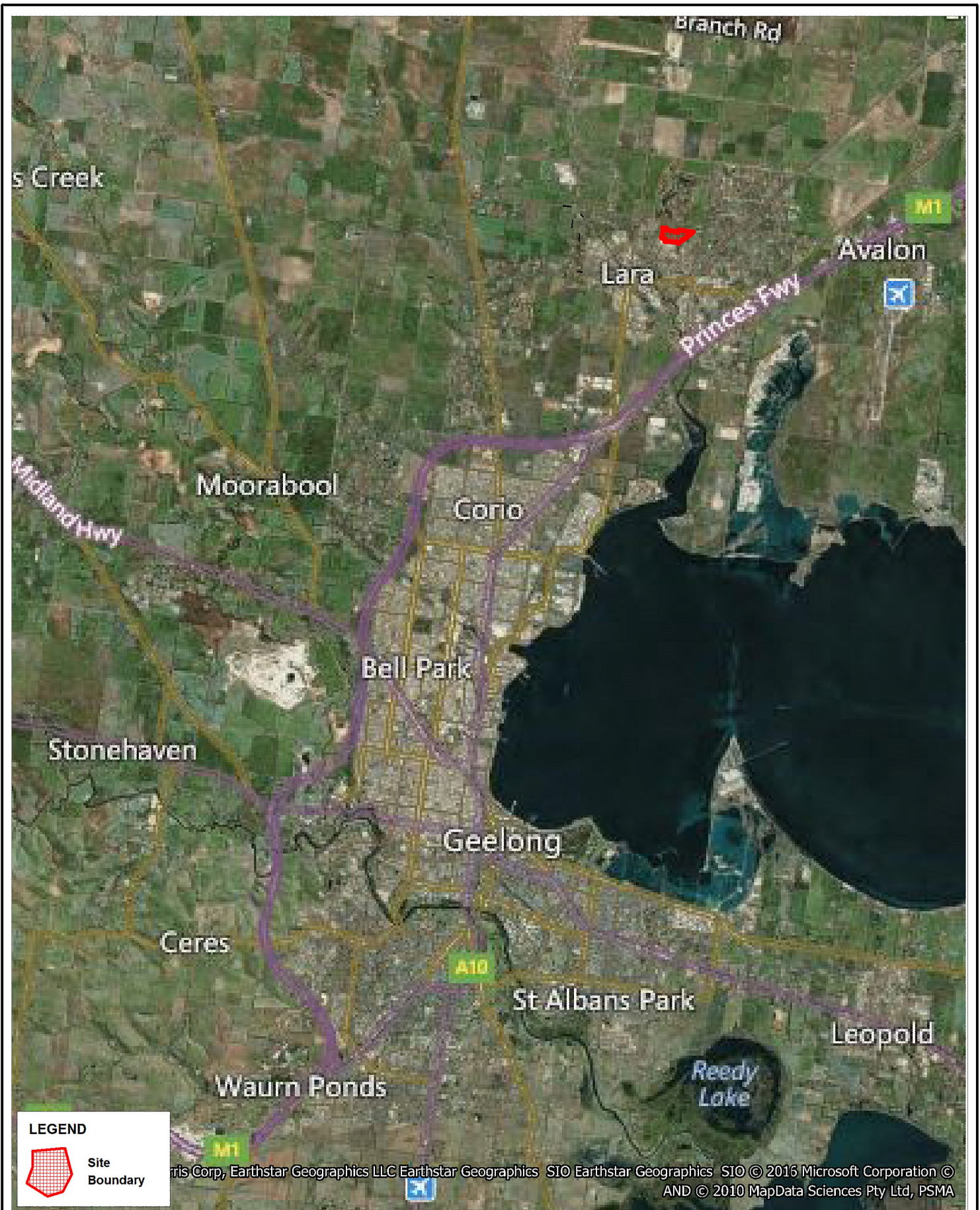
1.4 Hydraulic Model Scales

Two hydraulic models were constructed: a regional scale and a local scale.

The regional scale model covered an area of approximately 5 km² and was used to:

- Establish flooding characteristics across the broader floodplain including Serendip and Hovells Creeks from catchment scale rainfall events;
- Establish flood levels on the Site from catchment scale rainfall events;
- Assess flood impacts of the proposed development external to the Site;
- Assess Site egress and hazard during catchment scale rainfall events.

The local scale model extent only included the Site itself, and was developed to determine the flood level, extent and flood hazard as a result of runoff from the Site itself.



LEGEND

 Site Boundary

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**Proposed Caddy Road
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2 Hydrological Modelling

The hydrological modelling provides inflow boundaries for the hydraulic modelling. Hydrological models were therefore required for the local and regional scale hydraulic models. The local scale hydrological modelling was undertaken by TGM and is discussed further in Section 3.2.2. BMT WBM undertook the hydrological modelling for the regional scale hydraulic model. This is discussed further below.

The Site lies within the Serendip Creek catchment, which itself is a tributary of the Hovells Creek catchment. Hydrological modelling was undertaken for the Serendip Creek and Hovells Creek catchments as part of the Lara Flood Mapping Study (2002) which was undertaken by BMT WBM (formerly known as WBM Oceanics Australia) for CoGG. The same model was used for this study. Due to a change in the RORB software (the original Lara Flood Study used RORB v4.2, whilst the current study used RORB v6.14), there are minor differences in the peak flow rates and volumes of the determined hydrographs. For example, the peak 1% Average Exceedance Probability (AEP) flow rate in Serendip Creek is 3% higher in the modelling undertaken for this study. Also, the design rainfall data used in the 2002 study could not be sourced and hence was reconstructed. This may have contributed in part to the small increase in the peak discharge.

The model was run for the 20, 10, 5, 2 and 1 % AEP rainfall events. In the 2002 study only the 36 hour storm event was analysed. Because flows across the Site are from smaller sub-catchments, a range of durations were assessed to determine the critical durations for the flows on to Site. The 1.5 hour storm duration was found to be critical for the sub-catchments to the north and east that drain across the Site, the 9 and 12 hour storms were critical in Serendip Creek (the duration varied depending on which AEP event was being analysed), and the 36 hour was critical in Hovells Creek. Each AEP event was run using these durations.

The model was run for the existing catchment and then modified to represent the proposed development by increasing the fraction imperviousness. In the context of the whole catchment this was only a minor change, but was required so that adjusted flow rates and timings could be used for the regional hydraulic model assessment.

Hydraulic Modelling

3 Hydraulic Modelling

The hydraulic modelling was done using the TUFLOW software platform. TUFLOW is an industry standard software for this type of application. This section describes the development of the TUFLOW models used to assess the flood impacts of the proposed development of the Site, and to assess Site and egress hazard. Impacts to flood height, duration of inundation, flood velocity and flood hazard were assessed.

1D/2D dynamically linked TUFLOW hydraulic models were used for both the regional and local scale models. For the regional model, unsteady state flow (flow varying with time) simulations were used so as to properly represent the effects of storage, including natural storage in overland flowpaths, and the timing of the rainfall inflows. The inflows to the hydraulic model were taken from the RORB hydrological models discussed in the previous section. Steady state flow conditions were used for the local model because the effects of storage and timing of rainfall inflows would be negligible.

BMT WBM developed a TUFLOW regional model covering the Caddys Road region for the Lara Flood Study (WBM, 2002). However, as this model was developed over 10 years ago, BMT WBM updated the TUFLOW regional model to ensure it meets current industry best practice for flood modelling. These updates included:

- Latest version of the software
- New topography covering the Site and nearby;
- Smaller numerical grid.

3.1 Assessment Scenarios Summary

Table 3-1 provides a summary of the assessments undertaken.

Table 3-1 Assessment Scenario Summary

Model Scale	Existing Case	Developed Case		% AEP events analysed
		Interim	Ultimate	
Regional	Yes	Yes	Yes*	20,10, 5, 2, 1
Local	No	Yes	Yes*	1

* The Ultimate Developed Case has previously been presented in BMT WBM (2014)

The following sections detail the development of the hydraulic models.

3.2 Model Schematisation

For the Ultimate and Interim scenarios (Regional Model), the TUFLOW model was required to cover the wider floodplain so as to properly represent the flooding characteristics of the broader floodplain and the impact of the development on the flooding characteristics. The extent of the TUFLOW developed as part of the Lara Flood Study (WBM, 2002) was appropriate for this and so was not adjusted for the current study.

Hydraulic Modelling

In the Local assessment, the TUFLOW model was only required to cover the extent of the proposed development. Therefore a smaller, but more detailed, TUFLOW model was developed.

Further details of the schematisation of these models are provided below.

3.2.1 Regional Model

3.2.1.1 Model Domains

The regional TUFLOW model's 2D domain extends from approximately 200 metres north of Windermere Road to approximately 200 metres south of Station Lake Road. The western edge of the model runs along Kees Road. The 2D model domain extent along with the 1D pipe network, are shown in Figure 3-1 and Figure 3-2. The 2D domain extent is identical in both the existing and developed case models and covers an area of approximately 5.0 km².

The geometry of the 2D models was established by constructing a uniform grid of square elements. One of the key considerations in establishing a 2D hydraulic model relates to the selection of an appropriate grid element size. Element size affects the resolution, or degree of accuracy, of the representation of the physical properties of the study area as well as the size, and thus memory request, of the computer model and its resulting run times. Selecting a very fine grid element size will result in both higher resolution results and longer model run times.

The adopted 3 m grid size provided a good definition of topography and floodplain storage, whilst keeping run times to an acceptable length. Each square grid element contains information on ground topography sampled from the DEM at 1.5 m spacing, surface resistance to flow (Manning's 'n' value) and initial water level.

To maintain an acceptable Courant number, the 2D domain of the model was run on a 1.5 second timestep. The timestep falls within the $\frac{1}{2}$ to $\frac{1}{5}$ times the grid cell size range that is recommended in the TUFLOW manual.

3.2.1.2 Topography

No single elevation data set was available to cover the complete 2D model domain. Therefore the elevation data was derived from the following data sets provided by CoGG and TGM:

- Lidar of the site and surrounds (provided by TGM, 28/11/2013)
- Photogrammetry of Lara from the 2002 flood study (WBM, 2002);

The sources above are listed in order of accuracy and hence reflect the priority given to the data in the TUFLOW model.

The resolution (size) of the model grid can in some circumstances mean that significant topographic features, such as road embankments and large table drains that affect flood flows, are not properly represented in the model. In TUFLOW such features are 'forced' in the 2D domain through the use of breaklines. Examples in this model include the road crown along Flinder Avenue, Windermere Road and Kees Road.

Hydraulic Modelling**3.2.1.3 Roughness Layer or Manning's *n***

A roughness layer, or Manning's 'n' layer, was based on areas of different land-use type, determined from planning maps, aerial photography and site inspections. These are summarised in Table 3-2. The values used are based on the values published in MW's Technical Specification and other standard texts such as Chow (1959). To represent the blockages caused by buildings and fences in residential areas, an average Manning's 'n' value over these blocks of 0.2 was adopted.

Table 3-2 2D Domain Manning's 'n' Coefficients – Regional Scenario

Land use	Manning's 'n'
Floodplain	0.06
New Residential	0.2
Smaller Rural-Residential blocks	0.04
Large rural-residential blocks	0.04
Crops	0.05
Road reserves	0.025
Golf course	0.05
Grassed reserve with some trees	0.035
Water body	0.02

3.2.1.4 1D Network*1D Pipe Network*

Key features of the drainage system, including pipes and pits, were modelled in 1D and dynamically linked to the 2D domain. A Manning's 'n' of 0.013 was adopted for the stormwater pipes. Pipes incorporated into the model included:

- The stormwater pipe network as included in the Lara Flood Study;
- Culverts under roads and cross-overs in the vicinity of the site, notably along Windermere Road.

The stormwater pipe network was provided by CoGG (as part of WBM, 2002). The culvert dimensions were measured (as required) by BMT WBM staff in the field. Where invert level data was not available, the invert was assumed to be the ground level in the DEM adjacent to the culvert.

The 1D domain of the model was run on a 0.5 second timestep. This timestep is within the range recommended in the TUFLOW manual.

The internal stormwater pipe network within the Site was modelled as it is used to convey waters from external to the site through the site. Details on the internal stormwater pipe network were supplied by TGM.

Embedded Open Channels

The existing swale drain along Windermere is represented in the model as a 1D embedded open channel to ensure that the conveyance is reliably represented. In the developed case model, this

Hydraulic Modelling

channel remains as 1D elements, however, it is modified to reflect the revised channels shape as part of the proposed development.

Structure Losses

Pipe losses were applied as appropriate to account for entrance and expansion losses at the first and final pipes respectively. Additional bend and junction losses were applied as appropriate.

3.2.1.5 *Boundary Conditions*

A hydraulic model requires the specification of inflow boundaries and outlet boundaries to allow water into and out of the model in a realistic manner. Often 2D hydraulic models will have external and internal inflow boundaries. The external inflow boundaries account for flow generated from outside of the model extents (external boundaries) whereas internal boundaries account for the runoff generated from within the model extents. Flow is removed from the model through downstream boundaries, which are generally a fixed water level or a rating curve.

In the case of the regional scenario model, the external inflow boundaries were extracted from the RORB model as a flow-time series (hydrograph). The model has one downstream boundary, on Hovells Creek, which was defined as a constant tailwater at 6.1 mAHD (consistent with the Lara Flood Study, WBM, 2000).

Internal inflow boundaries were applied at the locations shown in Figure 3-1 and Figure 3-2. The internal boundaries were applied by distributing the flow to the surface either at a discrete point or distributed over a region.

3.2.1.6 *1D / 2D Linking*

The 1D network was dynamically linked to the 2D domain through boundary cells. These boundary cells pass water from one domain to the other. In urban models it is usual for the exchange of water between the 1D pipe network and the 2D domain to occur at pits. Accordingly, boundaries were set at these locations in the model.

Each pit within the model was connected to a single 3 m wide 2D model grid cell. The pits were connected to the pipe network through a use of a weir to transition the flow to the pipe. This configuration ensured that the pipe capacity, rather than the pit inlet capacity, was the limiting factor for the pipe network.

For 1D entrance and exit pipes with headwalls the preferred connection method between domains was the use of SX connectors.

3.2.1.7 *Interim Development Model Changes*

The interim development case model was the same as the existing case model apart from the proposed geometry changes and the inclusion of local Site drainage in the form of pipes, drains, floodways and retarding basins. These changes are listed in Section 1.2. The proposed geometry changes and internal pipe network were supplied by TGM in a series of 12d files (*tin design 2014.08.28.12da*, *Tin Cooks Design 20160405.12daz*, *drainage network A 2014.08.28.12.12da*, *drainage networks 2014.07.02.12da* and *Drainage Network Combined 2016.04.05.12daz*). The proposed location and dimensions of the site access crossings over the enlarged Windermere

Hydraulic Modelling

Road swale were taken from BMT WBM (2010), whilst the swale dimensions were included in the provided surface.

The retarding basin storage dimensions were schematised within the 2D domain. Outflows from the retarding basin were via twin 450 mm RCP culverts which discharge to Serendip Creek

In addition to the geometry changes for the proposed development of Caddys Road, the RORB model (as described in Section 2), was amended to account for the increased fraction imperviousness of the proposed development. These increased flows were applied to the TUFLOW model at the boundaries representing the proposed development.

3.2.1.8 Design Event Modelling

The hydraulic modelling was undertaken for the 20, 10, 5, 2 and 1 % AEP rainfall events for the 4 storm durations listed in Table 3-3.

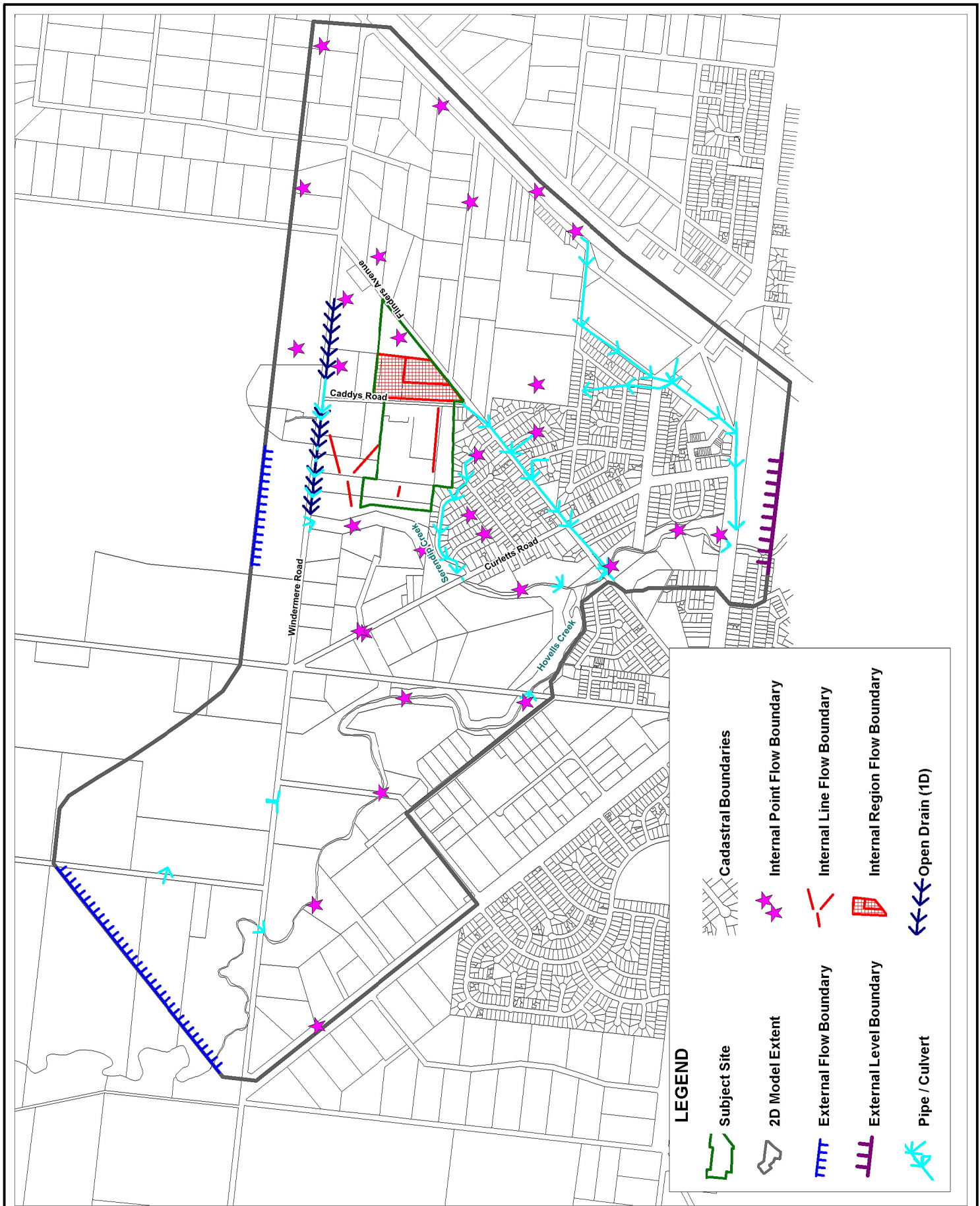
Table 3-3 Storm Durations for Initial Hydraulic Modelling

Storm duration	1.5 hr	9 hr	12 hr	36 hr
-----------------------	-----------	---------	----------	----------

A peak flood height and extent envelope was developed from the 4 durations and the peak envelope flood surfaces mapped. The mapping is presented in Section 4.

3.2.1.9 TUFLOW Version

Model runs were performed with the 2012-05-AE build of TUFLOW. The double precision version of TUFLOW was used for the modelling runs.



Title:
Details of Existing Condition TUFLOW Model

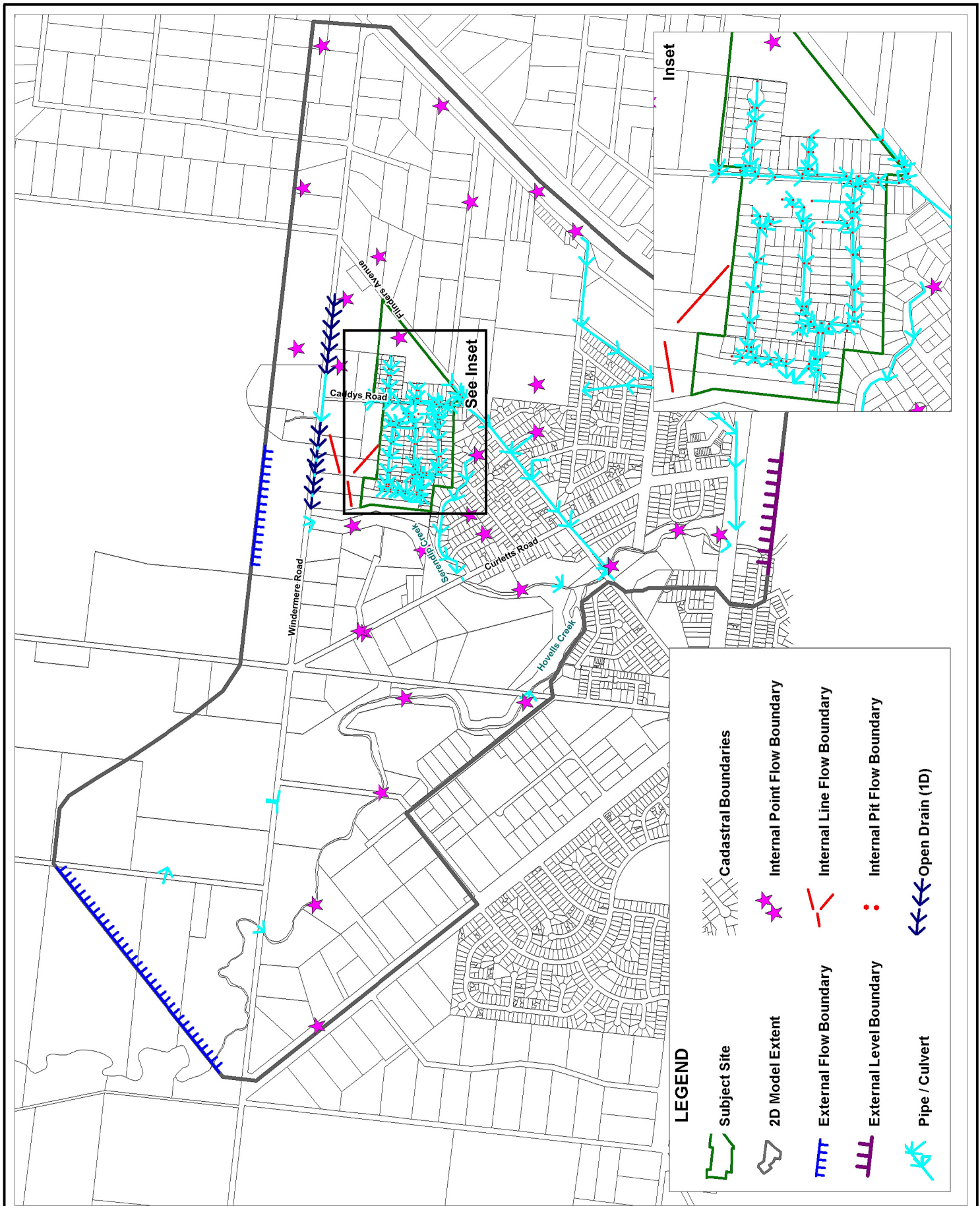
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Hydraulic Modelling

3.2.2 Local Model

3.2.2.1 Local Caddys Road Model Layout and Coverage

A separate local 1D-2D TUFLOW model of the development was established to assess flood safety within the Site during a short duration local catchment event, where the local catchment was the proposed development itself. This was done because peak flow rates within the development would be higher for a short duration local storm, than for a regional catchment (longer duration) assessment.

The TUFLOW model boundaries were at the extents of the proposed development and did not include any of the surrounding areas.

3.2.2.2 Local Caddys Road Model Development

A local TUFLOW model with 0.5 m grid was developed across the development site. The high resolution TUFLOW model allowed for the topography, including road crests and gutters, to be represented at a scale appropriate for the assessment of flood safety.

Details of the minor drainage network were provided by TGM and the entire pipe drainage network, including inlet pits, was incorporated into the model as 1D elements. The pipes were dynamically nested within the 2D domain to allow the interchange of flow between overland and sub-surface flow. This allowed a reliable assessment of the flows down streets and floodways. In this simulation it was assumed that the pits did not restrict the flow of water into the pipes, i.e., the pipe network itself was the limiting control, not the side entry pits or filed inlets.

3.2.2.3 TUFLOW Boundary Conditions

Inflow boundary conditions to the TUFLOW model were supplied by the TGM and consisted of peak flows for each of the sub-catchments within the development site. These peak sub-catchment flows were applied at the location of the field inlet or side entry pit for each respective sub-catchment throughout the development. The model was run under steady-state conditions with the peak flow applied at a constant value. This was a conservative approach, as it does not account for the varying times to peak flow that would occur through the development.

The locations of all inflow points within the TUFLOW model are shown in Figure 3-3.

3.2.2.4 Manning's Roughness Values

Due the fine scale of the model, the definition of the Manning's 'n' roughness values throughout the model could also be undertaken on a fine scale. The selection of roughness was undertaken using the supplied drawings from TGM and in particular the road and kerb alignments. The roadways, nature strips and footpaths were all identified and assigned a suitable Manning's 'n' roughness value. The main flood channel, defined overland flow paths and the residential properties were also identified and assigned a suitable roughness value.

The adopted Manning's 'n' values are presented in Table 3-4.

Hydraulic Modelling

Table 3-4 2D Domain Manning’s ‘n’ Coefficients – Local Model

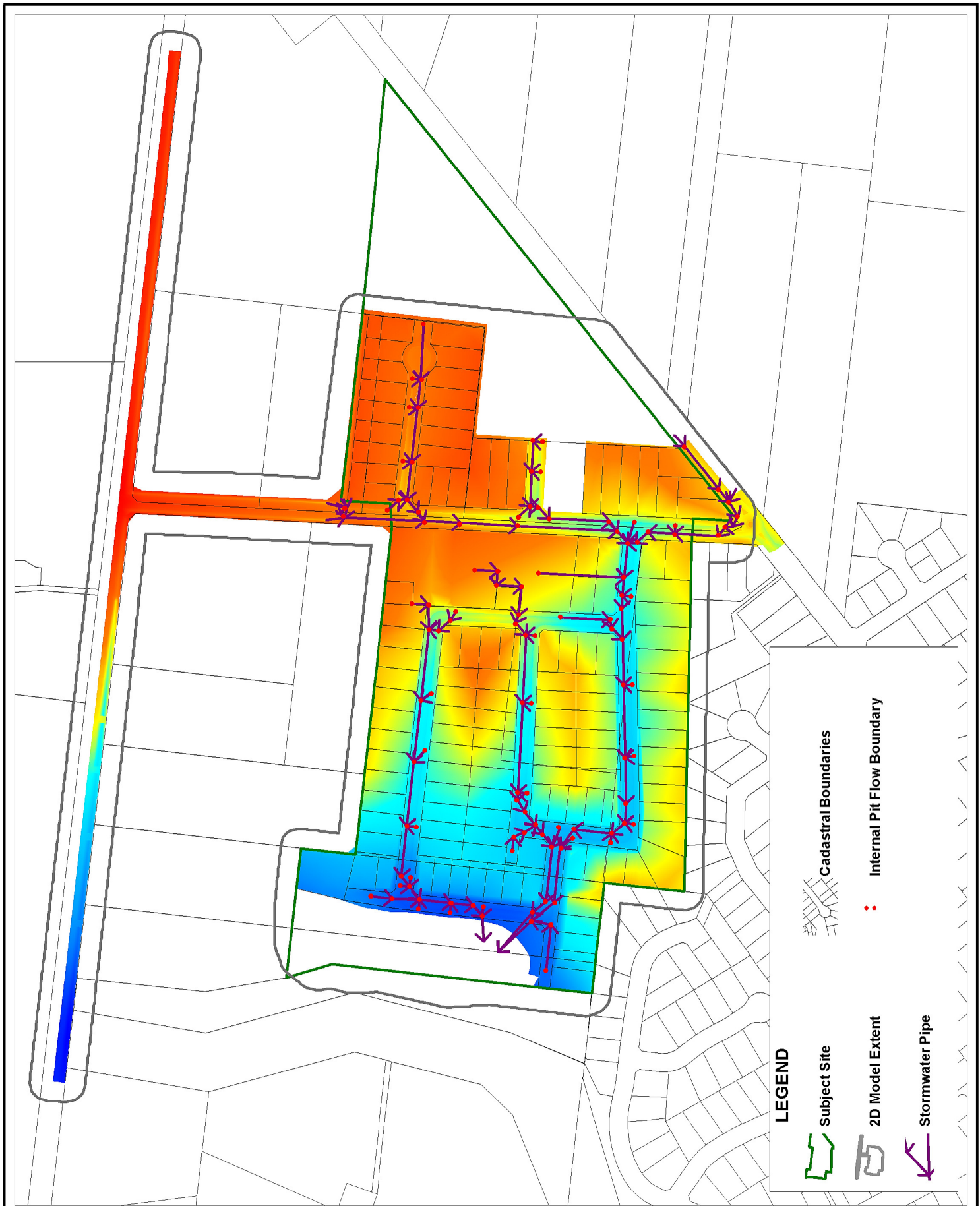
Land use	Manning’s ‘n’
Asphalt	0.015
Nature Strips	0.025
Footpaths	0.02
Floodway	0.03
Main Floodway and Lakes	0.03
Residential Properties	0.2

3.2.2.5 Design Event Modelling

Peak flows for all standard duration between 10 minutes and 90 minutes were provided by TGM. For the purposes of modelling local conditions an envelope of peak flows resulting from provided durations of the 1% AEP flood event was created and applied to the model as steady-state boundaries. The model was run for a sufficient period to allow flood levels to reached steady-state conditions where total flow into and out of the model had equalised.

3.2.2.6 TUFLOW Version

Model runs were performed with the 2012-05-AE build of TUFLOW. The double precision version of TUFLOW was used for the modelling runs.



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Details of Local Caddys Road Model Development

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4 Flood Impacts Assessment and Mapping

This section provides an overview of the flood mapping process used in this investigation, presents the flood impact assessment results and flood height and hazard mapping. For the flood impacts assessment, the impact of the proposed development on peak flood height, peak flood velocity, duration of inundation and hazard is assessed.

4.1 Mapping Methodology

TUFLOW was used to produce geo-referenced datasets defining peak water depths and levels throughout the model domain. For each AEP event, the peak flood value from each of the 9 storm durations was selected for each computational cell to generate an envelope of peak flood level, velocity, depth and velocity x depth product (v.d). The data was imported into GIS to generate a digital model of the flood height, velocity, depth, and v.d. Flooding impact mapping (height and velocity) is then generated by subtracting the existing case mapping from the developed case mapping.

4.2 Discussion of Results

4.2.1 Existing Conditions

The existing condition 1% AEP flood extent and flood depth are shown in Figure 4-1. Flood depth results for other AEP events are presented in Appendix A.

4.2.2 Flood Surface Impact Mapping

The changes in 1% AEP flood level for the modelled interim development are shown in Figure 4-2. All other AEP flood impact results for the interim scenario are presented in Appendix B. In these figures, the colours indicate the flood extent and the change in flood level in accordance with the magnitude indicated in the legend. The lemon colour indicates areas where there is no change within a ± 0.03 m modelling tolerance, the brown/red shades indicate increases in flood level and the green shades indicate decreases. Pink shading indicates areas that were flooded but would no longer be flooded with the development in place, and blue is vice versa.

The change in 1% AEP flood level in the Interim Development scenario are summarised as follows:

- There are no significant increases in flood level across the floodplain as a result of the development.
- Localised increases of up to 0.15 metres in the Bisinella owned land immediately to the north of development.
- Decreases of up to 0.2 metres and the removal of flooding in some areas to the south of the proposed development. This is due in part to the development intercepting the overland flows flowing south and diverting them to Serendip Creek.

4.2.3 Flood Velocity Impact Mapping

The changes in 1% AEP flood velocity for the modelled interim development are shown in Figure 4-3. All other AEP flood velocity impact results for the Interim scenario are presented in Appendix

Flood Impacts Assessment and Mapping

C. In these figures, the colours indicate the flood extent and the change in flood level in accordance with the magnitude indicated in the legend. The lemon colour indicates areas where there is no change within a ± 0.01 m/s modelling tolerance, the brown/red shades indicate increases in flood velocity and the green shades indicate decreases.

The change in 1% AEP flood velocity in the Interim Development scenario are summarised as follows:

- There are no significant increase in velocity across the floodplain as a result of the proposed development;
- Localised changes at the stormwater pipe outlets to Serendip Creek;
- Increases in flood velocities of up to 0.8 m/s along the open drain on Windermere Avenue; and
- Decreases in flood velocities of up 0.2 m/s in the land to the north of the development.

Additionally, there are some noticeable changes in the flood velocity within the development, however, these are a result of changes in terrain and associated flow depths through this region.

4.2.4 Flood Depth and Extent Mapping

The flood depth and flood extent maps for the 100 year ARI flood event for the regional model (Figure 4-4) and the local model (Figure 4-5), shows that the proposed lots of the Caddys Road development are flood free. Flood depth results for other AEP events are presented in Appendix D.

4.3 Flood Hazard

In assessing flood hazard, it is necessary consider site (on lot) safety in vehicle egress during the 1% AEP flood event. In the proposed development all lots are above the 1% AEP event and therefore requires no further consideration.

For the assessment of vehicle egress Australian Rainfall and Runoff Revision Project 10 provides the following criteria:

- Depth should be no more than 0.30m; and
- Velocity should be no more than 3.0 m/s; and
- The product of depth and velocity should be no more than $0.30 \text{ m}^2/\text{s}$.

These criteria, which were adopted for this current assessment, are slightly more stringent than those in Melbourne Water's Guidelines for Development in Flood Prone Areas and are the same as those recommended in the Corangamite Catchment Management Authority's letter dated 17/12/2013 (Ref: F-2013-0692).

4.3.1 Regional Modelling

Results of the regional Caddys Road model were mapped in terms of flood hazard and are presented in Figure 4-6.

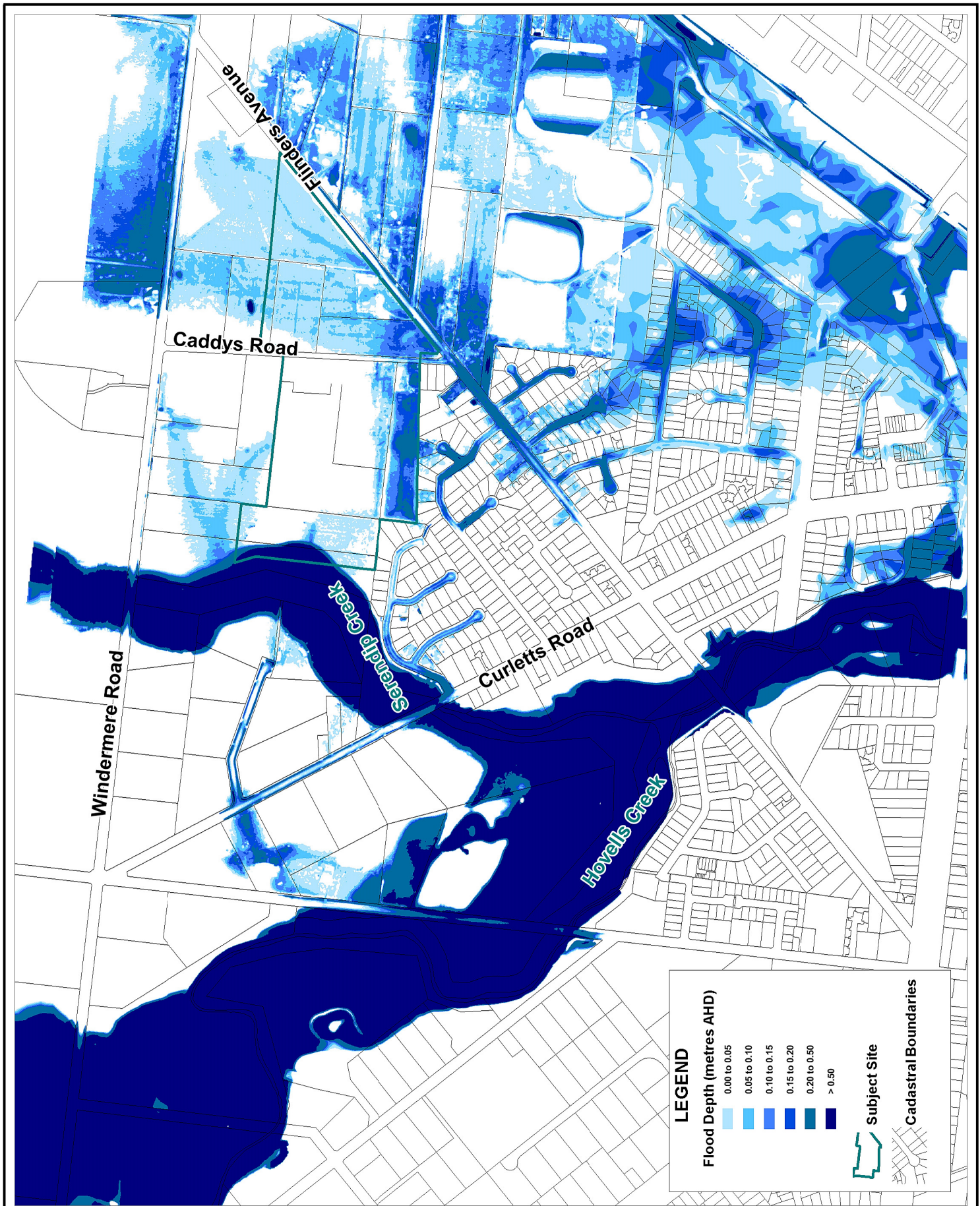
As seen in Figure 4-6, the proposed development meets the defined flood hazard criteria within the Site and safe egress routes are available to either Windermere Road or to Flinders Avenue.

Flood Impacts Assessment and Mapping

4.3.2 Local Modelling

Results of the local Caddys Road model were mapped in terms of flood hazard (as defined in the criteria detailed in Section 4.3) and are presented in Figure 4-7. In this figure, the safety criterion is only applied to the roads and properties within the development and not detention basin located on the western edge of the site. Depths within the basin are exempt from the hazard criteria because it does not form part of a vehicular egress route from the Site. This is consistent with the Melbourne Water Land Development Manual state that floodways and basins like this are exempt from the hazard criteria because the 'visual nature and setting are clearly discernible to be an open waterway likely to be subject to flooding from time to time'.

As seen in Figure 4-7, the proposed development allows safe vehicular egress along all roads during a 1% AEP flood event. There is one localised location within the development where the flood hazard criteria is exceeded. This is on the most northern of the proposed streets off Caddys Rd. Although there are two small regions of flooded roadway which exceed the hazard criteria, access to and from all properties and access along all roadways is maintained. The area where the flood hazard is exceeded is confined to the gutters on the north and south sides of the road (a width of less than 0.85 metres from the gutter and extending less than 15 meters along the gutter). A roadway width of approximately 5.5 metres adjacent to this location is deemed to have a 'safe' flood hazard, ensuring safe egress from this court during times of flood.



Title:
**Peak 1% AEP Existing Flood Depth
 Regional Model**

Figure:
4-1

Rev:
A

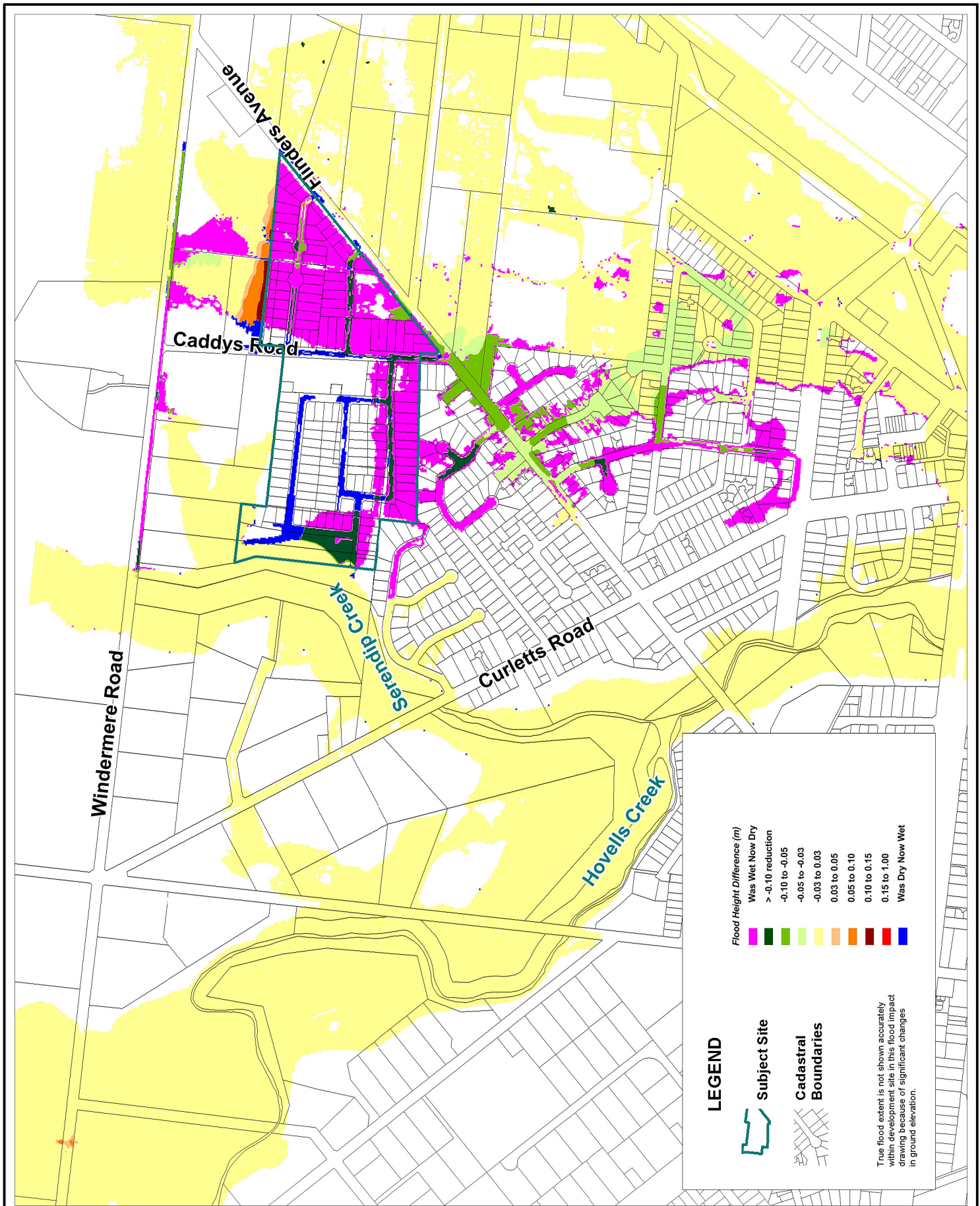
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0 250 500m
 Approx. Scale



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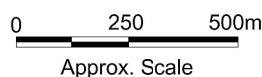


Title:
**Change in 1% AEP Peak Flood Height
 Central Lara Development - Regional Model**

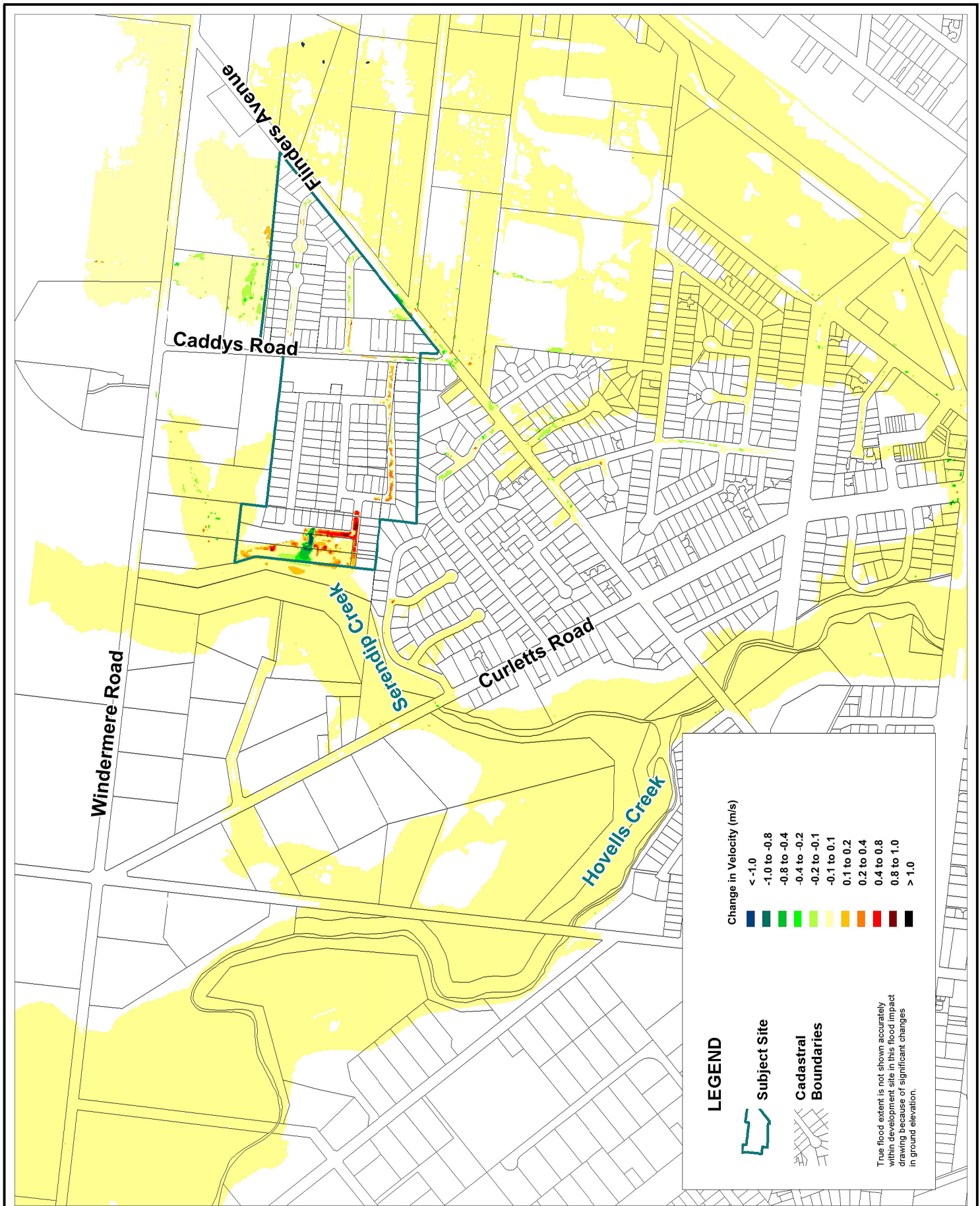
Figure:
4-2

Rev:
C

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Title:
**Change in 1% AEP Peak Flood Velocity
 Development - Regional Model**

Figure:
4-3

Rev:
C

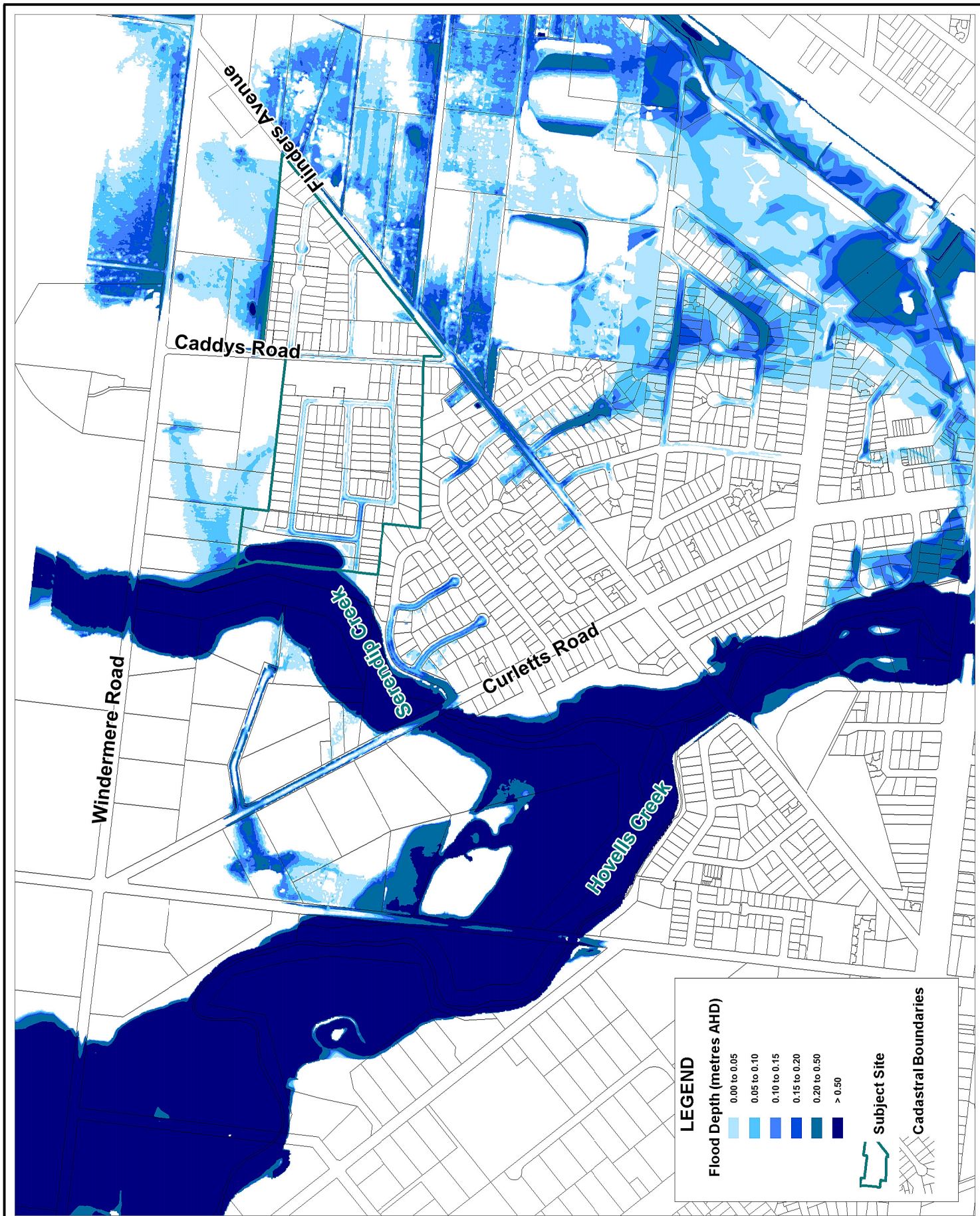
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Title:
**Peak 1% AEP Development Peak Flood Depth
 Regional Model**

Figure:
4-4

Rev:
C

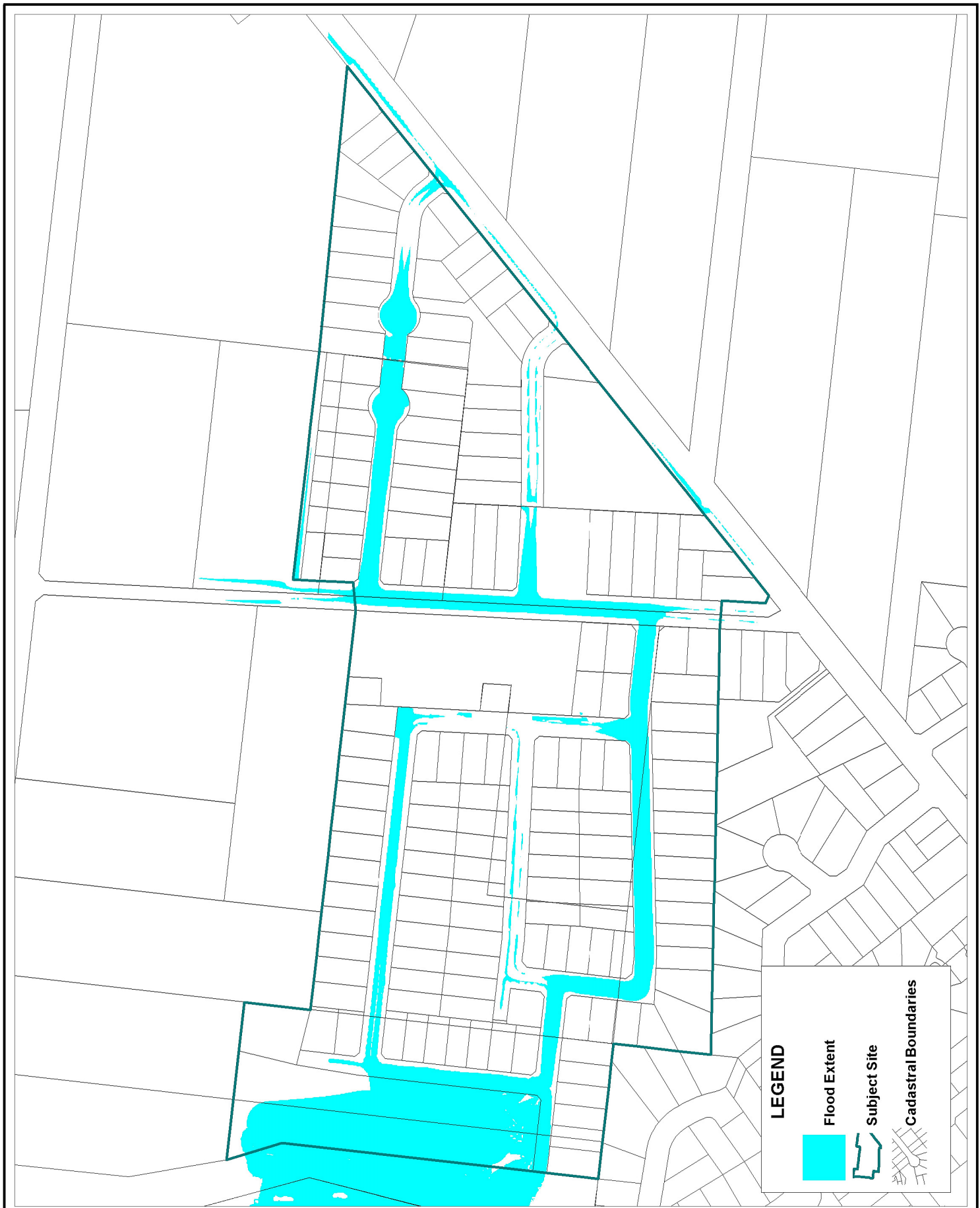
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Title:
**Peak 1% AEP Development Flood Extent
 Local Model**

Figure:
4-5

Rev:
C

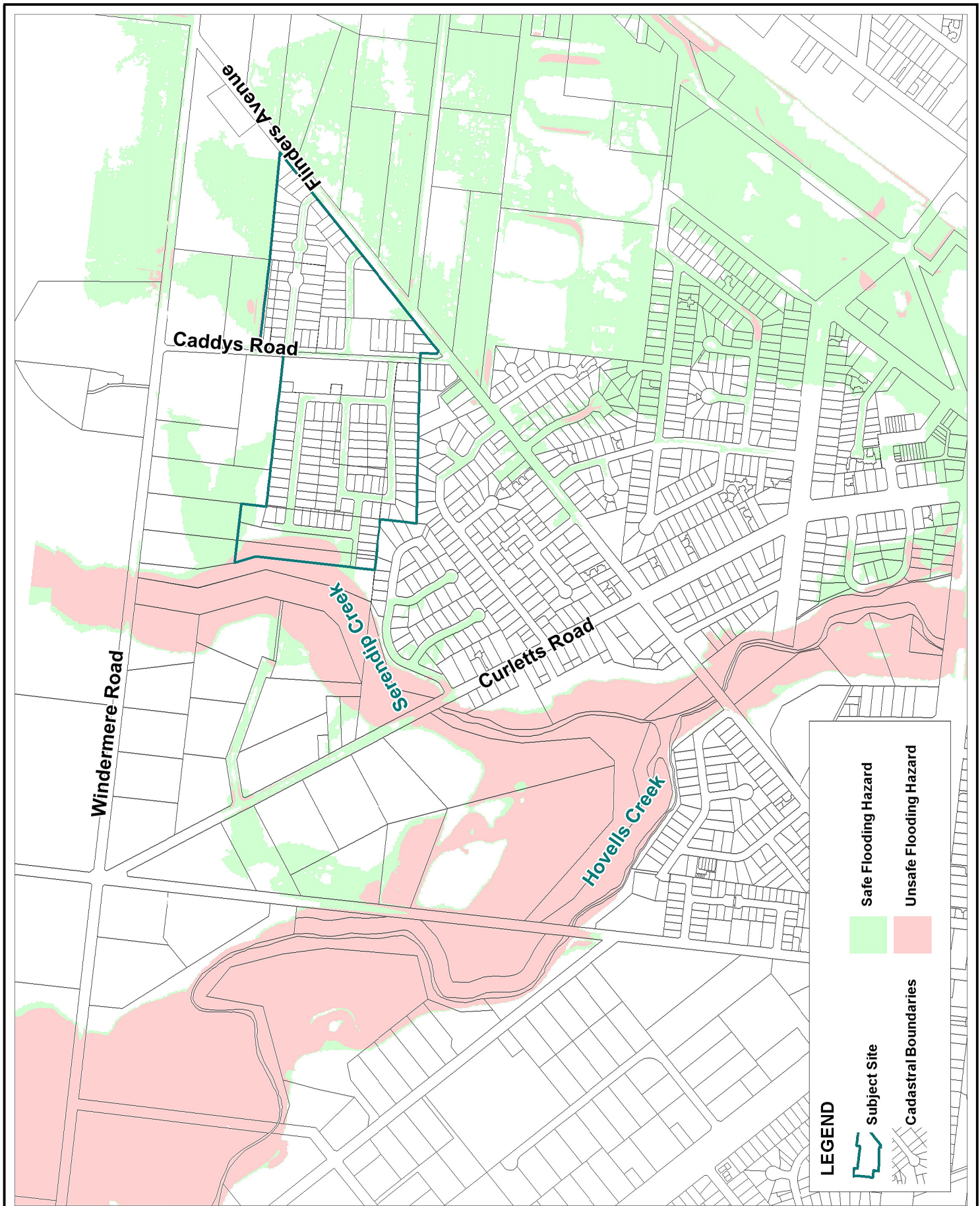
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



0 50 100m
 Approx. Scale



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LEGEND

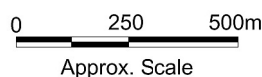
-  Safe Flooding Hazard
-  Unsafe Flooding Hazard
-  Subject Site
-  Cadastral Boundaries

Title:
**Peak 1% AEP Development Flood Hazard
 Regional Model**

Figure:
4-6

Rev:
C

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Title:
**Peak 1% AEP Development Flood Hazard
 Local Model**

Figure:
4-7

Rev:
C

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Conclusions

5 Conclusions

A flood impact and flood hazard assessment has been undertaken for the proposed development of Caddys Road in Lara on behalf of L. Bisinella Developments Pty Ltd. The current assessment considered an interim development scenario with regard to the proposed future development of the Site.

An existing hydrological model of Hovells Creek and Serendip Creek was utilised for the purposes of calculating catchment flows to be used as inputs into the TUFLOW hydraulic model. 1% AEP flows were supplied by TGM for the local modelling scenario.

Hydraulic modelling was undertaken using a 1D/2D dynamically linked TUFLOW hydraulic model. The model was designed to cover the site and surround area such that boundary conditions would not influence the impact assessment. Overland flow paths and storages were modelled in the 2D domain and underground drainage structures were represented as 1D elements dynamically linked to the 2D domain.

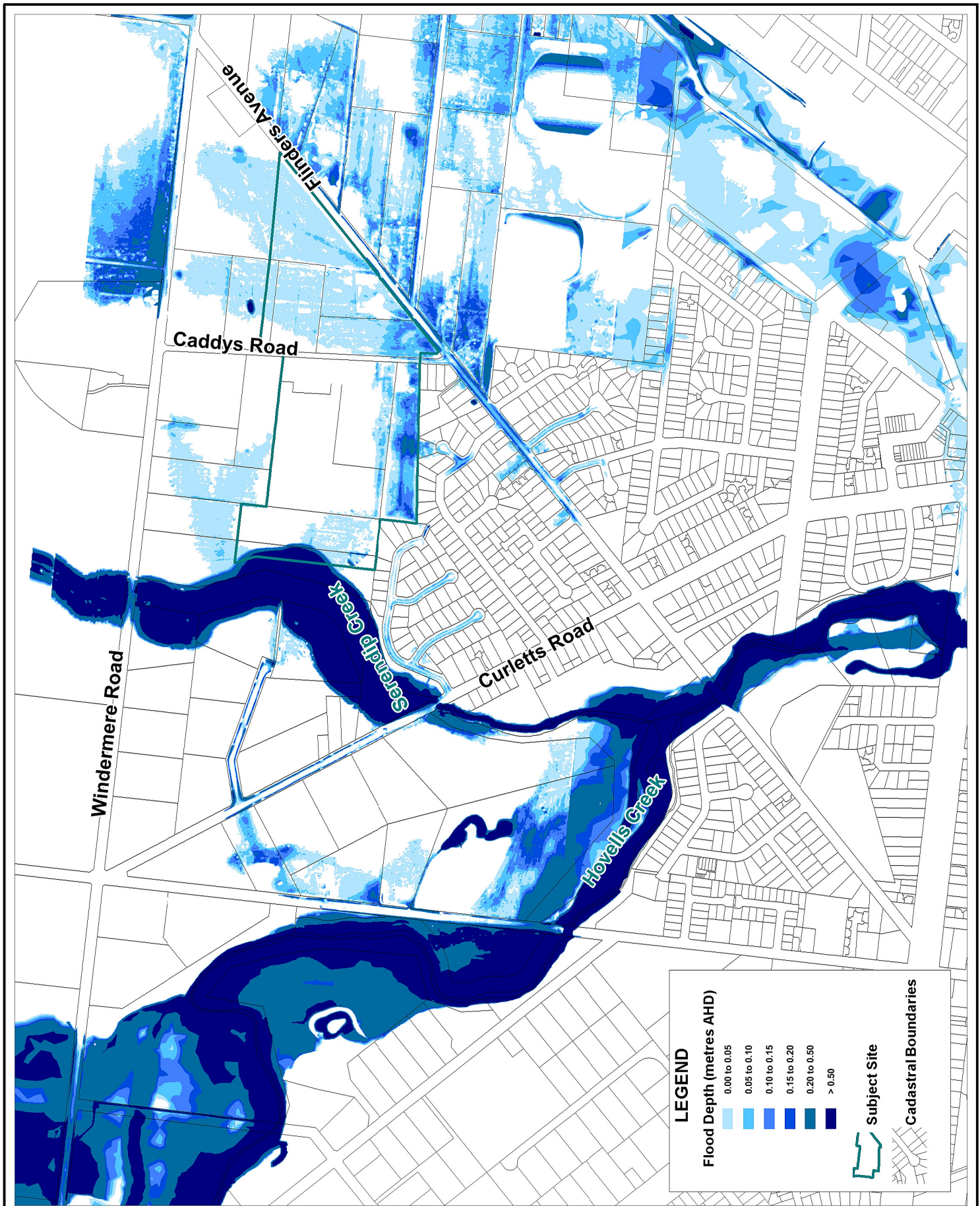
The impact assessment of the development was considered for the 20%, 10%, 5%, 2% and 1% AEP events for a range of storm durations. In summary the analysis found that the proposed development would:

- Significantly reduce flood levels and extent of flooding on the existing urban development to the south of the Site;
- Localised increases of up to 0.15 metres in the Bisinella owned land immediately to the north of development.
- Not increase flood duration or velocity external to the Site;
- Not result in any significant change to flood hazard external to the Site;
- Ensure all proposed lots are above the 1% AEP flood extent;
- Satisfy site safety and egress requirements

6 References

- BMT WBM (2014a), Proposed Development of Caddys Road, Lara – Flood Impact Assessment. January 2014, Report No. R.M20250.001.00.ModellingReport.pdf
- BMT WBM (2014b), Proposed Development of Caddys Road, Lara – Flood Impact Assessment. December 2014, Report No. R.M20250.001.00.ModellingAddendum1.pdf
- BMT WBM (2010), Amendment C73 and C198 to the City of Greater Geelong Planning Scheme Drainage at Caddys Road Property – Expert Witness Statement. May 2010. Report No. R.M7076.002.00.ExpertReport.pdf
- BMT WBM (2007), Caddys Road Development Drainage Assessment Report, BMT WBM Pty Ltd, February 2007. Report No. R.M7076.001.00.ExpertReport.pdf
- WBM (2002), Lara Flood Study Stage One, WBM Oceanics Australia Pty Ltd, January 2002, Report No. R.W00241.001.002.FinalReport.pdf

Appendix A Existing Flood Depth Maps



Title:
**Peak 20% AEP Existing Flood Depth
 Regional Model**

Figure:
A-1

Rev:
A

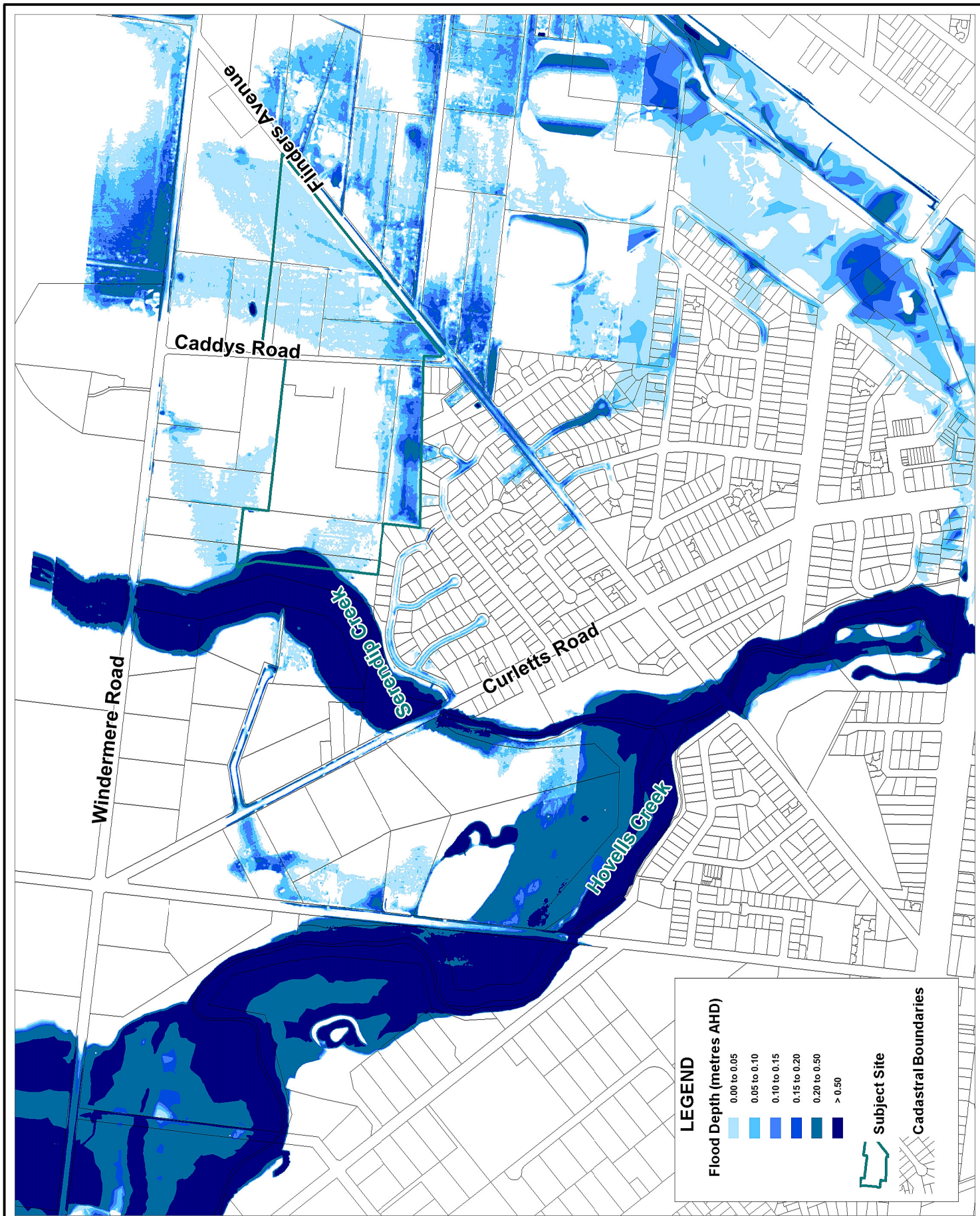
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0 250 500m
 Approx. Scale



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Title:
**Peak 10% AEP Existing Flood Depth
 Regional Model**

Figure:
A-2

Rev:
A

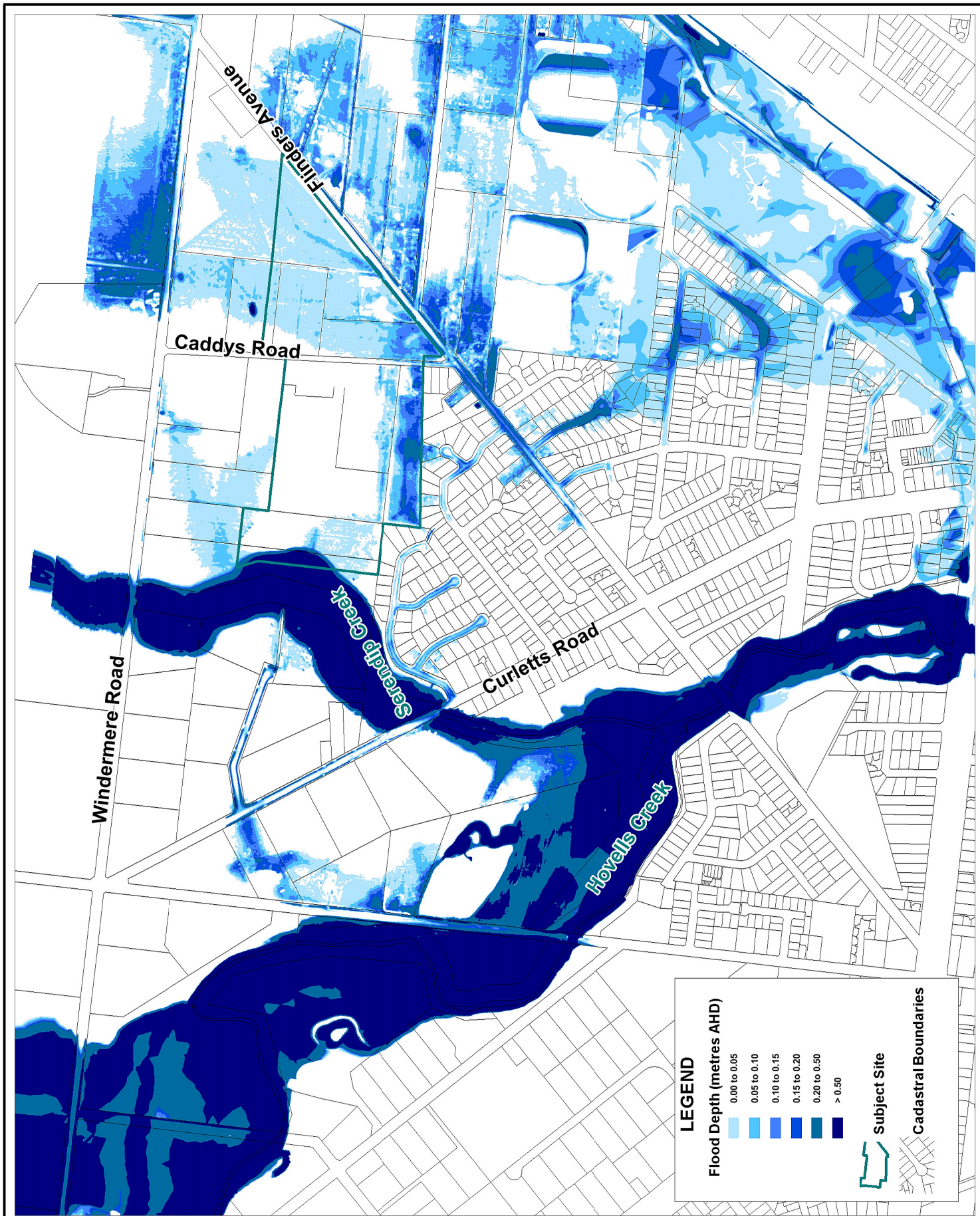
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0 250 500m
 Approx. Scale



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Title:
**Peak 5% AEP Existing Flood Depth
 Regional Model**

Figure:
A-3

Rev:
A

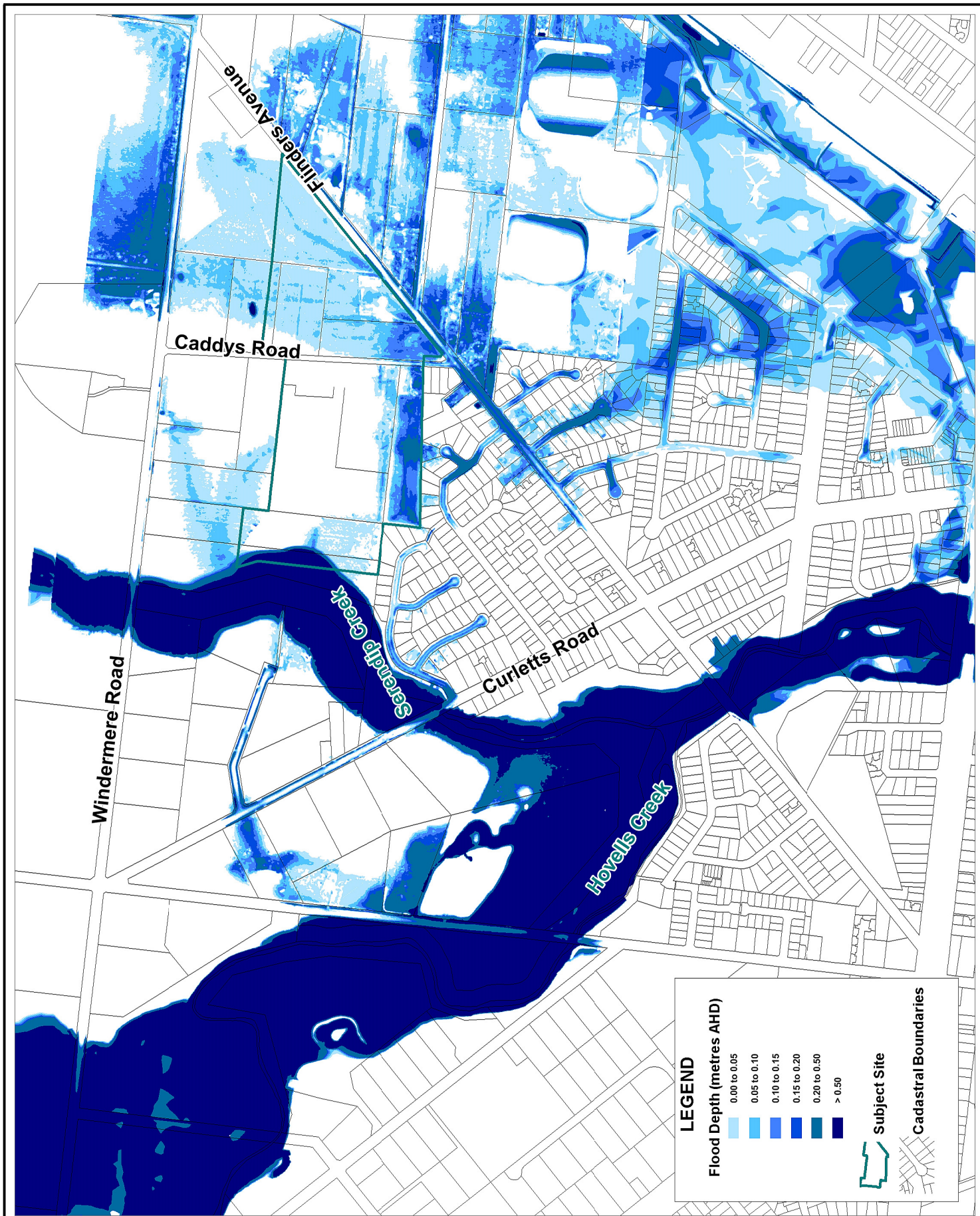
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Title:
**Peak 2% AEP Existing Flood Depth
 Regional Model**

Figure:
A-4

Rev:
A

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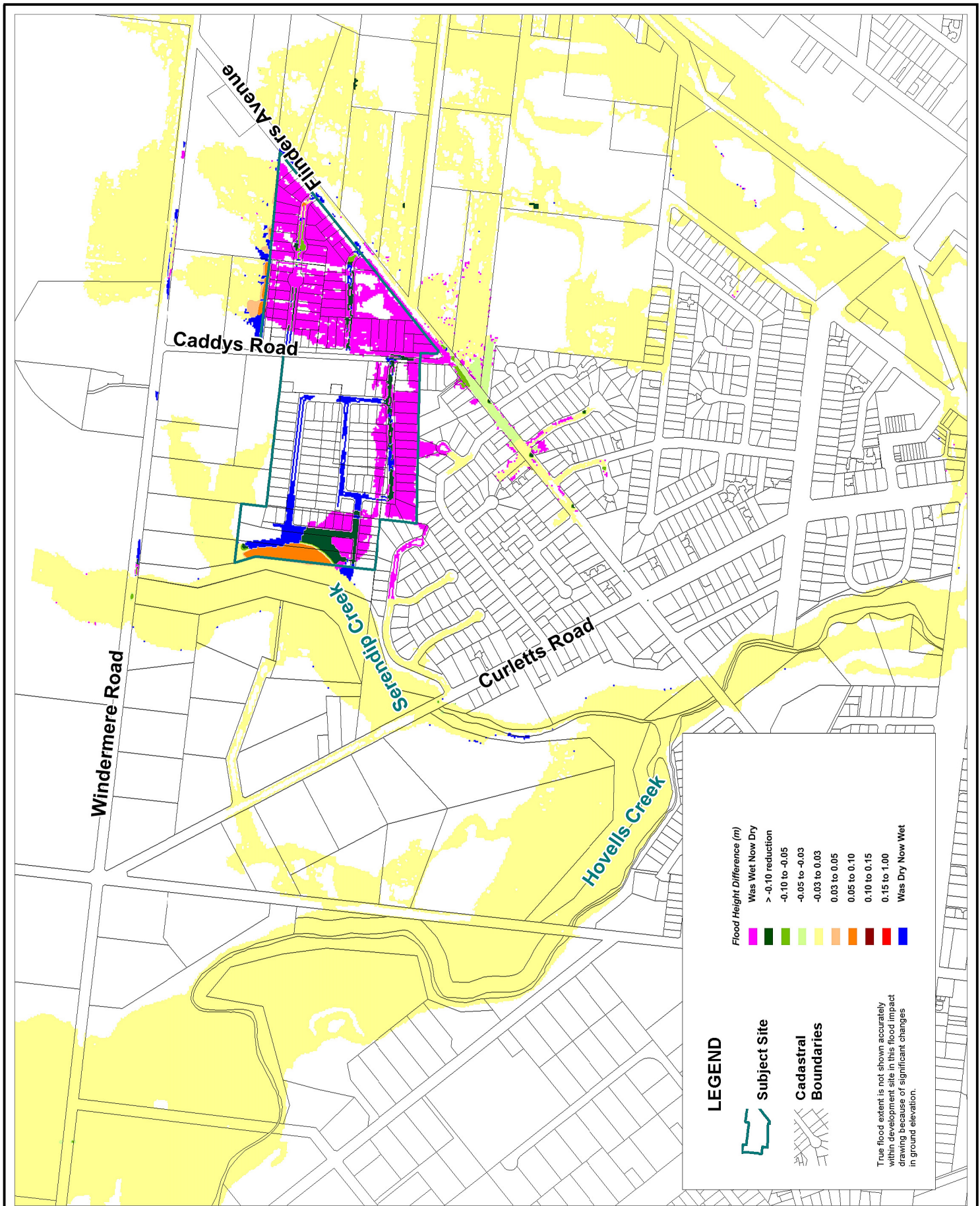


0 250 500m
 Approx. Scale



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Appendix B Peak Flood Height Impact Maps

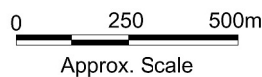


Title:
**Change in 20% AEP Peak Flood Height
 Central Lara Development - Regional Model**

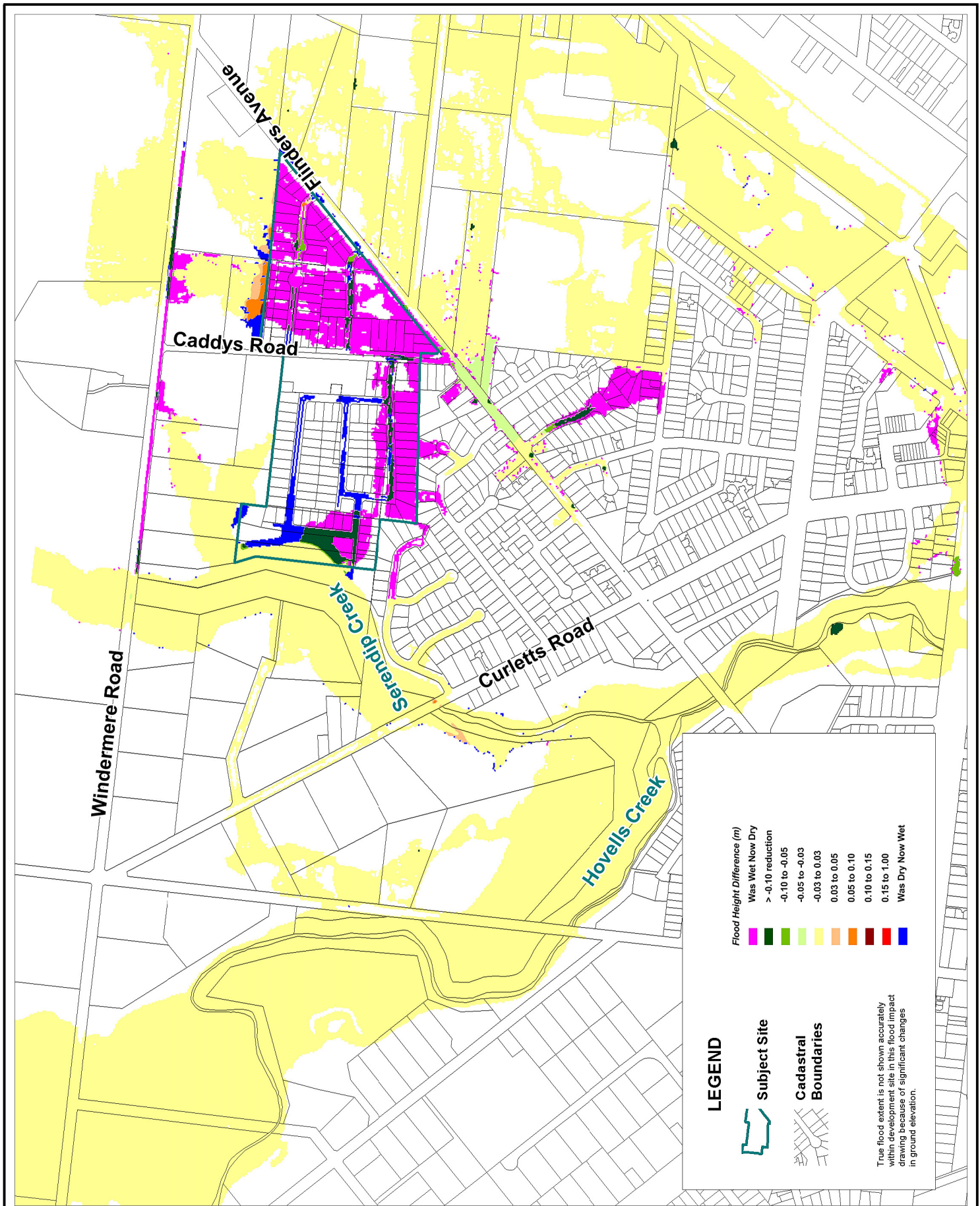
Figure:
B-1

Rev:
C

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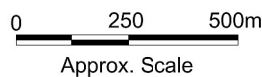


Title:
**Change in 10% AEP Peak Flood Height
 Central Lara Development - Regional Model**

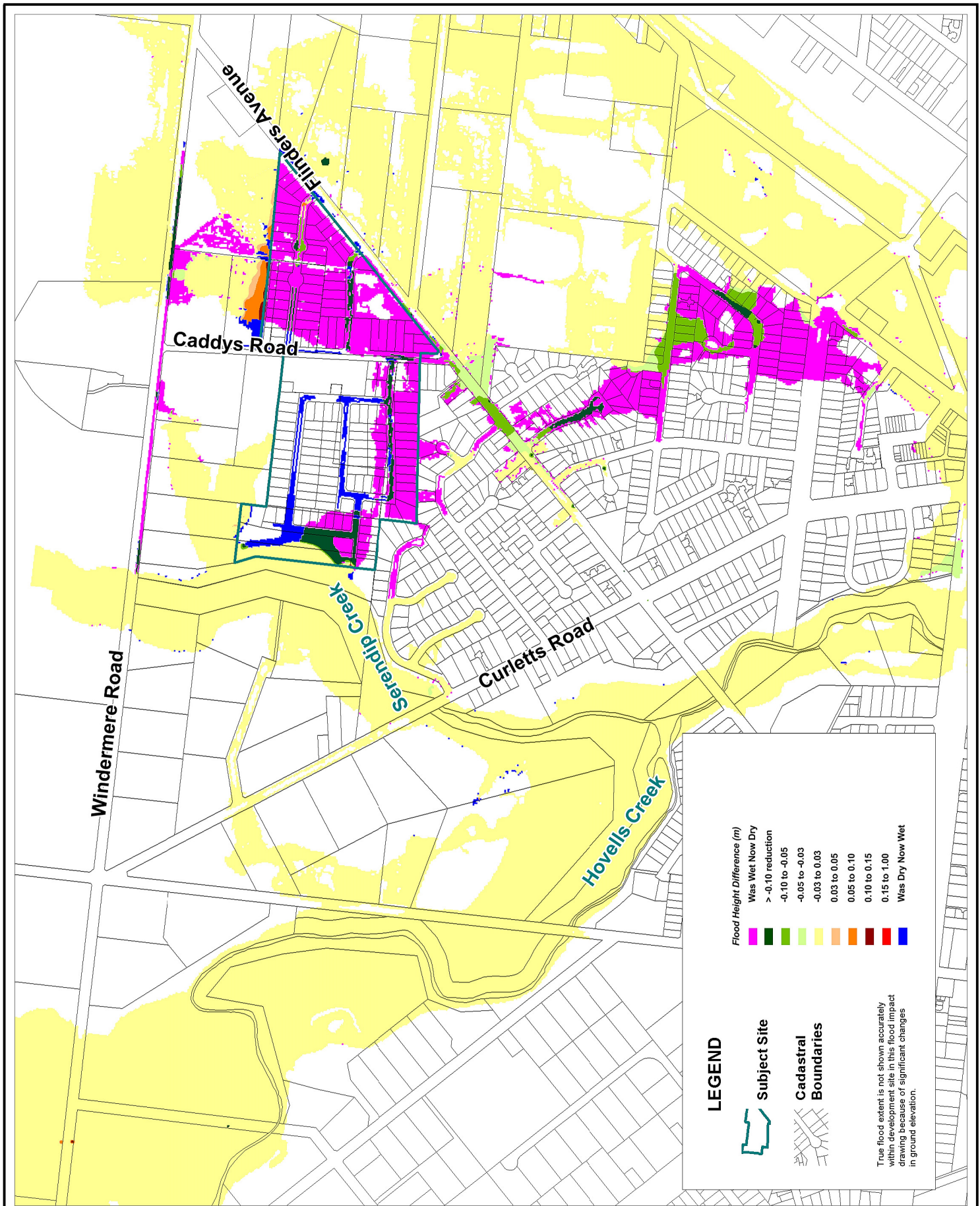
Figure:
B-2

Rev:
C

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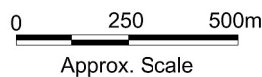


Title:
**Change in 5% AEP Peak Flood Height
 Central Lara Development - Regional Model**

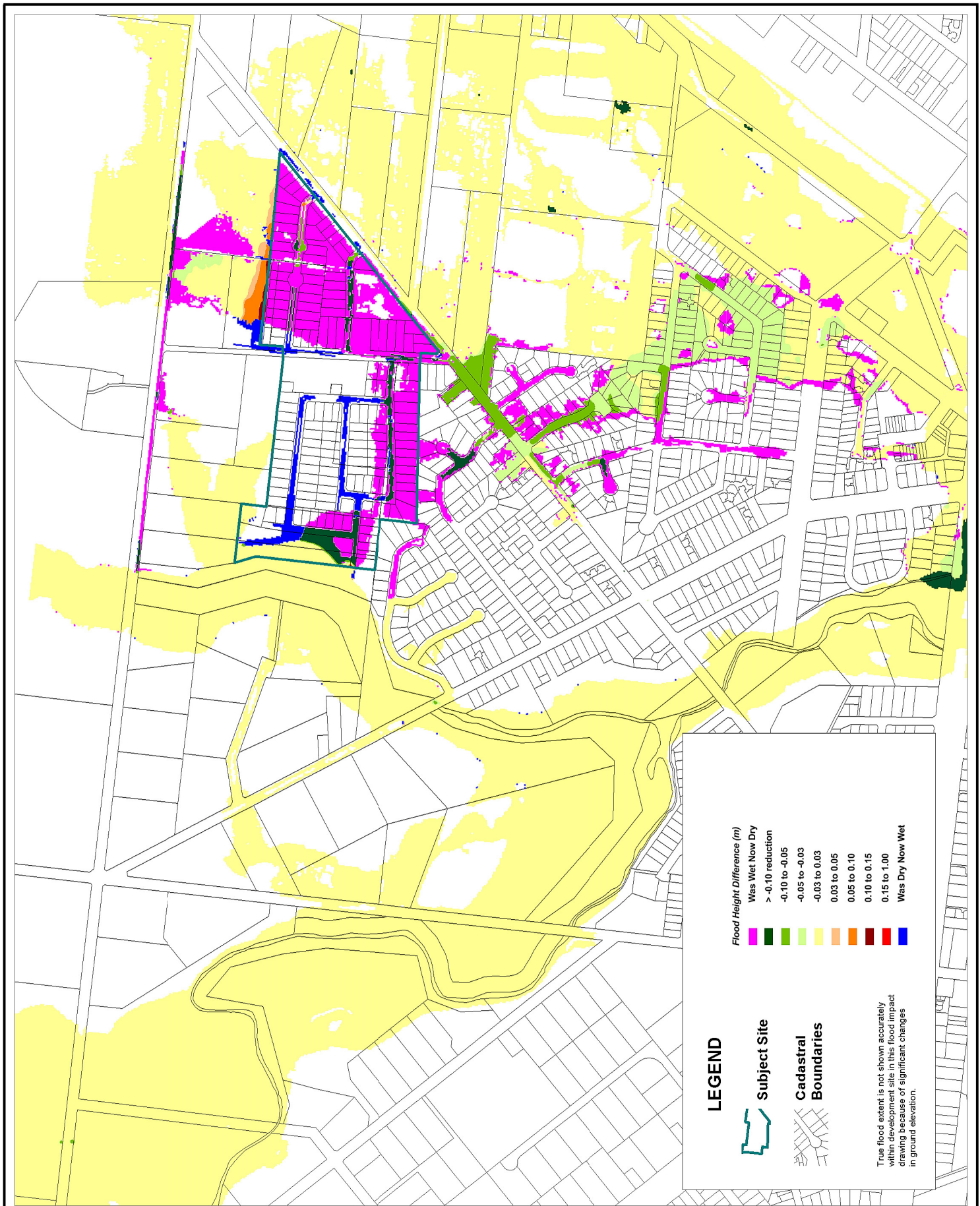
Figure:
B-3

Rev:
C

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Title:
**Change in 2% AEP Peak Flood Height
 Central Lara Development - Regional Model**

Figure:
B-4

Rev:
C

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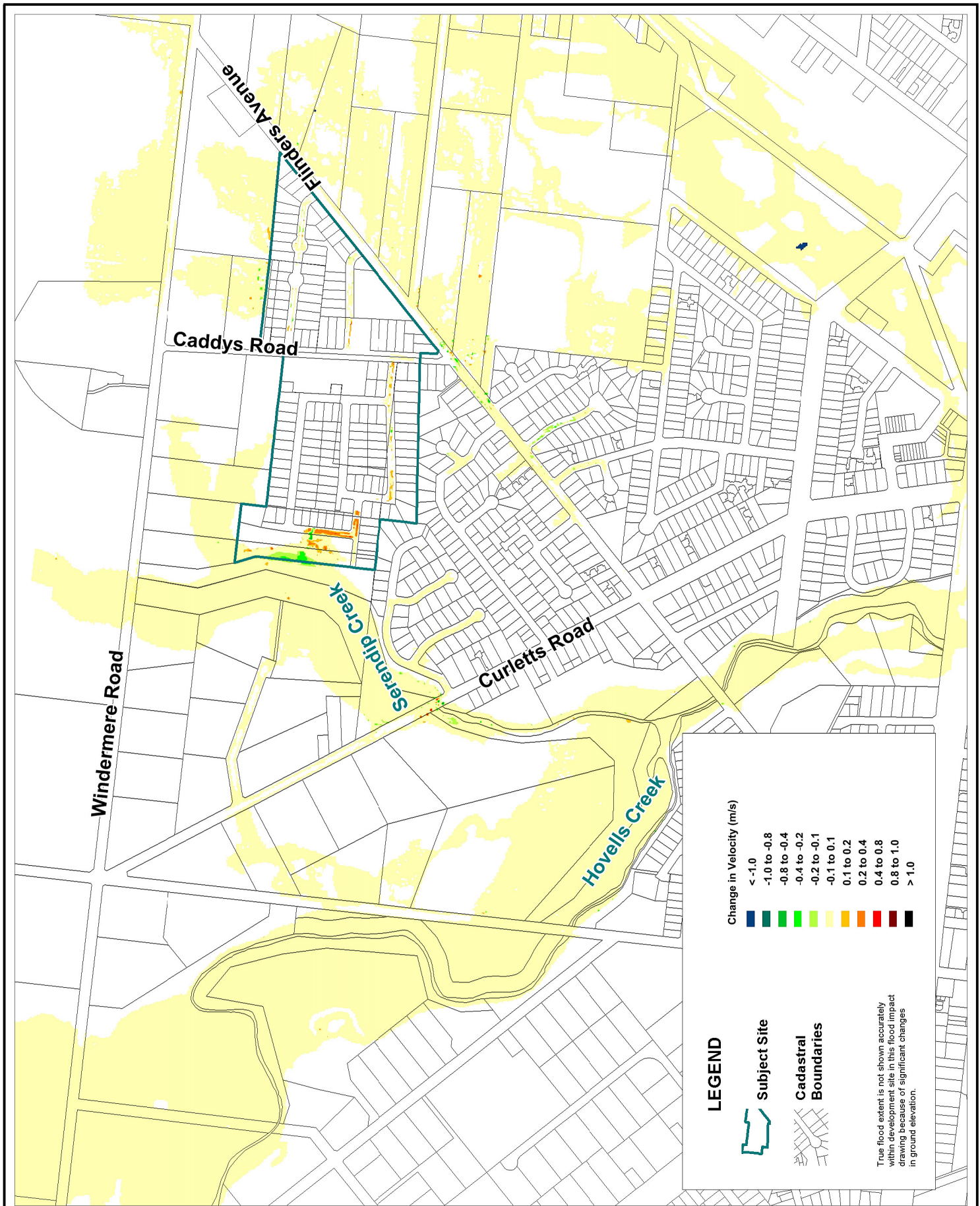


0 250 500m
 Approx. Scale



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Appendix C Peak Flood Velocity Impact Maps

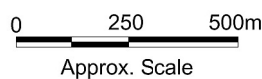


Title:
**Change in 20% AEP Peak Flood Velocity
 Development - Regional Model**

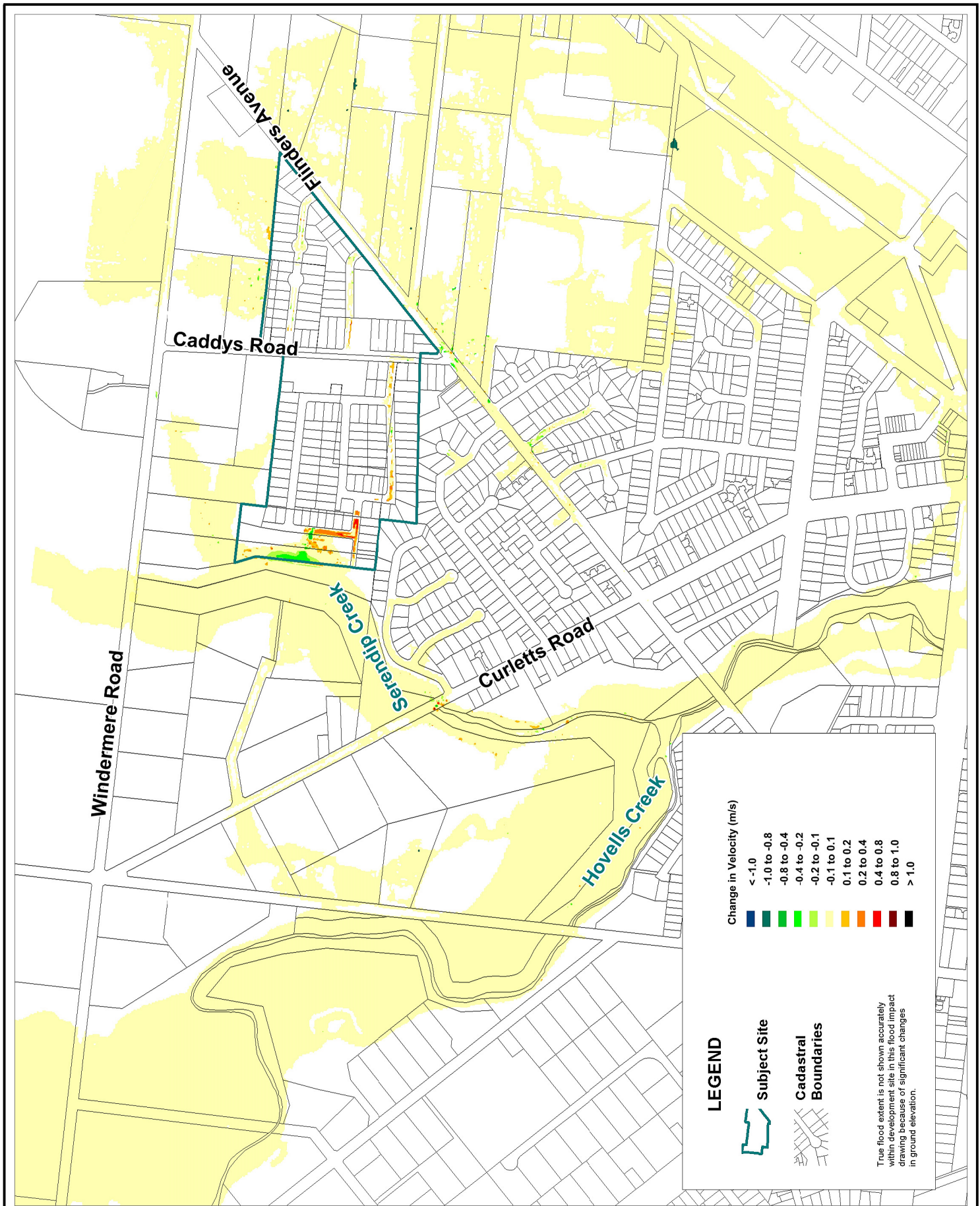
Figure:
C-1

Rev:
A

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Title:
**Change in 10% AEP Peak Flood Velocity
 Development - Regional Model**

Figure:
C-2

Rev:
A

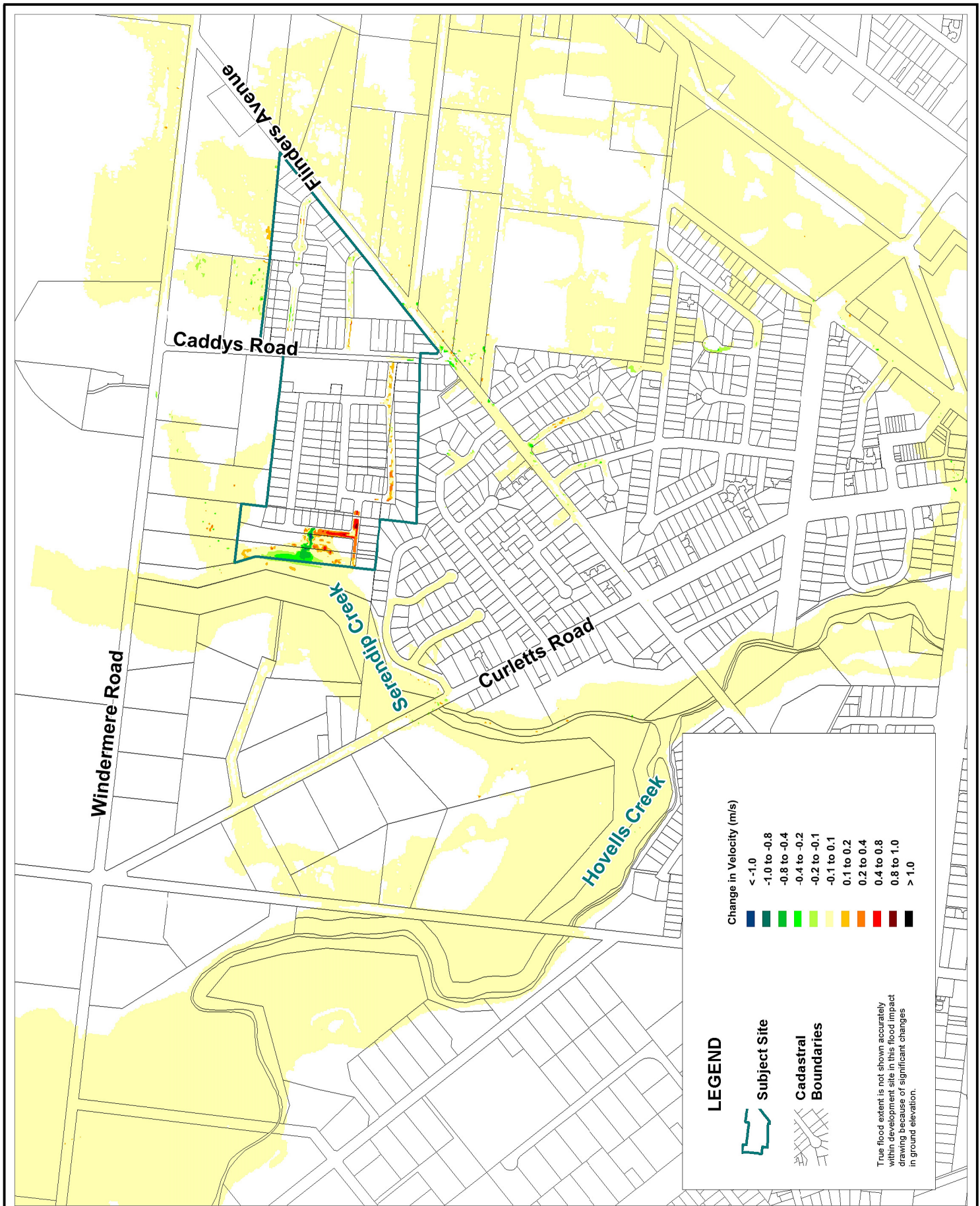
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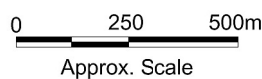


Title:
Change in 5% AEP Peak Flood Velocity Development - Regional Model

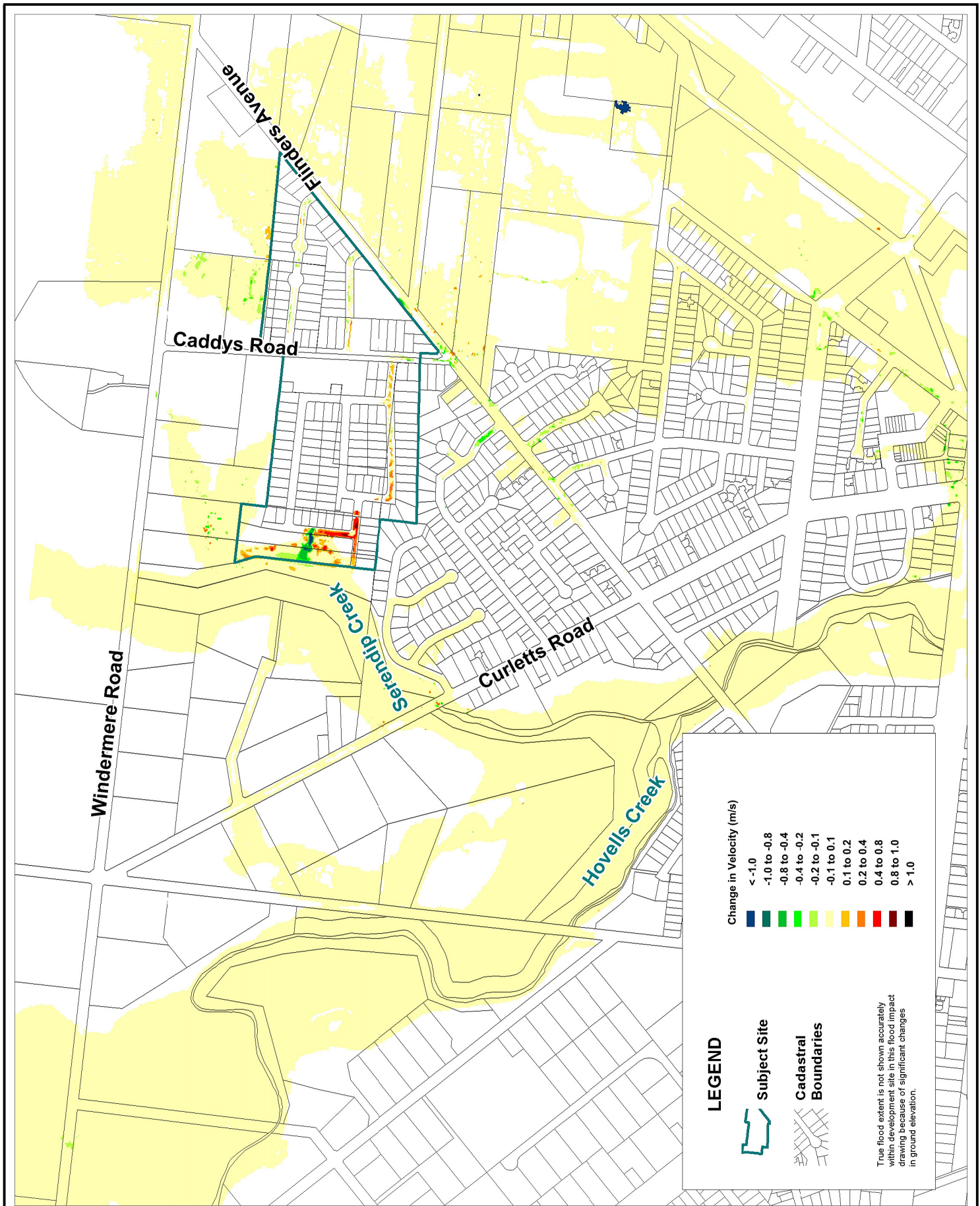
Figure:
C-3

Rev:
A

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Title:
**Change in 2% AEP Peak Flood Velocity
 Development - Regional Model**

Figure:
C-4

Rev:
A

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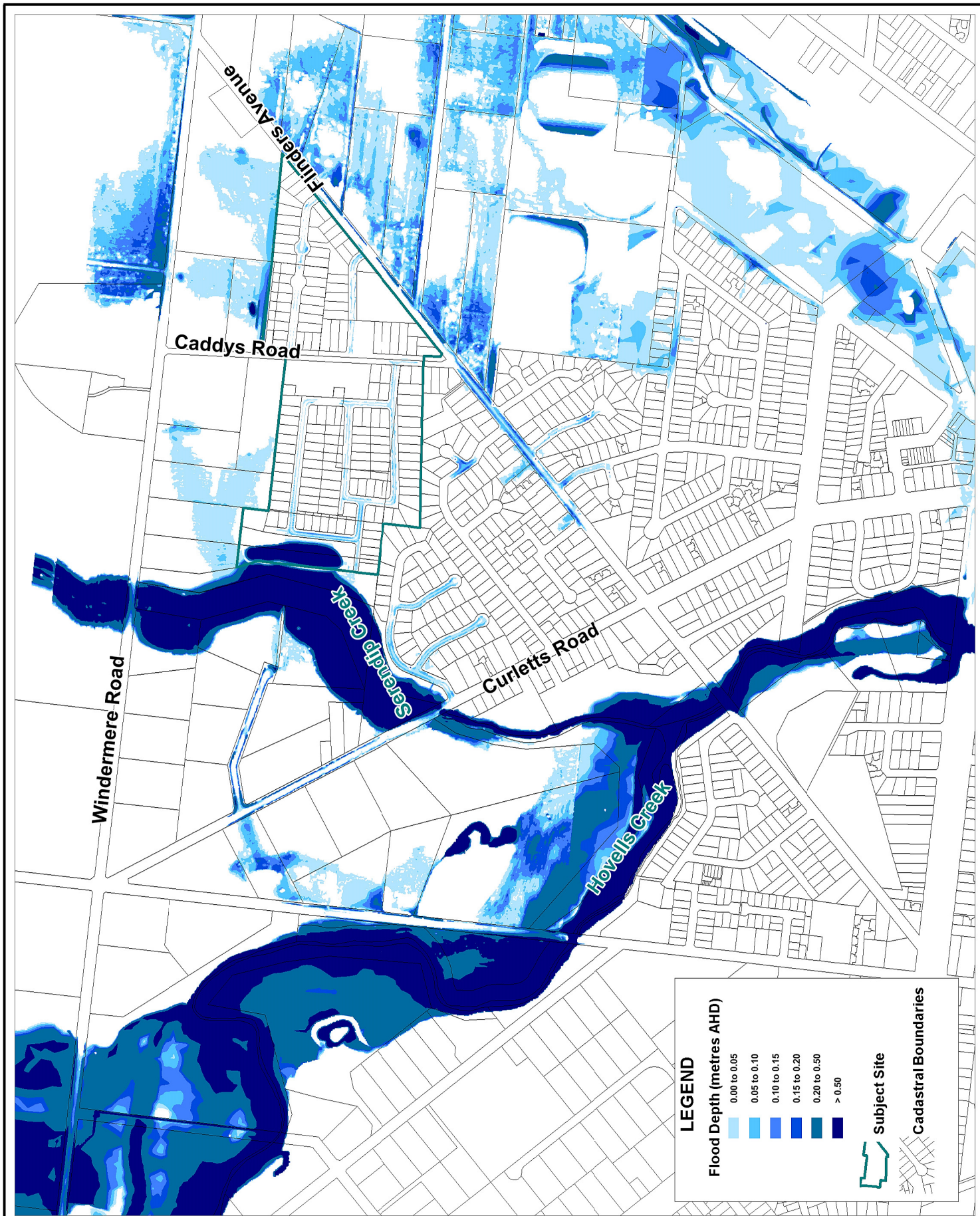


0 250 500m
 Approx. Scale



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Appendix D Interim Development Flood Depth Maps



Title:
**Peak 20% AEP Development Peak Flood Depth
 Regional Model**

Figure:
D-1

Rev:
B

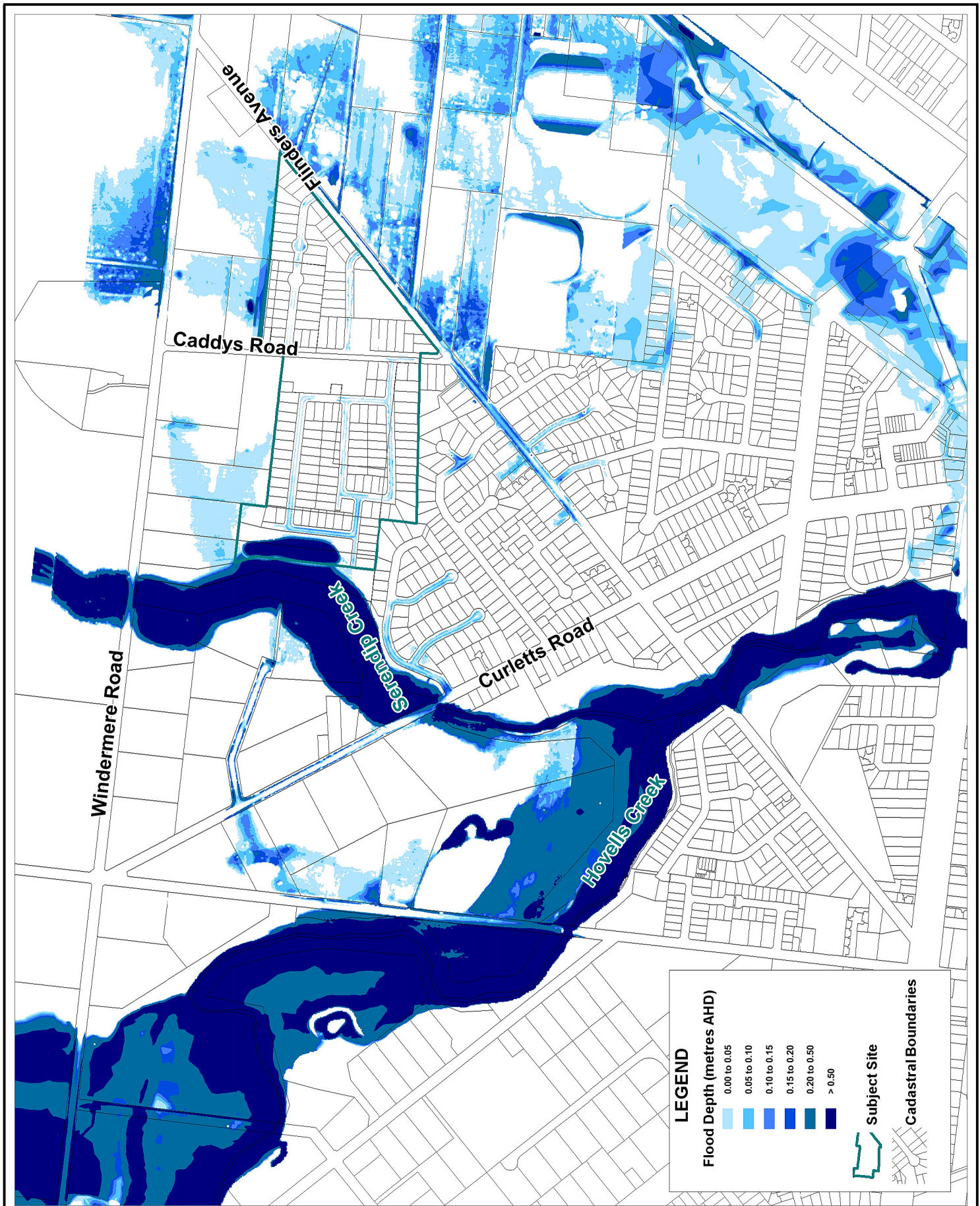
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Title:
**Peak 10% AEP Development Peak Flood Depth
 Regional Model**

Figure:
D-2

Rev:
B

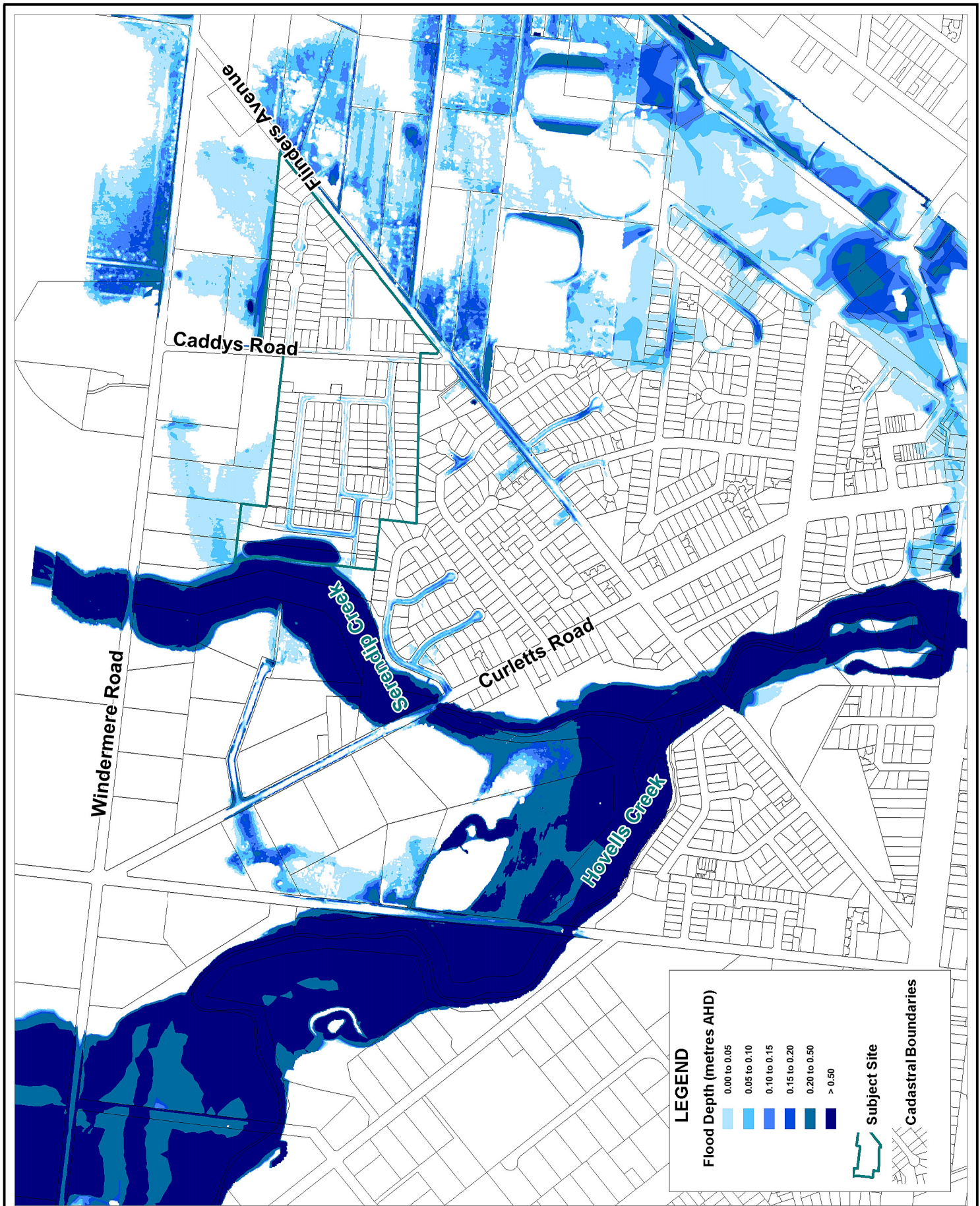
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 Approx. Scale



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Title:
**Peak 5% AEP Development Peak Flood Depth
 Regional Model**

Figure:
D-3

Rev:
B

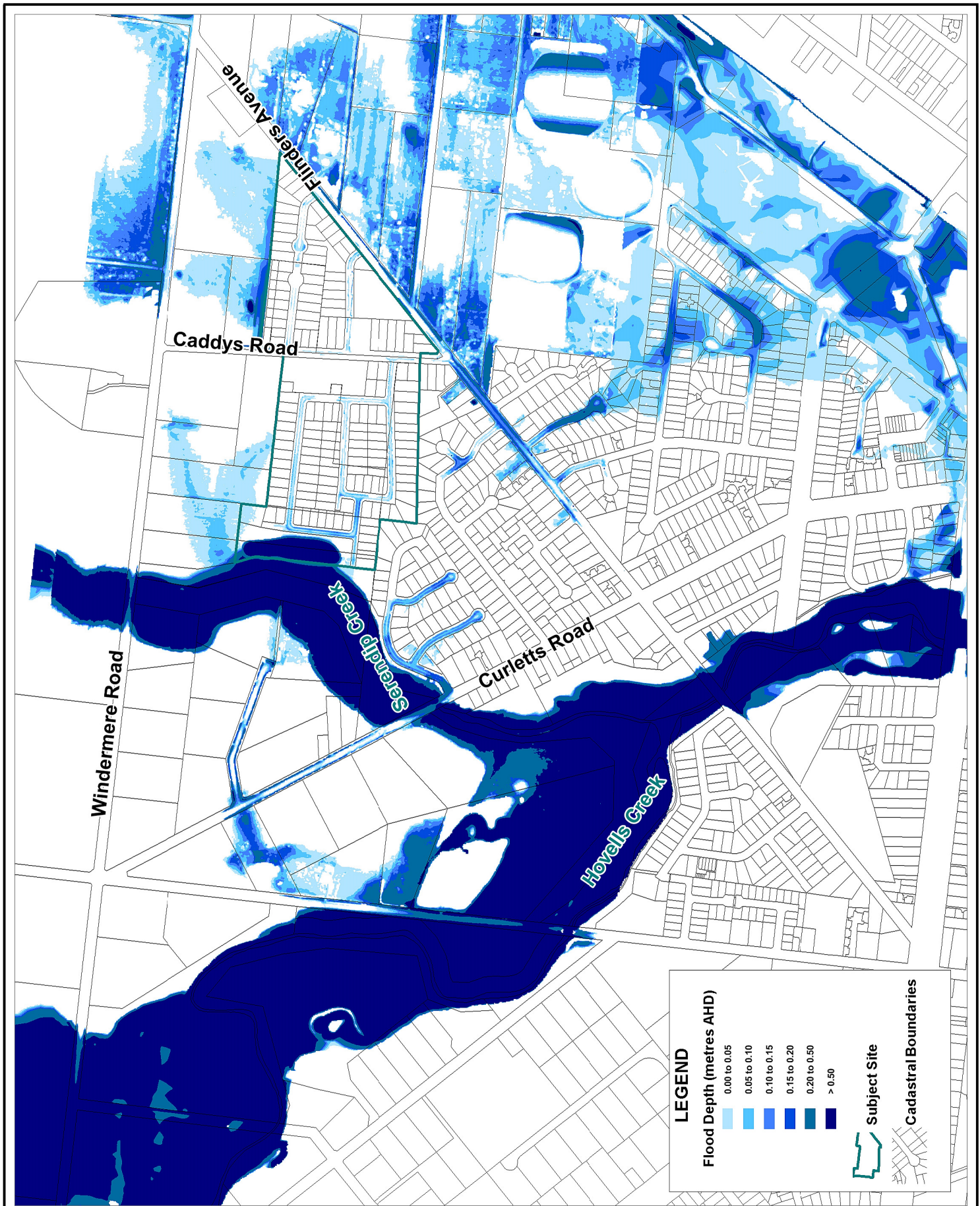
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Title:
**Peak 2% AEP Development Peak Flood Depth
 Regional Model**

Figure:
D-4

Rev:
B

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