South Gippsland Shire Council

ENGENY WATER MANAGEMENT

Planisphere Pty Ltd and South Gippsland Shire

Nyora Development Strategy

Nyora Stormwater Management Plan

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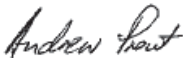
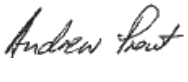
Signatures					

EXECUTIVE SUMMARY

Nyora is located in South Gippsland, approximately 90 kilometres south east of Melbourne. The town is forecast to grow considerably as people are attracted to the affordable semi-rural lifestyle on offer and its relatively close proximity to Melbourne and other commercial centres. The Nyora Stormwater Management Plan (SMP) is a catchment scale stormwater infrastructure plan that was developed with and informed by the Nyora Development Strategy, prepared by Planisphere Pty Ltd. (Planisphere) on behalf of South Gippsland Shire Council (SGSC).

The Nyora SMP provides an approach to managing stormwater in Nyora that meets appropriate standards for drainage, flood protection, water quality, waterway health and amenity.

Flooding

Hydraulic modelling was undertaken using TUFLOW 1D/2D hydrodynamic software and RORB to generate catchment flows. The modelling identified that there are a number of locations in Nyora that are currently flood prone, including 2 properties (located on Yannathan Road and the corner of Henley Street and Hewson Street respectively) that were considered likely to experience above floor flooding for the 18% AEP event. Glovers Road and Walters Street were concluded to experience frequent and significant flooding. Flood mitigation options were proposed to mitigate flooding at these locations and two additional locations; at Hatchs Road near the intersection of Hewson Street and Davis Street.

Hatchs Road was an area raised in relation to flooding concern by residents in a community consultation session undertaken by Planisphere. This location was identified by the modelling as flood prone but with no floors affected. A local ground shaping and bunding mitigation option was proposed to keep flow out of what was understood to be the affected property however further investigation and discussion with the residents is recommended to inform this solution (refer to **Section 5.3** for further discussion). The location near the intersection of Hewson Street and Davis Street has no formal existing flow path and development in the upstream Precinct A catchment area is likely to result an increased flood risk to building floors. A flood mitigation solution involving a pipe upgrade and inlet works was proposed to convey major storm flows at this location.

Administration of flood prone land

In many locations existing overland flow paths can be incorporated into future development precincts as part of future major and minor drainage systems or as part of designated waterway corridors. However in some locations existing flooding will not be resolved as part of future development or flood mitigation works, such as behind the railway embankment and major road embankments.

Urban Flood Zone (UFZ) and flood overlays, the Special Building Overlay (SBO), Land Subject to Inundation Overlay (LSIO) and the Floodway Overlay (FO) designate land that

is subject to flooding and provide statutory authorities with a means for regulating or prohibiting development within a hazardous area under Section 62(e) of the Planning and Environment Act 1987. The statutory authorities responsible for collecting flood information and managing development in flood prone land in Nyora are SGSC and Melbourne Water.

Given Nyora's relatively small size it is considered that SGSC could potentially manage development applications on a case by case basis without the implementation of flood related planning zones or overlays. However it is recommended that SGSC further consider the practical implementation and internal processes required to assess development applications in flood prone areas and the option of using overlays such as an SBO or LSIO.

Stormwater management for future development in Nyora

Existing natural values, future urban form and Nyora's vision (refer to **Section 3.1**) were used to inform the type and location of stormwater assets that were proposed for the SMP.

The long term plan (>20 years) for the management of stormwater flows in Nyora is summarised as follows:

- Construct piped systems with kerb and channel roads in the urban growth areas of precincts A, B, C, D and F, the commercial centre in precinct A and the industrial area on Yannathan Road.
- Maintain existing open swales to convey flow in the low density and rural living areas of precinct E, G and H.
- Designate waterway corridors for existing waterways where the GGEO shows the presence of the Giant Gippsland Earthworm.
- Implement on site detention in accordance with the IDM standards to retard minor development flows back to existing conditions in infill development precincts.
- End of line retarding basins to mitigate the 1% AEP peak flow back to existing conditions at town boundaries, prior to discharge to downstream properties.
- End of line sedimentation basins and bioretention basins and distributed street scale bioretention basins to manage stormwater quality to BPEM targets in greenfield development precincts and precincts A and B.
- On-lot WSUD within the low density and rural living precincts E, G, H.
- GPT's are proposed at 3 locations to intercept flows discharging from the commercial and industrial areas in precincts A and E respectively.

Costing

Concept level costing of stormwater assets at Nyora was undertaken using the development services scheme costing spreadsheet that is used by Melbourne Water for these projects.

The cost estimation included the following works:

- flood mitigation
- water quality
- future drainage works for properties greater than 0.4 hectares.

The total estimated cost of the stormwater works required to achieve the long term stormwater water management strategy at Nyora is $11,150,000.

The cost estimate excluded land acquisition for drainage assets. The total land acquisition required for drainage assets is approximately 10.7 hectares. The land requires includes some publically owned land (VicTrack) and is located across a range of zones according to the current planning zones.

Funding mechanisms

A number of mechanisms may be available to SGSC for the funding of works required to mitigate existing flooding, including Special Charge Schemes and Section 173 Agreements. Based on discussions with SGSC, the preferred mechanism for funding flood mitigation works in Nyora is by way of Section 173 agreements between SGSC and landowners proposing development. There are existing examples of Section 173 agreements in Nyora (refer to the Nyora Development Strategy for details) where a contribution to drainage improvement works is included in the agreement.

There are a number of mechanisms available to fund the stormwater infrastructure required to convey, treat and retard additional stormwater that results from development, including a Developer Contributions Plan (DCP) administered by SGSC and a Development Services Scheme (DSS) administered by Melbourne Water. The funding approach for major drainage works should be determined in discussions with Melbourne Water and may include a combined Section 173 agreement and DSS approach in areas such as precinct B where existing and greenfield development will occur (refer to **Section 13.5** for further discussion).

It is recommended that SGSC consider adopting the Nyora SMP as a framework for managing development and stormwater infrastructure into the future. Further discussion with Melbourne Water and GGE specialists is recommended as part of future development of the plan with respect to managing funding and the treatment and retardation approaches adopted in some locations.

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1. INTRODUCTION & BACKGROUND

1.1 Introduction

Nyora is located in South Gippsland, approximately 90 kilometres south east of Melbourne. The town is forecast to grow considerably as people are attracted to the affordable semi-rural lifestyle on offer and its relatively close proximity to Melbourne and other commercial centres. The Nyora Stormwater Management Plan (SMP) is a catchment scale stormwater infrastructure plan that was developed with and informed by the Nyora Development Strategy, prepared by Planisphere Pty Ltd. (Planisphere) on behalf of South Gippsland Shire Council (SGSC).

The Nyora Development Strategy outlines a strategic vision for managing development in Nyora over the next 20 years which includes the densification of existing development in some areas and the establishment of new development precincts in currently undeveloped areas. Eight (8) separate precincts with different existing and future development values cover Nyora. A description of the existing development and development values for each precinct is provided in the Nyora Development Strategy (Planisphere, 2016).

The increase in development density and coverage in Nyora will lead to an increase in stormwater runoff and a subsequent increase in pollutant wash-off. Without appropriate stormwater management it could also have detrimental effects on the receiving waterways. In setting the urban structure, it is critical that assets required for drainage purposes are determined early. This allows for the impacts from the increase of stormwater runoff arising from urbanisation to be mitigated and all new development to proceed without the risk of flooding the development site, without the risk of flooding neighbouring properties and without impacting on the natural environment, receiving waterways and ultimately, Western Port Bay.

The Nyora SMP provides an approach to managing stormwater in Nyora that meets appropriate standards for drainage, flood protection, water quality, waterway health and amenity. The infrastructure requirements identified in the SMP are costed to establish contributions under the Water Act 1989 that could be utilised by SGSC or the catchment management authority, Melbourne Water, to fund the implementation of the infrastructure. Engeny Water Management (Engeny) was engaged by Planisphere to prepare the Nyora SMP.

1.2 Supporting documents

The following reports and investigations have been undertaken for Nyora and were used to inform the SMP.

- Nyora Structure Plan (Planisphere, 2013)
- Nyora Structure Plan Submission (Beveridge Williams, 2011)

- development forecasts for Nyora (Nott and More, 2010)
- strategy and audit for social community infrastructure 2014 - 2029 (South Gippsland Shire Council)
- Flood Management Plan for South Gippsland Shire Council, Melbourne Water and West Gippsland CMA (prepared in collaboration, 2013).

Prior to this SMP Melbourne Water undertook investigations to inform the Draft Nyora Development Services Scheme (DSS) which was put on hold pending the outcome of a decision to provide a reticulated sewerage system to the town (refer to the Nyora Development Strategy, Planisphere 2016 for further details). The following documentation from the Draft DSS was provided by Melbourne Water and used to inform this study.

- Part A - Nyora Development Services Scheme Summary Report (Alluvium, 2009)
- Part B - Preliminary Environmental Assessment (DRAFT) Nyora Development Services Scheme (Alluvium, 2009)
- Nyora Development Services Scheme Water Quality Report (BMT WBM, 2009)

Additional background information is provided in the Drainage Investigation report presented in **Appendix A**.

2. PLAN PREPARATION METHODOLOGY

The following key steps were undertaken to prepare the Nyora SMP:

- review of background information
- drainage and existing flooding investigations (refer to the Drainage Investigation Report in **Appendix A**):
  - TUFLOW flood modelling the existing conditions 18% AEP and 1% AEP event
  - identification of existing flooding hotspots
  - stormwater issues and opportunities identification
- preliminary stormwater infrastructure delineation, including location of flood mitigation assets
- meetings with SGSC and Melbourne Water
- pipe sizing based on Rational Formula calculations to size works in accordance with IDM / Melbourne Water methods (refer to **Section 6**)
- identification of waterway protection corridors and constructed waterways (refer to **Section 7.3.3 and 7.3.4** respectively**)**
- MUSIC modelling to size treatment assets (refer to **Section 7.3.3**)
- plan costing using Melbourne Water's Development Services Scheme (DSS) costing spreadsheet (refer to **Section 11**).

3. OBJECTIVES AND VISION

3.1 Vision

The Nyora Development Strategy (Planisphere, 2016) describes Nyora's vision around community and open space, environment and water, economy and infrastructure and the movement network. **Figure 3.1** from the Nyora Development Strategy presents Nyora's vision in each of these areas.

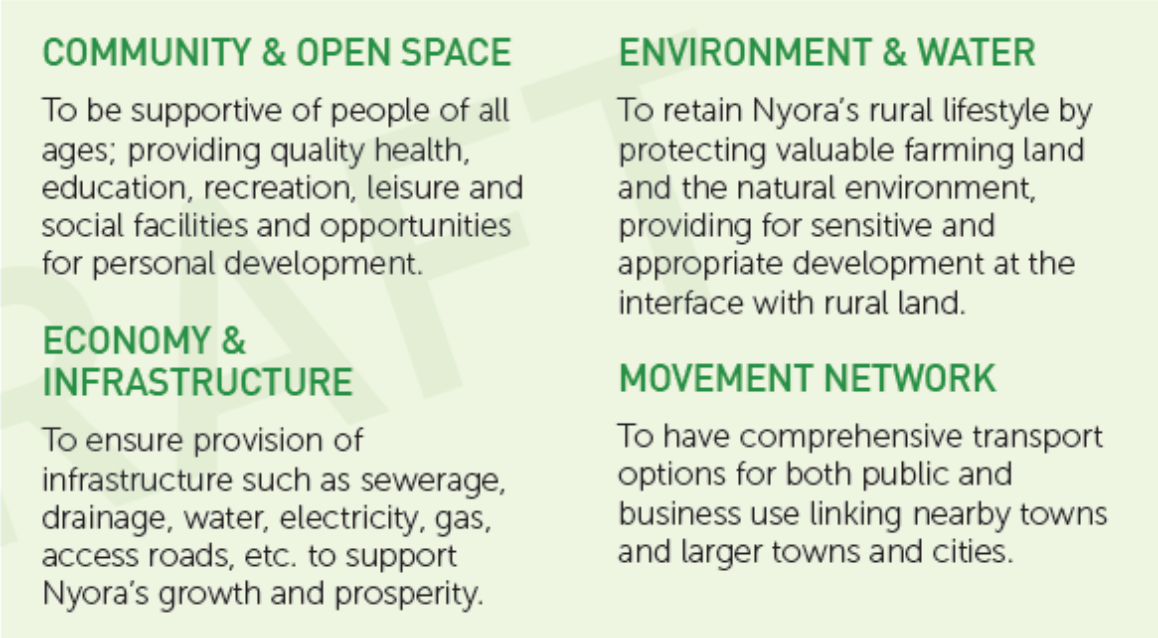

Figure 3.1 Nyora's vision (source: Nyora Development Strategy, Planisphere 2016)

The Nyora vision was used to guide the development of the SMP which was undertaken in collaboration with SCSC, Melbourne Water and the community.

3.2 Objectives

Key objectives of the Nyora SMP that were developed in consultation with SGSC, Melbourne Water and via community feedback through submissions through the Nyora Development Strategy include:

- Resolve existing flooding at hotspot locations.
- Treatment of all urban runoff derived from future development to Best Practice Environmental Management Guidelines (BPEMG) in terms of water quality. The urban runoff treatment objectives are[1]:

[1] Schedule F8 of the State Environment Protection Policy (Waters of Victoria) is for Waters of Western Port and Catchment and applies to the catchment areas in Nyora. The associated water quality targets are more stringent than the BPEMG targets. Discussion on the utilisation of the F8 objectives at Nyora is presented in **Section 8**.

- 80% removal of total suspended solids
- 45% removal of total phosphorous
- 45% removal of total nitrogen.

- Natural waterways are to be protected and retained.

- Giant Gippsland Earthworm habitat and significant vegetation is to be protected.

- A drainage outlet from the low point of all developable properties greater than 0.4 hectares is to be provided.

- Pipe capacities have been sized based on SGSC drainage design standards. SGSC adopts the Infrastructure Design Manual (IDM) which specifies the following standards:

- urban residential: 18% AEP2
- commercial centres: 10% AEP
- industrial areas: 10% AEP
- rural living: 18% AEP.

- Peak flow control to maintain existing conditions peak flows.

Previous work by or on behalf of Melbourne Water has identified that the receiving waterways are environmentally sensitive and may be prone to erosion. The SMP outlines a strategic direction for protecting the receiving waterways from changes to hydrological regimes that may occur as catchments are developed.

[2] Storm event terminology referenced by the Infrastructure Design Manual (v4.4.2) has been adopted for this report. Refer to the Drainage Investigations Report (Appendix A) for a definition of the AEP terminology and how it relates to ARI event description.

4. THE CATCHMENT

4.1 Description

Nyora is located amongst undulating hills in the fertile west Gippsland region and has an annual rainfall that exceeds 1000 mm. Eight (8) catchments were defined around existing waterways to include all the Nyora development precincts. The catchments discharge into three (3) major waterways, the Little Lang Lang River, Bass River and Adams Creek and include a total area of approximately 580 hectares. All of these waterways ultimately discharge into Western Port Bay. **Figure 4.1** shows the location of the Nyora catchments and identifies the receiving waterway for each catchment.

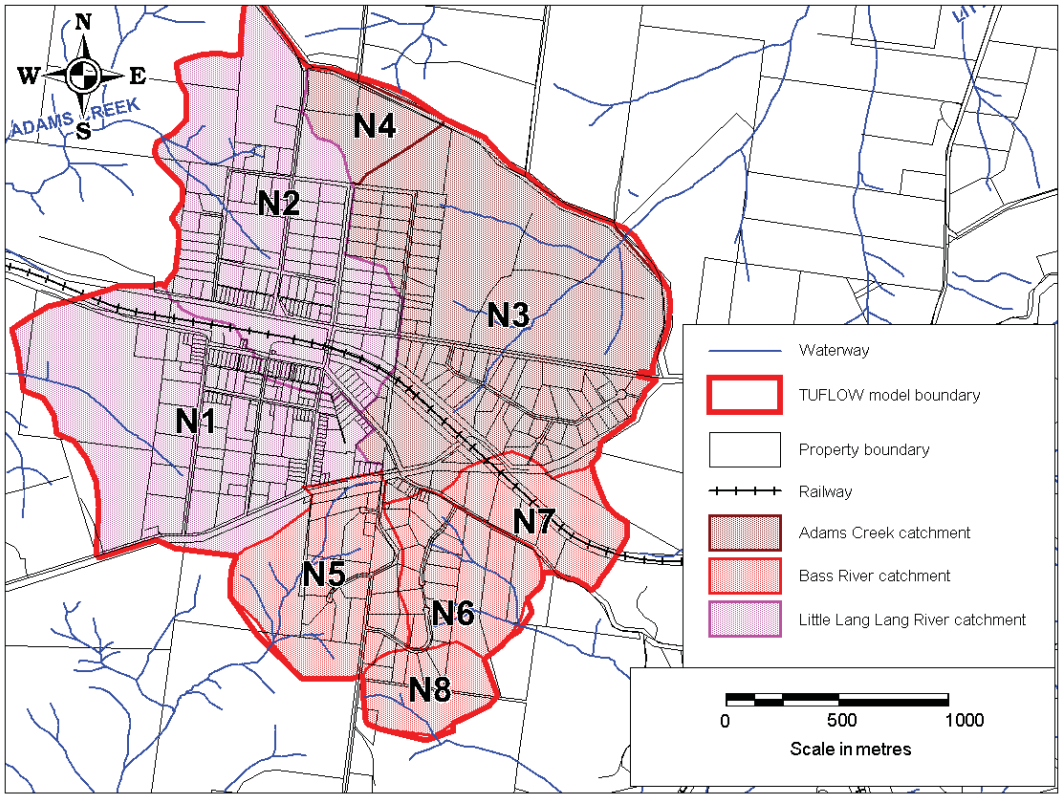

Figure 4.1 Nyora catchments

Catchment areas in Nyora vary between 172 hectares (N3) and 18 hectares (N4).

Section 2.2 of the Drainage Investigations Report (presented in **Appendix A**) provides a more comprehensive description of existing catchment conditions. Photographs from a site visit undertaken by Engeny, SGSC and other members of the Nyora development strategy team are presented in Section 3.2 of the Drainage Investigations Report.

The existing drainage network is comprised of open channels and underground pipe drainage. SGSC is responsible for the majority of the drainage network but VicTrack and VicRoads are responsible for culverts that cross the South Gippsland tourist railway and the Lang Lang - Poowong Road respectively.

4.2 Existing Planning Surface Water Planning Controls

4.2.1 Planning zones and overlays

Figure 4.2 shows the planning scheme at Nyora. At the time of reporting the land that is located between Glovers Road and Lang Lang - Poowong Road (precinct F) was being re-zoned from Farming Zone (FZ) to General Residential Zone 1 (GRZ1) as part of Planning Scheme Amendment C97.

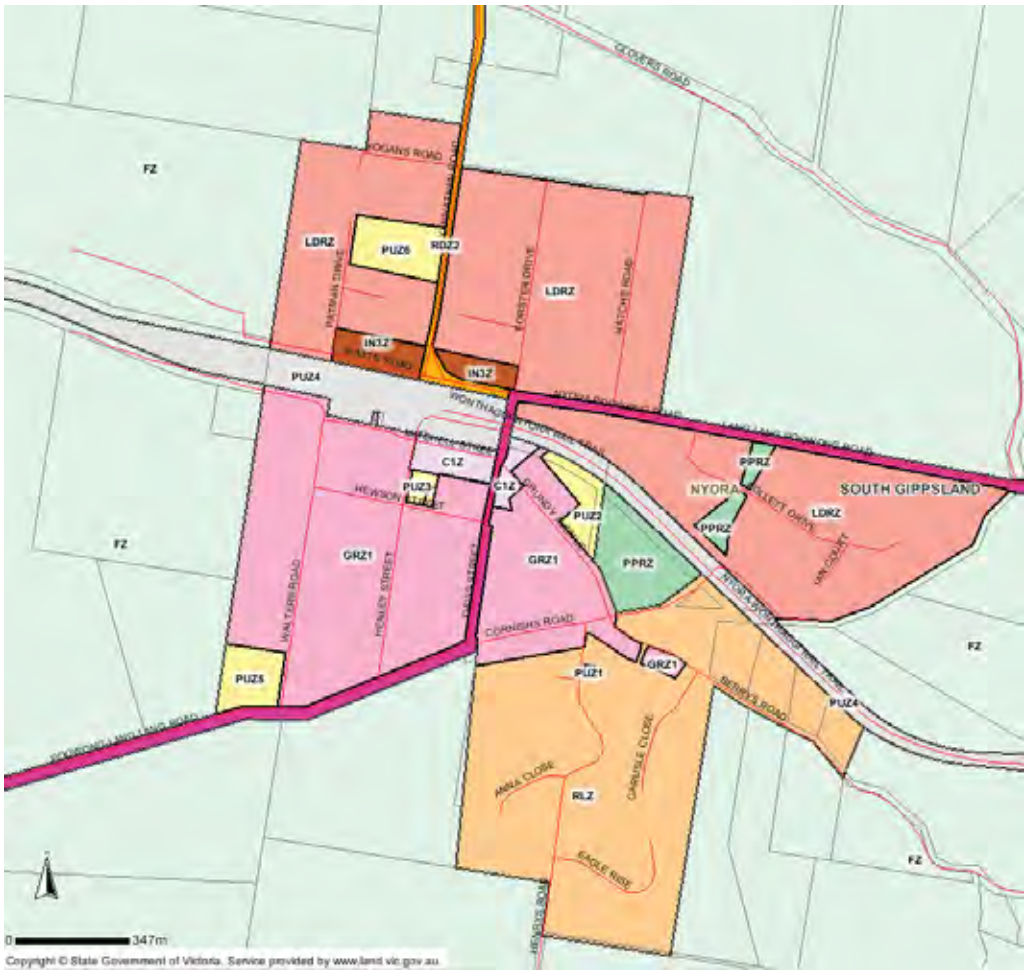

Figure 4.2 Nyora planning zones (source: Department of Land Water and Planning)

At Nyora there are currently no stormwater related planning zones or overlays. However land use and development in flood prone land that is located in Precinct H, between Cornishes Road and the Lang Lang - Poowong Road, is currently being controlled by a Public Parks and Recreation Zone (PPRZ).

The Giant Gippsland Earthworm Overlay (provisional at the time of reporting) and the existing vegetation layer (EVC100) do not designate land that is subject to flooding. However the habitat of Giant Gippsland Earthworm and remaining vegetation in Nyora correlate very closely with overland flow paths and waterways in many locations. A key objective of the SMP is to protect land covered by these overlays.

4.2.2 Development Plan Overlays

The following Development Plan Overlay's (DPO's) are active in Nyora:

- DPO5 was implemented following the C72 Planning Scheme Amendment which rezoned areas of Nyora located in Precinct A and B to GRZ1. The DPO5 considers that subdivision of the area "must plan for and contribute towards improved road, pedestrian and drainage infrastructure and avoid isolated, internally-focused developments, especially on larger lots."

- DPO10 applies to Precinct F (recently introduced by Amendment C97 to the South Gippsland Planning Scheme) which requires a stormwater and drainage management plan to be prepared with detailed costings of all stormwater drainage works to occur on public land or outside of the development plan area if directly related to the development. A section 173 agreement is in place with the land owners of Precinct F for the land owners to provide contributions of $9,000 per lot as development occurs. Some of these funds are expected to be used to address drainage issues in the area.

Development that is proposed in areas controlled by DPOs generally requires a planning permit which will not be issued unless the developer's plan for the development is submitted and approved by the relevant authorities.

5. FLOODING

5.1 Existing flooding

The Infrastructure Design Manual (IDM) has been adopted by SGSC and provides the current design standards for major and minor drainage systems according to the land-use type. The current minor system drainage standards that are applicable to development in Nyora are summarised below:

- urban residential: 18% AEP
- commercial centres: 10% AEP
- industrial areas: 10% AEP
- rural living: 18% AEP.

The major system standard is for the 1% AEP event.

Refer to Section 6 of the Drainage Investigations Report located in **Appendix A** for definitions of major and minor drainage systems.

An investigation of existing flooding in Nyora was undertaken using a 1D/2D hydrodynamic TUFLOW flood model with inflows generated using a RORB hydrological model. Modelling was undertaken for the 18% and 1% AEP events. Details of the flood modelling methodology are presented in the Drainage Investigations Report that is located in **Appendix A**.

The following summarises the findings of the investigation:

- Walters Road and Glovers Road are subject to nuisance flooding for the 18% AEP event and major flooding for the 1% AEP event.
- Two properties are at risk of significant flooding for the 18% AEP event. The properties are located on the corner of Henley and Hewson Street and on Yannathan Road respectively.
- Twenty eight (28) properties are at risk of significant flooding for the 1% AEP event.

The criteria used to determine major flooding at roads was a depth of ≥ 200 mm and velocity depth produce of ≥0.35 m^2/s.

The criteria used to determine major flooding at properties was where flood waters on main flow paths inundates building footprints to a depth of ≥ 100 mm which was assumed to be the point where above floor flooding occurs. As floor levels were not available for this study, the actual flooding that occurs at some properties may not be as significant as

this study reports. It is recommended that SGSC consider undertaking floor level survey to further inform the hydraulic modelling and associated flood risk within the catchment.

Further discussion on the existing conditions flood modelling is presented in the Drainage Investigations Report that is presented in **Appendix A**. Flood mitigation works that are proposed to mitigate existing flooding at Nyora are presented in **Section 5.3**.

5.2 Locations of increased risk of flooding from development

Increase in development density results in a higher fraction of the catchment being covered by surfaces that are impervious to rainfall and runoff. This in turn results in increased runoff volumes and peak flows. If appropriate flow management measures are not implemented to control flow changes that result from new development, then increased flooding can occur. Flow management measures include retardation basins to reduce peak flows and upgraded drainage systems to capture and convey development flows.

Flood modelling of the ultimate development conditions (1% AEP event) was undertaken using the TUFLOW hydraulic model to determine existing development that is most at risk from increased flooding from increased development densities **if** appropriate measures are **not** introduced to manage development flows. **Table 5.1** presents the average lot size and impervious fractions assumptions adopted for the developed conditions flood modelling. Impervious fraction assumptions for existing conditions are document in Table 2 of the Drainage Investigations Report in **Appendix A.**

Table 5.1 Developed conditions impervious fractions for GRZ1 and LDRZ zoned land

Precinct (ID)	Average Lot Size (m^2)	Impervious Fraction	Zone Code
A	667	0.55	GRZ1
B	750	0.5	GRZ1
C	750	0.5	GRZ1
D	750	0.5	GRZ1
E	2000	0.3	LDRZ
F	750	0.5	GRZ1
G	4000	0.25	LDRZ
H	10000	0.2	RZ

The results of the flood modelling show that the locations most at risk of increased flooding are those where there is:

- a large increase in development density
- existing development is already flood prone
- the existing development is located on flatter land and near embankments (formed by roads or other features) where a small increase in flow can result in a large increase in flood extent.

These locations include areas upstream of Walters Road and Glovers Road, the industrial area at Yannathan Road and properties subject to existing flooding on Hewson Street.

Appendix B presents the results of the TUFLOW modelling for ultimate development conditions with **no** flow management controls in place

5.3 Flood mitigation works

Priority flood mitigation works were identified at Yannathan Road and Henley Street where the flood modelling indicated that flooding to building floors is likely to occur for the 18% AEP event.

Flood mitigation works were also proposed for properties located on Hewson Street between Davis Street and Henley Street. At this location there is no allowance for an overland flow path to convey major flows and building floor levels are likely to be effected if development in the upstream precinct A catchment is initiated.

Flood mitigation works were also identified at Walters Road, Glovers Road and a property at the north end of Hatchs Road, which was identified as subject to flooding during the community consultation period. The flood modelling indicated that flooding at the rear of the property occurs at Hatchs Road but that it does not affect the building. This could be a function of the resolution of the model at this location and further investigation including discussion with the landowner regarding the location of problem flooding is recommended before mitigation works are undertaken. The mitigation works at Walters Road and Glovers Street will become more of a priority as local areas develop.

The major and minor drainage systems prepared for this SMP identifies an approach for mitigating 1% AEP flooding at existing properties and roads in other locations. It also identifies approaches to prevent flooding from increasing due to future development.

The flood mitigation works presented have been investigated using a high level assessment appropriate for this plan, based on available information. It is recommended that further investigation and design be undertaken prior to implementation of these works.

Table 5.2 presents a description of flood mitigation works at the various locations. **Figure 5.1** to **Figure 5.6** present concept sketches of the flood mitigation works.

Table 5.2 Description of flood mitigation works

Flooding Hotspot	Issue	Mitigation approach	Development context
1. Hewson Street between Davis Street and Henley street	No dedicated major drainage flow path exists. Flows in excess of the pipe drainage system are conveyed through residential development. Insufficient minor drainage system capacity (400 mm diameter pipe). 4 no. properties effected.	Construct 1% AEP capacity drainage pipe (1 no. 525 mm diameter) and inlets to replace existing pipe.	1% AEP capacity defined on ultimate development density. Works to be completed prior to construction occurring within the upstream Precinct A catchment. Consider funding mechanisms through the development of upstream catchment.
2. Henley and Hewson Street	Trapped low point upstream of residential property. Flows in excess of the pipe drainage system are conveyed through the property	Construct 1% AEP capacity drainage pipe (1 no. 375 mm diameter) and inlets to replace existing pipe.	1% AEP capacity defined on ultimate development density. Works to be completed prior to construction occurring within the upstream Precinct A catchment. Consider funding mechanisms through the development of upstream catchment.
3. Yannathan Road industrial properties	Insufficient minor drainage system capacity (open channel). No major drainage system pathway in the road reserve.	Regrade the Davis Street / Lang Lang – Poowong Road intersection to direct major flows from LDRZ east of Forster Drive into the VicTrack land north of the railway. Formalise the existing defacto storage on the VicTrack land located north of the railway by constructing a retarding basin and associated open drains and culverts. Construct pipe drainage to replace existing	The ultimate drainage solution could be rolled out as development occurs within the Industrial zone. Future development in the industrial area would be required to have onsite detention in accordance with the requirements presented in Table 7.4. An alternative solution to providing a major drainage flow path down Yannathan Road could include requiring future development to mitigate the 1% AEP event to the developed conditions 18% AEP event in order to reduce property discharges to a flow rate that can be contained within the

		open channel drainage on both sides of Yannathan Road. Pipe drainage sized to convey the 10% existing conditions AEP event on Yannathan Road. Lower Yannathan Road by approximately 200 mm and provide kerb and channel drainage for major event flows.	proposed pipe network.
4. Walters Road	Existing road cross drainage insufficient capacity	Excavate open channel to convey the 1% AEP event into the existing waterway. The open channel extends through the Giant Gippsland Earthworm Overlay. Construct 2 no. 1050 mm pipe culverts under Walters Road with inlet works. These culverts will form the outlets of the underground pipe drainage system for the fully developed Precinct A and B catchment.	An open channel is required downstream to outlet the culvert assuming the finished road surface remains at the existing road surface level. The size and location of the Walters Road culverts should be consistent with the future minor drainage system for the area.
5. Glovers Road	Existing road cross drainage insufficient capacity	Construct 2 no. 450 mm culverts to convey the existing conditions 10% AEP flow. Excavate existing channel upstream and downstream of crossing as required.	The impact of the Glovers Road flood mitigation works requires further consideration given the potential impact of the works on Giant Gippsland Earthworm habitat and significant vegetation.
6. Hatchs Road residential property	No formal major or minor drainage system.	Local terrain shaping and a 300 mm high bund to prevent overland flow entering the Hatchs Road property	Future minor and major drainage system is proposed as part of the stormwater management works plans for Precinct E and Precinct F that are presented in Section 0 and Section 9.6 respectively.

Figure 5.1 Hewson Street flood mitigation works

Figure 5.2 Henley and Hewson Street flood mitigation works

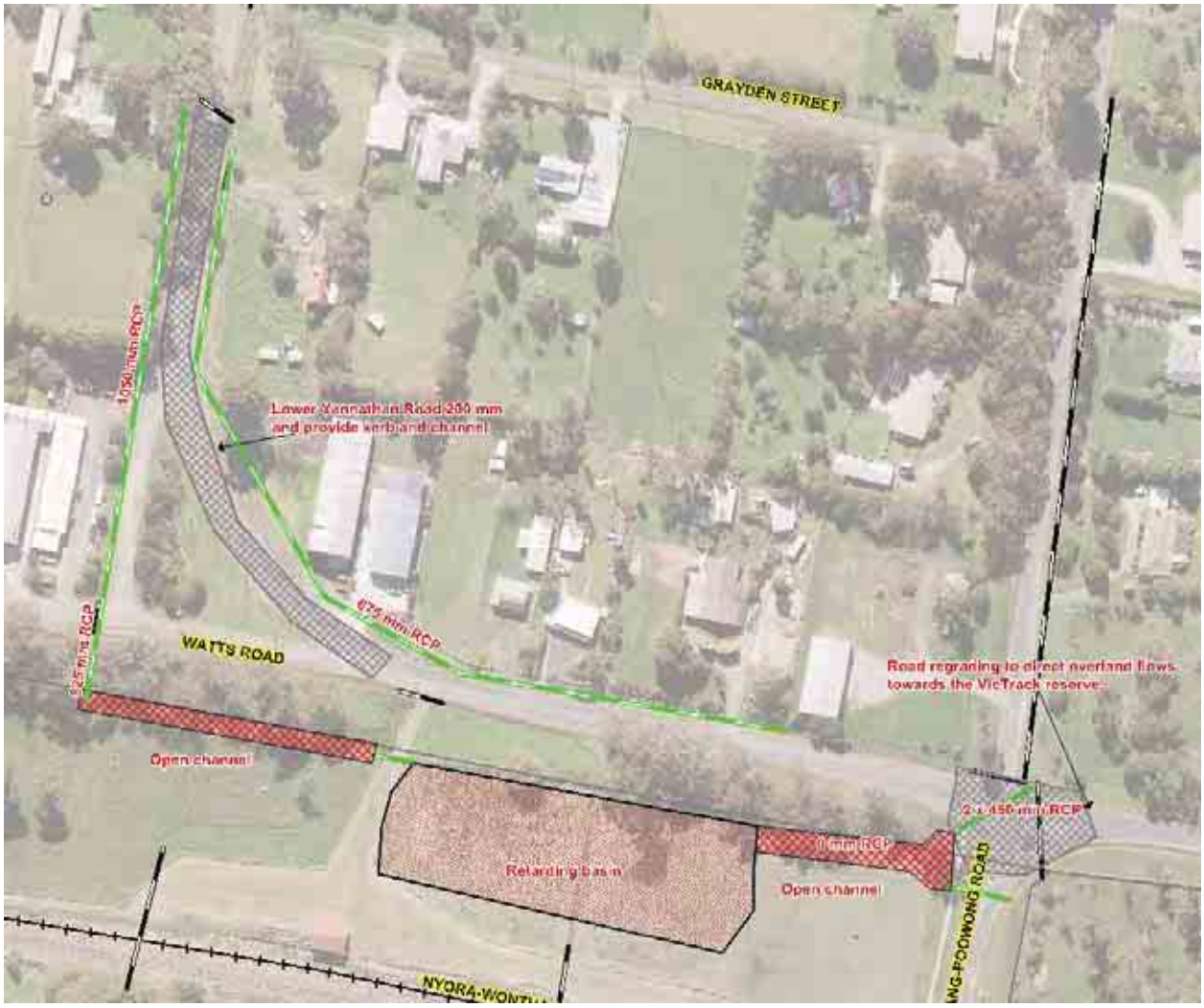

Figure 5.3 Yannathan Road flood mitigation works

Figure 5.4 Walter Street flood mitigation works

Figure 5.5 Glovers Road flood mitigation works

Figure 5.6 Hatchs Road flood mitigation works

6. ADMINISTRATION OF DEVELOPMENT IN FLOOD PRONE AREAS

6.1 Planning overlays

Planning zones are used to control land use as well as development. The Urban Flood Zone (UFZ) and flood overlays, the Special Building Overlay (SBO), Land Subject to Inundation Overlay (LSIO) and the Floodway Overlay (FO) designate land that is subject to flooding and provide statutory authorities with a means for regulating or prohibiting development within a hazardous area under Section 62(e) of the Planning and Environment Act 1987. The statutory authorities responsible for collecting flood information and managing development in flood prone land in Nyora are SGSC and Melbourne Water.

A planning scheme amendment is required to incorporate a flooding overlay or zone into the planning scheme, which can be an arduous and expensive process. The decision is sometimes made to avoid implementing a flooding overlay, such as in circumstances where the proposed planning scheme is a temporary measure that will be removed once flood mitigation works are implemented or where there are existing zones or overlays that can be used to manage development appropriately. Further discussion on the application of flood related planning zones and overlays including implementation examples can be found in *Planning Practice Note 12: Applying the Flood Provisions in Planning Schemes, a guide for Councils (June 2015).*

The TUFLOW flood modelling undertaken for the existing conditions 1% AEP event (refer to **Appendix A** for details) shows that there are a number of overland flow paths where SGSC could consider implementing planning scheme controls such as the SBO, LSIO or UFZ in Nyora. In many locations the overland flow paths can be incorporated into the development precincts as part of future major and minor drainage systems or as part of designated waterway corridors. However in some locations existing flooding will not be resolved as part of future development or flood mitigation works, such as behind the railway embankment and major road embankments.

Given Nyora's relatively small size it is considered that SGSC could potentially manage development applications on a case by case basis without the implementation of flood related planning zones or overlays. This approach is understood to be SGSC's preference and further discussion on how this might be undertaken on a zone by zone basis is provided in **Section 6.2**. However it is recommended that SGSC further consider the practical implementation and internal processes required to assess development applications in flood prone areas and the option of using overlays such as an SBO or LSIO.

6.2 Planning approvals

6.2.1 General Residential Zones (GRZ)

An Outline Development Plan (ODP) includes a stormwater and drainage management plan and is a requirement of the IDM (and therefore SGSC) where land is subject to a Development Planning Overlay (DPO). Existing DPO's (DPO5 and DPO10) cover areas in Nyora that are currently zoned or currently being re-zoned as GRZ1, including those located within Precinct A, B and F (refer to **Section 4.2.2** for more information).

The information required as part of an ODP submission is given in Section 4.3 of the IDM (v4.4.2). It is recommended that the flood modelling undertaken for this SMP be used by SGSC to assess ODP's and establish minimum requirements for overland flow paths, floor levels and building layouts.

6.2.2 Other Zones

Land zoned Low Density Residential (LDRZ) and Rural Living (RLZ) cover large areas of Nyora, particularly to the north and south east of the town centre. In both zones the landowner requires a permit for subdivision and the construction of a building of >100 square metres.

Land zoned Industrial Zone 3 (IN3Z) is located on the Lang Lang - Poowong Road north of the town centre. A landowner requires a permit for subdivision and for construction (with some exceptions).

Land zoned C1Z is located in the Nyora town centre. A landowner requires a permit for subdivision and for construction of a building.

It is recommended that SGSC consider adopting the flood modelling undertaken for this SMP as part of the permit assessment process for any proposed subdivisions and buildings in these zones to ensure that the proposed development does not result in adverse flooding to neighbouring properties and to ensure appropriate offsets and floor levels are applied.

7. STORMWATER QUANTITY

7.1 Guiding principles

Existing natural values, future urban form and Nyora's vision (refer to **Section 3.1**) were used to inform the type and location of stormwater assets that were proposed for the SMP.

The Giant Gippsland Earthworm is a federally protected species and its location is identified by the provisional Giant Gippsland Earthworm Overlay (ESO9 C107). Works in areas covered by the Giant Gippsland Earthworm Overlay (GGEO) were avoided where possible and retardation solutions such as on-site detention proposed to minimise development changes to the hydrological regime that could also affect the Earthworm. The proposed drainage layout also considered existing stands of existing vegetation, which were avoided where possible.

The drainage system at Nyora should be designed to ensure no urban property flooding occurs for events up to the 1% AEP and stormwater runoff can be safely conveyed through the development to the receiving waterway. To achieve this, a minor / major drainage system philosophy is proposed. This approach is outlined in Chapter 14 of Australian Rainfall and Runoff – Flood Analysis and Design 2001. The principals of major and minor drainage systems are discussed further in the Drainage Investigation Report presented in **Appendix A**.

The following guidelines were used to inform the development of the Nyora stormwater quantity plan:

- Waterway Corridors in Greenfield Development Guidelines (Melbourne Water, 2013)
- Constructed Waterways in Urban Development Guidelines (Melbourne Water, 2009)
- Principles for Provision of Waterway and Drainage Services for Urban Growth (Melbourne Water, 2007)
- Infrastructure Design Manual (v4.4.2).

7.2 Nyora stormwater quantity plan

The long term plan (>20 years) for the management of stormwater flows in Nyora is summarised as follows:

- Construct piped systems with kerb and channel roads in the urban growth areas of precincts A, B, C, F and D, the commercial centre in precinct A and the industrial area on Yannathan Road.

- Maintain existing open swales to convey flow in the low density and rural living areas of precinct E, G and H.
- Designate waterway corridors for existing waterways where the proposed Giant Gippsland Earthworm Overlay (GGEO) shows Giant Gippsland Earthworm habitat.
- Implement on site detention in accordance with the IDM standards to retard minor development flows back to existing conditions in infill development precincts.
- End of line retarding basins to mitigate the 1% AEP peak flow back to existing conditions at town boundaries, prior to discharge to downstream properties.

7.3 Methodology

7.3.1 Pipe drainage

Stormwater pipes were sized for fully developed conditions using the lot densities presented in **Section 5.2** and in accordance with SGSC underground pipe system design standards from the IDM (presented in **Section 3.2**).

Stormwater pipes were sized using Melbourne Water's DSS costing spreadsheet.

7.3.2 Major flow paths (roads)

Indicative locations for proposed roads to convey major flow paths were determined for precinct B and presented on **Figure 7.1.**

The location of roads in greenfield precincts (C,D and F) should be determined by the developer (in accordance with the methodology described in the IDM). No roads were required by the Nyora Development Strategy in other precincts.

An urban access road cross section with a SM2 kerb and minimum 20 metre road reserve width was used to check the flow capacity of the proposed road reserves against the gap flow between the 18% AEP pipe system capacity and the 1% AEP event.

The edge of the road reserve was assumed to be 150 mm higher than the top of kerb irrespective of the width of the reserve.

Table 7.1 presents the road locations, flows for the pipe system and roads based on the Rational Method and a minimum road reserve width required to convey the flow. Final road designs and checks for safely conveying overland flow will need to be done at the subdivision design stage.

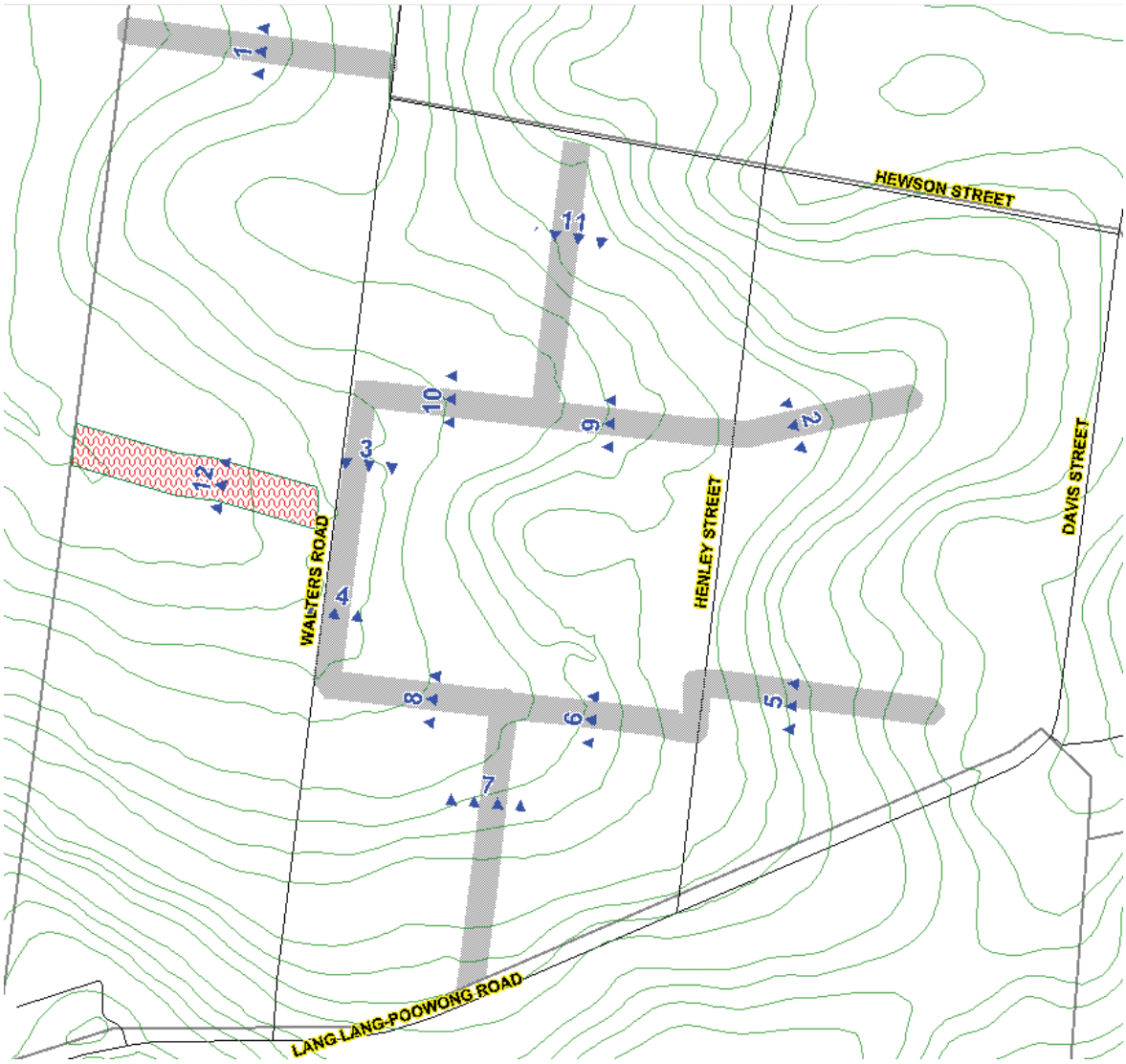

Figure 7.1 Precinct B major drainage system

The flow major flow path in the area of flow locations 8, 6 and 7 passes through vegetation that SGSC may wish to retain. An alternative approach to constructing a road through this area is to allow the existing overland flow path to remain through the vegetated area with the major and minor road and pipe system positioned to capture flow as it leaves the vegetated area. Further hydraulic analysis is required to confirm the feasibility of this option.

Table 7.1 Major flow paths in roads

Road (location)	Pipe ID	1% AEP developed conditions flow (m^3/s)	18% AEP developed conditions pipe flow (m^3/s)	Gap flow in the road reserve (m^3/s)	Road reserve width (m)
1	B41-B42	1.2	0.5	0.7	20
2	B11-B12	2.8	1.2	1.7	20
3	B15-B16	5.0	2.0	2.9	30
4	B33-B34	4.8	2.0	2.8	30
5	B29-B30	0.9	0.4	0.6	20
6	B31-B32	1.8	0.7	1.0	20
7	B37-B32	0.2	0.1	0.1	20
8	B32-B33	4.1	1.7	2.4	25
9	B13-B14	3.6	1.5	2.1	20
10	B14-B15	4.4	1.8	2.6	25
11	B27-B14	0.3	0.1	0.2	20
12	WW1-WW2	8.1	-	-	

7.3.3 Waterway corridors

Waterway corridors were used to identify development limits adjacent to existing waterways that are declared under Section 188 of the Water Act 1989 and should be preserved an existing state due to environmental considerations. The preservation of existing waterway corridors in Nyora was determined on a precinct by precinct basis:

- In greenfield precincts (e.g. C and F) where designated waterways exist, waterway corridors were generally proposed instead of constructed waterways for the primary reason of minimising impact to the Giant Gippsland Earthworm habitat, which covers the majority of waterways in Nyora.
- In precincts with existing development the Giant Gippsland Earthworm habitat was generally less prevalent and additional consideration was given to public amenity, economic factors and stormwater requirements.

Existing designated waterways within Nyora either have a Strahler value of 1 or 2 based on the methodology for classifying stream type that is described in the Waterway Corridors in Greenfield Development Guidelines (Melbourne Water, 2013). In accordance with the guidelines, waterway corridors in Nyora are generally proposed to have a width of 45 metres, which is based on a 5 metre top of bank width between reference points (as shown in **Figure 7.2)** and a 20 metre setback distance from these reference points. The waterway corridor in Precinct C is a 60 metre width which extends from the constructed open waterway and is positioned where it is for the purposes of maintaining Giant Gippsland Earthworm habitat. Melbourne Water has indicated that a 60 metre waterway corridor width may be required in other locations in Nyora to preserve existing environmental values. It is therefore recommended that further discussion be had with Melbourne Water to determine the appropriate width of waterway corridors around Nyora.

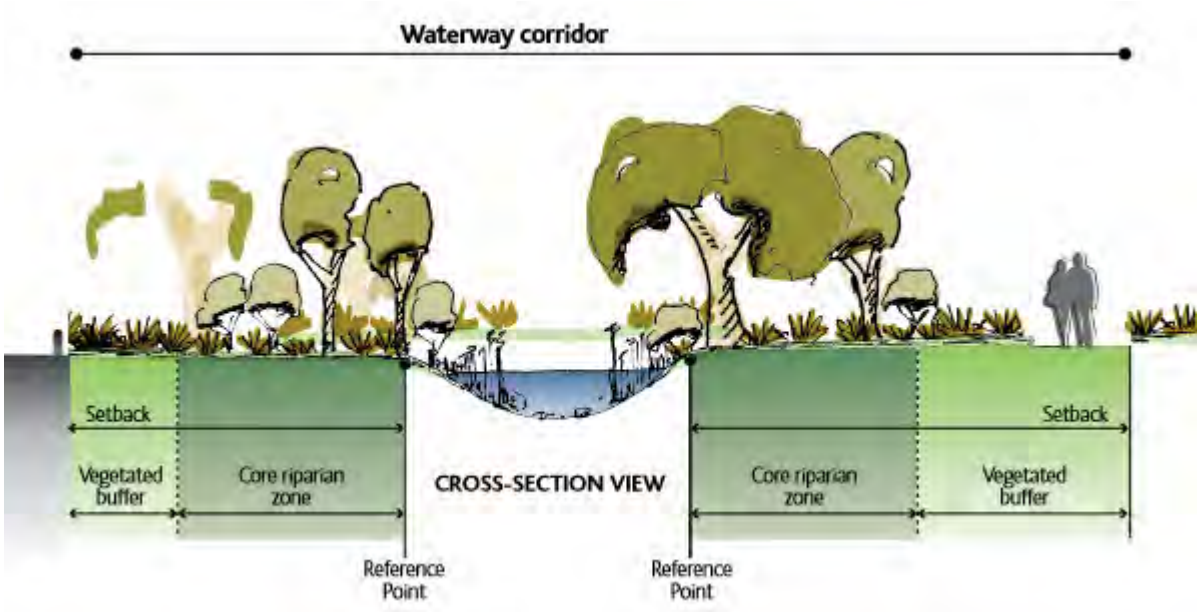

Figure 7.2 Waterway Corridor (Source: Melbourne Water's Waterway Corridors Guidelines, 2013)

7.3.4 Constructed waterways

Constructed waterways were proposed where:

- development flows are discharged to a waterway without mitigation
- waterway works are required to mitigate existing flooding.

Two (2) constructed waterways are proposed at Nyora. These are located west of Walters Road (Precinct B and C) and downstream of an existing dam located in Precinct F which will be removed when development occurs.

Figure 7.3 shows a typical cross section adopted by Melbourne Water for constructed waterways.

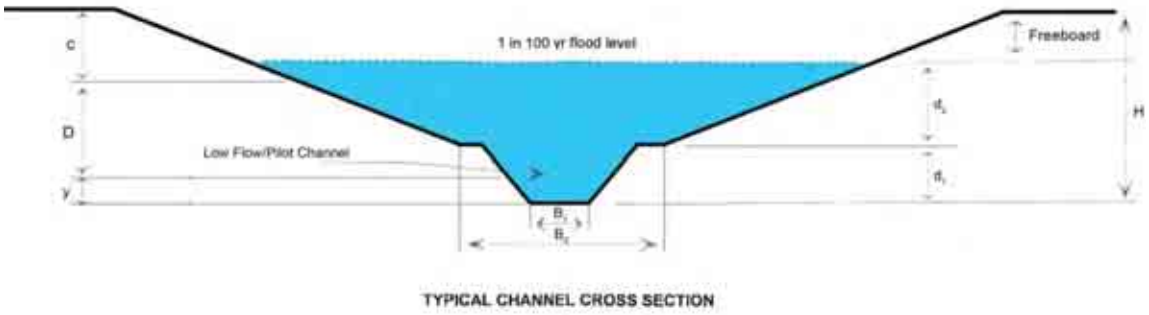

Figure 7.3 Constructed waterway typical cross section

Constructed waterways were sized to convey the unmitigated developed conditions 1% AEP event.

Table 7.2 presents the constructed waterway dimensions.

Table 7.2 Constructed waterways

Precinct	Pipe ID	1% AEP developed conditions flow (m^3/s)	Low flow channel base width	Min depth (including 600 mm freeboard)	Top width (including 600 mm freeboard)	Total Corridor Width including setbacks (m)
C	WW1-WW2	8.8	1.5	1.4	27.1	60
F	WW4-WW5	5.0	1	1.4	26.6	60

Both constructed waterways will require works within the GGEO and it is recommended that further investigations be undertaken to determine whether alternative works can be undertaken to reduce the impact to the Giant Gippsland Earthworm.

As part of the development of this SMP with the Nyora Development Strategy (Planisphere, 2016), the option of a possible green East-West connection was identified for Precinct B. The provision of a constructed waterway at this location was not investigated but is considered to be a potentially viable alternative to the pipes and road approach documented in this SMP.

7.3.5 End of line retardation basins

End of line retarding basins were proposed to mitigate the peak 1% AEP development conditions flow back to existing conditions at the town boundaries.

The location and sizing of retarding basins was based on the following assumptions:

- Retarding basins were located at the downstream boundaries of precincts that discharge outside the town boundaries.

- Retarding basins were located at the downstream boundaries of precincts that discharge to other precincts (within the town boundaries) where retarding basins could not be located downstream. For example no retarding basins were proposed on Adam's Creek in precinct E to avoid impact to the existing environmental values of that waterway.

- Where possible, a single retarding basin was preferred over multiple retarding basins on the same waterway. For example a single retarding basin located in precinct C that captures flows from precinct B and C was adopted over two retarding basins that capture flows from precinct B and C separately.

- Concept retarding basins sizing was based on the attenuation of development conditions 1% AEP flows back to existing conditions 1% AEP flows. Based on advice from Melbourne Water, existing conditions flows were estimated using TUFLOW assuming existing farm dams were full at the start of the design storm event.

- Retarding basins were sized using Boyd's method. The peak existing conditions flow at each retarding basin was established using the Rational Method or using hydrographs extracted from the existing conditions TUFLOW results. The results are considered to be suitable for strategy level sizing estimates however it is recommended that the sizes of the retarding basins be confirmed at later stages of design.

- Concept retarding basins were modelled to be at least partially in-cut in order to minimise the associated dam-break hazard. However retarding basins that were located in areas covered by the provisional GGEO were assumed to require headwalls rather than being in-cut. It is recommended that SGSC undertake further consultation with Melbourne Water to determine whether this design approach is appropriate and whether there are any special design approaches that could be adopted to reduce the impact of proposed retarding basins to existing GGE populations.

Table 7.3 presents the retarding basin concept designs for each precinct.

Table 7.3 Retarding basin concept designs by precinct.

Precinct	Retarding Basin	Catchment (ha)	Invert (m AHD)	Design Storage Volume (m^3)	Peak outflow (m^3/s)
A	RB8	35.9	118.3	3650	2.14
B	-	-	-	-	-
C	RB1	126.3	98.00	19000	5.48
C	RB2	6.5	105.00	800	0.45
C	RB3	0.8	105.00	80	0.07
D	RB4	8.2	113.00	660	0.81
D	RB7	4.8	129.00	360	0.49
D	RB10	2.5	131.00	230	0.26
E	-	-	-	-	-
F	RB5	5.8	114.20	370	0.58
F	RB6	5.6	114.00	3800	0.59
F	RB9	164.7	101.00	23500	6.62
G	-	-	-	-	-
H	-	-	-	-	-

The design of retarding basins in Nyora should be undertaken in accordance with the design standards described in the IDM.

Retarding basins were considered to be the most cost effective approach for mitigating catchment flows up to the 1% AEP from a construction and maintenance perspective.

The VicTrack land located north of the railway currently acts as a defacto retarding basin by providing storage for flood waters. The land is undulating and poorly drained and areas are understood to remain inundated for long periods after a rainfall event. The formalisation of this land into a shallow dry retarding basin, in combination with the associated pipe drainage system upgrades on Yannathan Road, is intended to mitigate flooding at the nearby industrial properties.

7.3.6 On site detention

On site detention (OSD) is a lot scale approach used to mitigate increases to catchment flows due to development. The objectives of OSD typically relate to preserving the capacity of the existing minor drainage system by mitigating against increases to flows from more frequent events (the 18% AEP for residential developments) that would otherwise occur from a development. OSD is often required by drainage authorities where incremental development occurs on a small spatial scale, such as infill development, where it is not practical to construct an end of line retarding basin. Where development occurs on a larger scale such as in greenfield developments an end of line retardation approach is typically preferred as this is the most cost effective approach and provides flood mitigation for events up to the 1% AEP.

The main considerations for the implementation of OSD at Nyora are:

- the nature of the development (infill areas versus greenfield)
- the capacity of the existing drainage system and existing flooding
- the type of development (e.g. Commercial versus residential)
- environmental sensitivity of the receiving waterways
- inspection, maintenance and management.

Table 7.4 presents the recommended on-site detention approach for Nyora based on precinct and land-use type. The storage volume requirements and allowable discharges were adopted from Table 13 of the IDM (v4.4.2).

On site detention can often be incorporated into rainwater tanks. By combining rainwater tanks and on site detention other benefits can be achieved, including:

- reduction in potable water demand
- reduction in pollutant load discharged to receiving waters
- reduction in the volume of water discharged to receiving waters, which can partly offset the overall increase in runoff caused by urban development.

Table 7.4 On-site detention requirements for new development by precinct and land-use type

Precinct	Land use type (Planning Zone)	Storage volume per m^2 of development	Allowable discharge (L/sec/ha)
A	GRZ1	9	37
A	C1Z	11	64
B	GRZ1	9	37
C	GRZ1	NO OSD	NO OSD
D	GRZ1	NO OSD	NO OSD
E	LDRZ	9	37
E	IN3Z	13	30
F	GRZ1	NO OSD	NO OSD
G	LDRZ	9	37
H	RLZ	9	37

7.3.7 Private dams

As per the advice from Melbourne Water, all existing dams that are located within properties proposed for development are to be decommissioned and demolished.

8. STORMWATER QUALITY

8.1 Water quality objectives

Urbanisation leads to an increase in stormwater runoff and a subsequent increase in pollutant wash-off. This has detrimental effects on the receiving waterways and ultimately Western Port Bay. Melbourne Water and Council are required to protect and enhance the water quality of waterways in accordance with clauses contained within the State Environment Protection Policy (Waters of Victoria) SEPP and the Victorian Planning Provisions (VPP).

The State Environment Protection Policy (Waters of Victoria) defines the required water quality conditions for urban waterways. The aim of stormwater quality treatment is to reduce typical pollutant loads from urban areas to Best Practice Environmental Management (BPEM) as defined by the targets presented in **Table 8.1**.

Table 8.1 BPEM stormwater quality targets

Pollutant	Performance Objective
Total Suspended Solids (TSS)	80% reduction from typical urban load
Total Phosphorous (TP)	45% reduction from typical urban load
Total Nitrogen (TN)	45% reduction from typical urban load
Gross Pollutants (GP)	70% reduction from typical urban load

Source: Urban Stormwater: Best Practice Environmental Management Guidelines – Victorian Stormwater Committee, 1999.

Schedule F8 of the State Environment Protection Policy (Waters of Victoria) is for Waters of Western Port and Catchment and applies to the catchment areas in Nyora. The schedule recognises that Western Port and its associated catchment is more ecologically sensitive than other waters of Victoria and therefore requires an increased level of protection. **Table 8.2** presents the recommended water quality targets to achieve the environmental indicators listed in the SEPP Schedule F8.

Table 8.2 SEPP Schedule F8 Pollutant Reduction Targets for Western Port

Pollutant	Performance Objective
Total Suspended Solids (TSS)	93% reduction from typical urban load
Total Phosphorous (TP)	66% reduction from typical urban load
Total Nitrogen (TN)	63% reduction from typical urban load

The best practice water quality targets presented in **Table 8.1** are a requirement for new residential development under clause 56.07 of the Victorian Planning Provisions (VPP) and are enforced by Melbourne Water and SGSC. The provision of water quality treatment for commercial and industrial development is not currently legislated for however it is common practice by Melbourne Water and Local governments to require that these development types meet water quality treatment standards.

The BPEM stormwater quality targets (**Table 8.1**) have been adopted for the purposes of sizing all water quality infrastructure at Nyora. Our understanding is that the Schedule F8 targets are not legally binding and have not been adopted to size stormwater quality infrastructure for this plan. They are also very difficult to achieve using current best practice water sensitive design methods. However it is recommended that SGSC consider in consultation with Melbourne Water whether the more stringent Schedule F8 targets should be adopted at Nyora.

8.2 Water quality plan

The stormwater quality plan at Nyora was developed for all precincts. In determining the appropriate water quality treatment for a given location, consideration was given to a number of factors, including:

- the type of development and the pollutants it was likely to generate - for example commercial areas are likely to generate more gross pollutants than residential areas
- the nature of the terrain and the constructability of treatment assets
- the size and nature of the development process that is likely to occur, for example:
  - End of line treatment assets were generally considered to be more appropriate for large greenfield developments where existing development does not restrict the construction of these typically larger assets.
  - On-lot treatment was proposed where subdivision is likely to occur on a lot by lot basis by the existing owner of the property, such as precincts E, G and H.
  - Street scale distributed water quality treatment was proposed for the future higher density residential and commercial areas in precincts A and B. In these locations, significant re-shaping of the street scape will be required to transition to the future urban form. This provides opportunities to construct water quality treatment assets that also add value to the urban landscape.
- environmental considerations, particularly the Giant Gippsland Earthworm - treatment assets were located to avoid impacting the Giant Gippsland Earthworm (as identified by the proposed Environmental Significance Overlay) where possible.

8.3 Treatment devices

8.3.1 Treatment summary by precinct

Table 8.3 summarises the stormwater treatment devices proposed for Nyora.

Table 8.3 Treatment devices

Scale	Treatment device	Precinct
On-lot	Bio-retention basins, vegetated swales, buffer strips, rainwater tanks	E, G and H
Street	Bioretention basins / tree pits	A and B. Some areas of C, D and F
	Gross Pollutant Trap (litter only)	A
	Gross Pollutant Trap (litter and sediment)	E (industrial area)
End of line (offline from waterways)	Sedimentation basins	B, C, D and F
	Bioretention basins	C, D and F

End of line wetlands located offline from waterways were considered where catchment areas were considered large enough for a sustainable wetland to be implemented. These locations were Precinct C (within RB1) and Precinct F (RB9). Wetlands were ultimately not adopted at these locations as it was considered that the earthworks required would be likely to impact negatively on the Giant Gippsland Earthworm. Given offline wetlands in these locations could reduce the maintenance burden associated with the distributed network of sedimentation and bioretention basins that is currently proposed, it is recommended that further investigation into the viability of constructing wetlands is undertaken in consultation with the river health team at Melbourne Water and Giant Gippsland Earthworm specialists.

8.3.2 Treatment devices

Bioretention basins

On-lot, street scale and end of line bioretention basins have been proposed for the Nyora SMP. Bioretention basins consist of rock mulch and vegetation, a filtration layer, a submerged zone and a drainage layer, similar to that depicted in **Figure 8.1**.

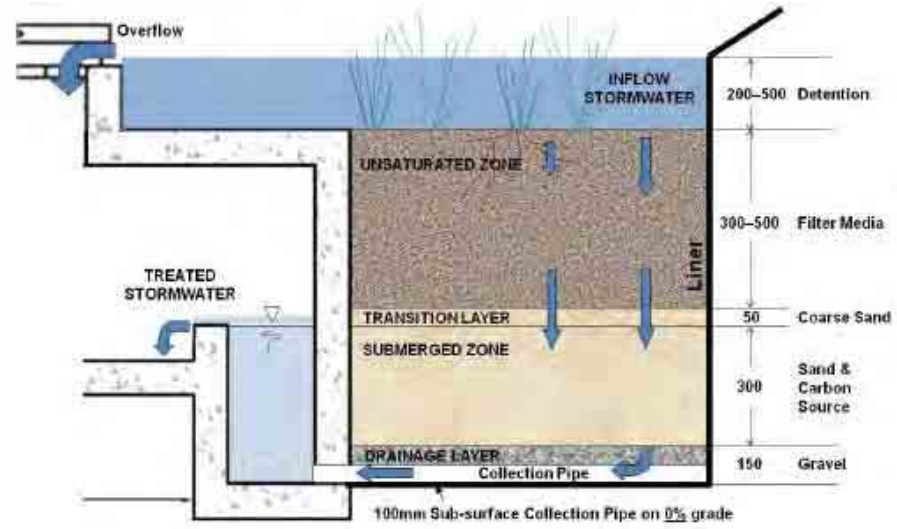

Figure 8.1 Cross section of bioretention basin (Source: Stormwater Biofiltration Systems Adoption Guidelines, FAWB, 2009)

Bioretention basins can be integrated within the urban landscape and planted with vegetation that provides effective vegetation removal (as shown in **Figure 8.2**) or grassed with turf. Recent cooperative research undertaken by the City of Manningham, Melbourne Water and the CRC for Water Sensitive Cities into Zero Additional Maintenance Water Sensitive Urban Design (ZAM-WSUD) is presented in ZAM-WSUD Handbook that provides design and construction advice for the implementation of grassed and planted biofiltration systems that require no additional maintenance relative to what would ordinarily be required by a grassed nature strip or planted area. It is recommended that ZAM-WSUD designs be considered for implementation of street scale WSUD in Nyora.

Figure 8.2 Street scale bioretention basin

Sedimentation basins

End of line sedimentation basins have been proposed at a number of locations by the Nyora SMP. Sedimentation basins are basins specifically designed to remove medium to coarse sized suspended solids via a settling process. Sedimentation basins use temporary detention to promote sediment settling and reduction of velocities. These basins can either be permanent or used as a temporary measure during construction.

Figure 8.3 Sedimentation basin (Source: Chapter 4 Urban Stormwater: Best Practice Environmental Management Guidelines. CSIRO, 2006)

Gross Pollutant Traps

Gross pollutant traps (GPT) are used as a primary treatment measure to remove litter, debris and coarse sediments. Gross pollutant traps designed specifically to remove litter have been proposed on the major drainage systems downstream of the commercial centre in Precinct A. A gross pollutant trap that captures litter and sediment has been located downstream of the industrial area in precinct E.

GPT's are advantageous in that they can be located underground in the form of a large drainage pit. They do, however, only remove a small portion of total phosphorous and total nitrogen from the runoff, only that which is attached to the coarse sediments being retained in the trap.

GPT's require regular manual maintenance to clean out the litter and debris, but are an ideal treatment for removal of unsightly gross pollutants as they have a very small footprint.

8.4 Water quality modelling

Water quality modelling was undertaken in MUSIC (version 6.1.).

Water quality models were developed to represent the fully developed catchment for the purposes of assessing pollutant reduction requirements and the size and distribution of water quality treatment assets required.

Figure 8.4 and **Figure 8.5** present screen shots from two of the MUSIC models created to assess the treatment performance of proposed water quality assets.

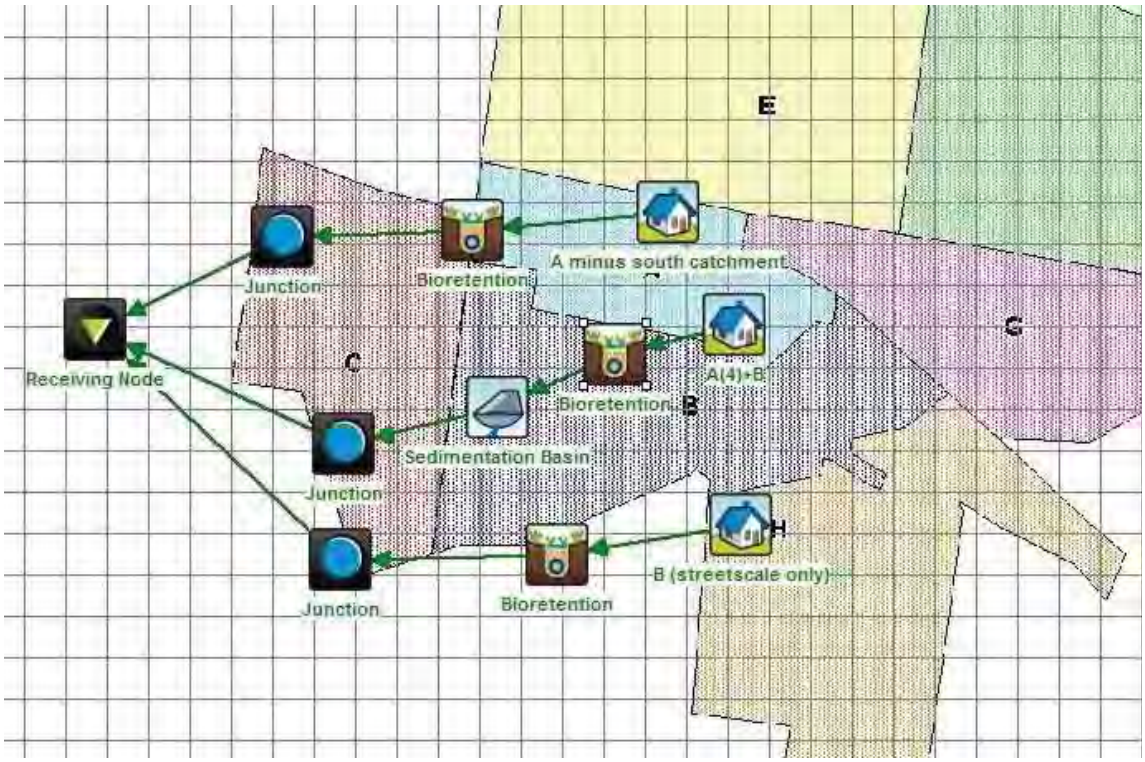

Figure 8.4 Street scale and end of line water quality modelling for precincts A and B

Figure 8.5 Street scale and end of line water quality modelling for precinct F

8.5 Pollutant generation

Table 8.4 presents the modelled volumes of key indicator pollutants, Total Phosphorus (TP), Total Nitrogen (TN), Total Suspended Solids (TSS) and Gross Pollutants (GP) generated in the fully developed catchment.

Table 8.4 Annual pollutant generation for the fully developed catchment

Precinct	Area (ha)	Developed Conditions FI	Flow (ML/yr)	TSS (kg/yr)	TP (kg/yr)	TN (kg/yr)	GP (kg/yr)
A	33.2	0.48	170	30700	64.7	482	5730
B	66.5	0.48	349	63800	134	977	12100
C	52.5	0.5	283	52100	110	803	9970
D	15.5	0.5	83.6	15600	32.6	235	2940
E	82.4	0.34	378	65900	141	1050	11300
F	114.3	0.5	617	114000	241	1740	21700
G	49.2	0.31	219	37400	80.7	606	6190
H	70.1	0.21	282	45900	103	770	6210

Table 8.5 presents the removal volumes for the key indicator pollutants in accordance with the BPEM objectives that are presented in **Table 8.1**. The treatment plan for Nyora achieves these removal volumes.

Table 8.5 Removal volumes required to meet BPEM water quality targets

Precinct	TSS (kg/yr)	TP (kg/yr)	TN (kg/yr)	GP (kg/yr)
A	24560	13815	29.115	4011
B	51040	28710	60.3	8470
C	41680	23445	49.5	6979
D	12480	7020	14.67	2058
E	52720	29655	63.45	7910
F	91200	51300	108.45	15190
G	29920	16830	36.315	4333
H	36720	20655	46.35	4347
TOTAL	340320	191430	408.15	53298

8.6 Water quality assets

8.6.1 MUSIC modelling parameters

Water quality treatment assets were sized using MUSIC.

Bioretention basins were sized using the generic parameters presented in **Table 8.6**.

Table 8.6 Bioretention basin parameters for MUSIC modelling

Parameter	Value
Low flow bypass (m^3/s)	0
High flow bypass (m^3/s)	100
Extended detention depth (m)	0.30
Filter depth (m)	0.5
Exfiltration rate (mm/hr)	0
Saturated hydraulic conductivity (mm/hr)	180
Orthophosphate content (mg/kg)	55

Sedimentation basins were sized using the Fair and Geyer equation to achieve a clean out frequency of 5 years and BPEM water quality treatment. The minimum constructible sediment basin size was assumed to be 300 m^2. **Table 8.7** presents the generic parameters adopted to size sediment basins at Nyora.

Table 8.7 Sediment pond surface area calculation

Parameter	Description	Value
λ	Hydraulic efficiency	0.41 (based on length to width ratio of 3:1)
n	Turbulence or short-circuiting factor (Equation 4.2 of WSUD Engineering Procedures)	1.7
v_s	Settling velocity for target sediment (0.125mm)	0.011 m/s
Q	Design flow	3 month flow ARI
d_e	Extended detention depth	0.3 m
d_p	Depth of the permanent pool	1.0 m
d*	Depth below permanent pool that is sufficient to retain sediment	0.5 m
R	Fraction of target sediment removed	>0.95
F_r	Desired clean-out frequency	5 years

8.6.2 Asset sizes

End of line assets were adopted where the upstream catchment exceed 5 hectares in area (subject to terrain, existing development and environmental constraints). **Table 8.9** presents a summary of the end of line sedimentation basin sizes by precinct. The location of each asset is presented in a plan presented in **Appendix C**.

Table 8.8 End of line sedimentation basins sizes

Precinct	Asset ID	Catchment Area (m^2)	Design Flow (m^3/s)	Surface Area (m^2)
A	-	-	-	-
B*	SB1	46.99	0.64	900
C	SC1	19.97	0.31	500
D	SD1	8.25	0.14	300
E	-	-	-	-
F	SF1	5.57	0.09	300
F	SF2	18.75	0.30	500
F	SF3	26.64	0.39	650
F	SF4	6.26	0.10	300
F	SF6	10.39	0.17	350
G	-	-	-	-
H	-	-	-	-
TOTALS	-	142.82	-	3800

*Inclusive of 3.99 hectares of precinct A

Table 8.9 presents a summary of the end of line bioretention basin sizes by precinct. End of line bioretention basins were located downstream of end of line sedimentation basins. The location of each asset is presented in a plan presented in **Appendix C**.

Table 8.9 End of line bioretention basin sizes

Precinct	Asset ID	Catchment Area (m^2)	Design Flow (m^3/s)	Filter Area (m^2)
A	-	-	-	-
B	-	-	-	-
C	BC1	19.97	0.31	600
D	BD1	8.25	0.14	100
E	-	-	-	-
F	BF1	5.57	0.09	40
F	BF2	18.75	0.30	550
F	BF3	26.64	0.39	650
F	BF4	6.26	0.10	80
F	BF6	10.39	0.17	240
G	-	-	-	-
H	-	-	-	-
TOTALS	-	95.83	-	2260

Distributed street scale bioretention were modelled for locations where drainage to a single end of line system was considered impractical due to the terrain, environmental values or existing development. Total filter areas for distributed street scale bioretention are presented by precinct in **Table 8.10**.

Table 8.10 Street scale distributed bioretention

Precinct	Catchment Area (ha)	Total Filter Area (m^2)
A*	29.18	1100
B*	46.99	2100
C	32.08	2620
D	7.78	300
E	-	-
F	46.72	1780
G	-	-
H	-	-
TOTALS	158.26	8000

*Inclusive of 3.99 hectares of precinct A

On-lot WSUD treatment could be achieved by a variety of methods including buffer strips, swales and infiltration trenches. It is recommended that SGSC direct developers to demonstrate that their development achieves best practice. Valid methods for sizing and designing the WSUD asset requirements include the use of MUSIC and Melbourne Water's STORM calculator.

The total areas presented in the tables above cannot be simply added together as this would result in double counting of some areas that are treated by multiple WSUD assets. However the following statistics summarise the treatment requirements:

- The total treated catchment area is 484 hectares, consisting of 282 hectares of end of line and street scale WSUD and 202 hectares of on-lot WSUD.
- The portion of the impervious catchment area required for treatment using end of line and street scales systems is approximately 1.0%. This estimate is for the treatment area only and a larger area around each asset will be required for the purposes of constructing access tracks, sediment laydown areas and other assets.
- Concept area requirements for each asset that include access and other requirements were estimated at a high level and have been included in the cost estimates. Refer to **Section 11**.

8.7 Stormwater and rainwater harvesting

A stormwater harvesting opportunity was identified near the Nyora Primary School. An existing dam located within the Public Parks and Recreation Zone appears to intercept water from the main flow path through this area and could be harvested to irrigate sports ovals. It is recommended that the ownership of this asset and the potential for it to be utilised for stormwater harvesting be investigated further.

Other stormwater and rainwater harvesting opportunities should be considered on a case by case basis as development occurs. Stormwater harvesting in the new development areas, particularly at the large retarding basins in Precinct F and C should be explored, particularly where opportunities to utilise water to irrigate areas of open space exist.

The use of rainwater tanks on lots should also be further considered by SGSC in all areas of Nyora. The use of rainwater tanks is likely to reduce the impact on the GGE by reducing changes to the flow regime. Rainwater tanks could be implemented in development areas using a Section 173 agreement with the developer.

9. STORMWATER MANAGEMENT BY PRECINCT

9.1 Precinct A

Table 9.1 presents a summary of the stormwater management plan for Precinct A. Refer to **Appendix D** for an A3 plan of the stormwater management plan.

Table 9.1 Precinct A stormwater management summary

Stormwater Management	Description
Description	Town centre
Flood Mitigation	Upgrade existing pipe drainage on Henley Street and Hewson Street. Upgrade existing pipe drainage on Hewson Street between Davis Street and Henley Street.
Minor Drainage System	Piped drains
Major Drainage system	Road Reserve
Flow Retardation	On site detention where development occurs. End of line retarding basin located in precinct C Retarding basin located north of the railway.
Waterways	N/A
WSUD	Distributed bio-retention and street trees, GPT (litter traps) at Walters Road (north) and Hewson Street

9.2 Precinct B

Table 9.2 presents a summary of the stormwater management plan for Precinct B. Refer to **Appendix D** for an A3 plan of the stormwater management plan.

Table 9.2 Precinct B stormwater management summary

Stormwater Management	Description
Development	Density transition area
Flood Mitigation	New pipe drainage on Hewson Street between Davis Street and Henley Street to 1% AEP standard to protect existing flood prone properties. This pipe or an alternative flood mitigation solution should be constructed prior to further development of the south east corner of precinct A between Henley Street and

	Davis Street.
Minor Drainage System	Piped drains
Major Drainage system	Road Reserve
Flow Retardation	On site detention where development occurs
Waterways	Constructed waterway between Walters street and the precinct boundary.
WSUD	Distributed bio-retention and sediment basin at Walters Street (south)

9.3 Precinct C

Table 9.3 presents a summary of the stormwater management plan for Precinct C. Refer to **Appendix D** for an A3 plan of the stormwater management plan.

Table 9.3 Precinct C stormwater management summary

Stormwater Management	Description
Description	Urban investigation area
Flood Mitigation	N/A
Minor Drainage System	Pipe drainage (network to be determined when development occurs)
Major Drainage system	Kerb and channel
Flow Retardation	End of line retarding basin Onsite detention to be further considered in addition to end of line retarding basin subject to further investigation on the impact of locally increasing catchment flows on the GGE.
Waterways	Waterway corridor for main flow path.
WSUD	Distributed bio-retention, end of line bioretention and sedimentation basins.

The ultimate drainage layout in precinct C will be subject to final approved subdivision layout and stormwater management plan.

9.4 Precinct D

Table 9.4 presents a summary of the stormwater management plan for Precinct D. Refer to **Appendix D** for an A3 plan of the stormwater management plan.

Table 9.4 Precinct D stormwater management summary

Stormwater Management	Description
Description	Urban investigation area
Flood Mitigation	N/A
Minor Drainage System	Pipe drainage (network to be determined when development occurs)
Major Drainage system	Road Reserve
Flow Retardation	End of line retarding basins
Waterways	N/A
WSUD	Distributed bio-retention, end of line bioretention and sedimentation basins.

The ultimate drainage layout in precinct D will be subject to final approved subdivision layout and stormwater management plan.

9.5 Precinct E

Table 9.5 presents a summary of the stormwater management plan for Precinct E. Refer to **Appendix D** for an A3 plan of the stormwater management plan.

Table 9.5 Precinct E stormwater management summary

Stormwater Management	Description
Description	Established low density residential with subdivision potential
Flood Mitigation	Retardation basin located in VicTrack land south of the Lang Lang – Poowong Road (in precinct A), new culverts under the Lang Lang – Poowong Road and pipe replacement of the open channel system on both sides of Yannathan Road. Works to provide for the existing 1% AEP flow to be contained within the pipe drainage system. SGSC to consider alternative option of lowering Yannathan Road to provide conveyance for major flows.
Minor Drainage System	Existing open drainage network to be maintained. Easement pipe drains to be constructed
Major Drainage system	Road Reserve and waterway corridors
Flow Retardation	On site detention where development occurs

Waterways	N/A
WSUD	On lot rainwater tanks, bio-retention, swales, infiltration strips and other WSUD as subdivision occurs. GPT downstream of the industrial precinct at Yannathan Road.

9.6 Precinct F

Table 9.6 presents a summary of the stormwater management plan for Precinct F. Refer to **Appendix D** for an A3 plan of the stormwater management plan.

Table 9.6 Precinct F stormwater management summary

Stormwater Management	Description
Description	Urban investigation area
Flood Mitigation	N/A
Minor Drainage System	Pipe drainage (network to be determined when development occurs)
Major Drainage system	Road Reserve in development areas, constructed waterway and waterway corridors in other locations.
Flow Retardation	End of line retarding basins
Waterways	Constructed waterway and waterway corridors
WSUD	Distributed bio-retention, end of line bioretention and sedimentation basins

The ultimate drainage layout in precinct F will be subject to final approved subdivision layout and stormwater management plan.

9.7 Precinct G

Table 9.7 presents a summary of the stormwater management plan for Precinct G. Refer to **Appendix D** for an A3 plan of the stormwater management plan.

Table 9.7 Precinct G stormwater management summary

Stormwater Management	Description
Description	New low density residential area
Flood Mitigation	Description of infrastructure required

Minor Drainage System	Existing open drainage network to be maintained.
Major Drainage system	Waterway corridor
Flow Retardation	On site detention where development occurs
Waterways	N/A
WSUD	On lot rainwater tanks, bio-retention, swales, infiltration strips and other WSUD determined by SGSC as subdivision occurs.

9.8 Precinct H

Table 9.8 presents a summary of the stormwater management plan for Precinct H. Refer to **Appendix D** for an A3 plan of the stormwater management plan.

Table 9.8 Precinct H stormwater management summary

Stormwater Management	Description
Description	Rural Lifestyle
Flood Mitigation	Description of infrastructure required
Minor Drainage System	Piped drains
Major Drainage system	Road reserve and existing natural flow paths
Flow Retardation	Onsite detention
Waterways	N/A
WSUD	Rainwater tanks, bio-retention, swales, infiltration strips and other WSUD determined by SGSC as subdivision occurs.

10. IMPLEMENTATION PLAN

The staging and timing of development in Nyora will ultimately determine the construction of the stormwater management system. Maps presenting a staged approach for implementing the stormwater management plan in the short term (5-10 year horizon), medium term (10-20 year horizon) are presented in **Appendix E**. The long term approach is presented as the ultimate stormwater management plan presented in **Appendix C** and **D**. The staged approach presented attempts to balance drainage, flood mitigation and water quality requirements at Nyora. A summary vision of the major stormwater works for construction in the short, medium and long term is presented below.

Short term (5 – 10 years)

- Partially construct flood mitigation works at Yannathan Road to divert flows from upstream residential development into VicTrack land north of the railway (subject to permission from VicTrack).
- Construct pipe upgrades in Precinct A and B on Hewson Street.
- Construct 1% AEP flood mitigation pipe on Hewson Street and Henley Street
- Construct bunding to mitigate existing flooding at Hatchs Road.
- Construct culverts under Walter Street and downstream open channel.
- Construct GPT at Yannathan Road.

Medium term (10 - 20 years)

- Construct trunk drainage system in precinct B.
- Construct sedimentation basin at Walters Road.
- Construct GPT at Walters Street.
- Construct underground pipe drainage system to replace open channel system at Yannathan Road.
- Construct stage 1 of retarding basin to mitigate precinct B development flows
- Construct GPT at Hewson Street.

Long term (>20 years)

- Lower Yannathan Road and provide kerb and channel major flow path.
- Construct remainder of the pipe drainage in Precinct A, B, E and H as subdivision requires.

- Development of precinct C and construction of stormwater management works, including the stage 2 upsizing of the retarding basin.

- Development of precinct D and construction of stormwater management.

11. PLAN COSTING

Concept level costing of stormwater assets at Nyora was undertaken using the development services scheme costing spreadsheet that is used by Melbourne Water for these projects.

Table 11.1 provides the summary table from the cost estimating spreadsheet for unallocated works in Nyora. Full details of rates and assumptions associated with costs are provided in the cost estimating spreadsheet, supplied to SGSC with this report.

The cost estimation includes the following works:

1. flood mitigation[3]
2. water quality
3. future drainage works for properties greater than 0.4 hectares

Private easement drains that were will be required as part of internal drainage to properties were not included in the costing. The figures in **Appendix D** identify which drainage was included in the costing.

No special allowance was made for filling in the large dam in precinct F.

In some locations, due to the low density development and sufficient open space, a 'greenfields' or 'reserve' rate has been adopted for costing pipes.

Table 11.1 Capital costs for unallocated works in Nyora

Works Description	Estimated Basic Construction Cost	Provisions
Pipes	$2,642,125	$184,949
Channels	$832,923	$0
Culverts	$179,584	$34,121
Retarding Basins	$1,162,711	$232,542
Sediment Basins	$1,426,074	$285,215
Litter Traps	$119,160	$23,832
Bio-Retention Basins	$717,491	$143,498

[3] Pipe drainage, permanent open channels and other works that form part of the ultimate stormwater plan were costed. Temporary works such as bunding and low flow channel excavation have not been costed. The cost of road works for lowering Yannathan Road were also excluded from the costing.

Sub-total 'A'	$7,080,068	$904,157
'A' x Site Establishment, Preparation & Reinstatement Costs @ 6%	$424,804	
'A' x Site Environmental & Traffic Management Plans @ 2.5%	$177,002	
Sub-total 'B'	$7,681,874	$904,157
'B' x Engineering Fee @ 15%	$1,152,281	$135,624
Sub-total 'C'	$8,834,155	$1,039,780
'C' x Administration Fee @ 9%	$795,074	$93,580
(Land Acq only) 'C' x Administration Fee @ 1%	-	-
Sub-total 'D'	$9,629,229	$1,133,361
'B' x Contingencies @ 5%	$384,094	-
UNALLOCATED COST	$10,013,322	$1,133,361
TOTAL COST (unallocated works only)	$11,146,683	
Rounded Estimate	$11,150,000	

Engeny has made no allowance for land acquisition. Some land acquisitions costs may be associated with the sediment basins and end of line bio-retention basins and this should be reviewed by SGSC. Estimated areas for the land acquisition required for the plan are provided in **Table 11.2**.

Table 11.2 Stormwater asset land-take estimates

Stormwater asset	Land take (hectares)
Channels	3.49
RBs	4.11
Sediment Basins	1.65
Bioretention Basins (end of line)	0.28
Bioretention Distributed	0.87

Pipes[4]	0.25
TOTAL	10.66

[4] Estimated allocation for a 2 metre width pipe easement at back of lot pipe drainage in precinct E and A.

12. FUNDING MECHANISMS

12.1 Context

The advice provided by Engeny in the following sections is in the context of our experience as stormwater consultants. Other funding mechanisms that are not mentioned here may be available to Council and it is recommended that SGSC engage the appropriate specialists to provide further advice on the implementation of the appropriate funding arrangement.

12.2 Flood mitigation works

A number of mechanisms may be available to SGSC for the funding of works required to mitigate existing flooding, including Special Charge Schemes and Section 173 Agreements.

The Local Government Act 1989 allows SGSC to recover the cost of underground drainage and other capital infrastructure work from the owner of a property that generally gains a special benefit from the construction works using a Special Charge Scheme. Implementing Special Charge Schemes to pay for flood mitigation in Nyora could be problematic in residential areas as many landowners are from low income households and may be unable to pay the required contributions. However a Special Charge Scheme applied to industrial properties on Yannathan Road may be appropriate to mitigate existing flooding at that location

Section 173 of the Planning and Environment Act 1987 refers to a voluntary and legally binding agreement between Council and another party such as a landowner. In discussion with SGSC the preferred mechanism for funding flood mitigation works in Nyora is by way of Section 173 agreements between Council and landowners proposing development. There are existing examples of Section 173 agreements in Nyora (refer to the Nyora Development Strategy for details) where a contribution to drainage improvement works is included in the agreement.

12.3 Development works

There are a number of mechanisms available to fund the stormwater infrastructure required to convey, treat and retard additional stormwater that results from development, including a Developer Contributions Plan (DCP) administered by SGSC and a Development Services Scheme (DSS) administered by Melbourne Water

The Planning and Environment Act (1987) allows the use of a DCP as a mechanism to levy new development for contributions to fund infrastructure (including stormwater infrastructure). The contribution is a dollar value across developable land to ensure equity in the payment contributions from all developers. A Development Contributions Plan Overlay (DCPO) and associated schedule is required to identify the area subject to the

DCP. A DCP could be considered by SGSC to manage large areas where relatively dense development is projected such as Precincts A and B.

A DSS could be an alternative to a DCP for the management of large development areas in Nyora. At the time of this SMP, Melbourne Water had indicated that it would consider renewing the Draft Nyora DSS if this was acceptable to Council. Renewing and implementing the DSS would mean that development contributions and works are managed through Melbourne Water rather than SGSC. Melbourne Water also indicated that it would also be acceptable if it was SGSC's preference not to initiate the DSS. If a DSS is implemented than funding contributions for stormwater infrastructure by developers in the DSS area would be administered by Melbourne Water.

Further collaboration is required between SGSC and Melbourne Water to determine whether Nyora is to be managed under a DSS arrangement. If SGSC choses to pursue a DSS arrangement then further discussions with Melbourne Water are required to define the boundaries of the DSS. The Draft Nyora DSS covers the greenfield areas of precinct C, D and F and most of the land now zoned as GRZ1 in precinct B. Given precinct A and precinct B discharge through precinct C, further consideration should be given to whether the DSS boundaries should include the total area of these precincts.

Based on discussions with SGSC and in lieu of a DSS and a DCP it is understood that Council's preferred mechanism for funding stormwater works required for new development is by way of a voluntary Section 173 agreement. From an administrative perspective this approach is likely to work most effectively where small numbers of developers are involved, such as where there is a single entity developing an area in which they can construct all of the works required to service their development and the use of an agreement will give Council and the landowner certainty of the infrastructure to be provided..

13. CONCLUSIONS

The Nyora SMP presents an approach to managing stormwater in Nyora that meets appropriate standards for drainage, flood protection, water quality, waterway health and amenity.

13.1 Flooding

Hydraulic modelling was undertaken using TUFLOW 1D/2D hydrodynamic software and RORB to generate catchment flows. The modelling identified that there are a number of locations in Nyora that are currently flood prone, including 2 properties (located on Yannathan Road and the corner of Henley Street and Hewson Street respectively) that were considered likely to experience above floor flooding for the 18% AEP event. Glovers Road and Walters Street were concluded to experience frequent and significant flooding. Flood mitigation options were proposed to mitigate flooding at these locations and two additional locations; at Hatchs Road and near the intersection of Hewson Street and Davis Street.

Hatchs Road was an area raised as flooding concern by residents in a community consultation session undertaken by Planisphere. This location was identified by the modelling as flood prone but with no floors affected. A local ground shaping and bunding mitigation option was proposed to keep flow out of what was understood to be the effected property however further investigation and discussion with the residents is recommended to inform this solution. The location near the intersection of Hewson Street and Davis Street has no formal existing flow path and development in the upstream Precinct A catchment area is likely to result an in increased flood risk to building floors. A flood mitigation solution involving a pipe upgrade and inlet works was proposed to convey major storm flows at this location.

13.2 Administration of flood prone land

In many locations existing overland flow paths can be incorporated into future development precincts as part of future major and minor drainage systems or as part of designated waterway corridors. However in some locations existing flooding will not be resolved as part of future development or flood mitigation works, such as behind the railway embankment and major road embankments.

Urban Flood Zone (UFZ) and flood overlays, the Special Building Overlay (SBO), Land Subject to Inundation Overlay (LSIO) and the Floodway Overlay (FO) designate land that is subject to flooding and provide statutory authorities with a means for regulating or prohibiting development within a hazardous area under Section 62(e) of the Planning and Environment Act 1987. The statutory authorities responsible for collecting flood information and managing development in flood prone land in Nyora are SGSC and Melbourne Water.

Given Nyora's relatively small size it is considered that SGSC could potentially manage development applications on a case by case basis without the implementation of flood related planning zones or overlays. However it is recommended that SGSC further consider the practical implementation and internal processes required to assess development applications in flood prone areas and the option of using overlays such as an SBO or LSIO.

13.3 Stormwater management for future development in Nyora

Existing natural values, future urban form and Nyora's vision (refer to **Section 3.1**) were used to inform the type and location of stormwater assets that were proposed for the SMP.

The long term plan (>20 years) for the management of stormwater flows in Nyora is summarised as follows:

- Construct piped systems with kerb and channel roads in the urban growth areas of precincts A, B, C, F and D, the commercial centre in precinct A and the industrial area on Yannathan Road.
- Maintain existing open swales to convey flow in the low density and rural living areas of precinct E, G and H.
- Designate waterway corridors for existing waterways where the proposed Giant Gippsland Earthworm Overlay (GGEO) shows Giant Gippsland Earthworm habitat.
- Implement on site detention in accordance with the IDM standards to retard minor development flows back to existing conditions in infill development precincts.
- End of line retarding basins to mitigate the 1% AEP peak flow back to existing conditions at town boundaries, prior to discharge to downstream properties.
- End of line sedimentation basins and bioretention basins and distributed street scale bioretention basins to manage stormwater quality to BPEM targets in greenfield development precincts and precincts A and B.
- On-lot WSUD within the low density and rural living precincts E, G, H.
- GPT's are proposed at 3 locations to intercept flows discharging from the commercial and industrial areas in precincts A and E respectively.

13.4 Costing

Concept level costing of stormwater assets at Nyora was undertaken using the development services scheme costing spreadsheet that is used by Melbourne Water for these projects.

The cost estimation included the following works:

- flood mitigation
- water quality
- future drainage works for properties greater than 0.4 hectares.

The total estimated unallocated cost of the stormwater works required to achieve the long term stormwater water management plan at Nyora is $11,150,000.

The cost estimate excluded land acquisition for drainage assets. The total land acquisition required for drainage assets is approximately 10.7 hectares. The land includes some publically owned land (VicTrack) and is located across a range of zones according to the current planning zones.

13.5 Funding mechanisms

A number of mechanisms may be available to SGSC for the funding of works required to mitigate existing flooding, including Special Charge Schemes and Section 173 Agreements. Based on discussions with SGSC, the preferred mechanism for funding flood mitigation works in Nyora is by way of Section 173 agreements between SGSC and landowners proposing development. There are existing examples of Section 173 agreements in Nyora (refer to the Nyora Development Strategy for details) where a contribution to drainage improvement works is included in the agreement.

There are a number of mechanisms available to fund the stormwater infrastructure required to convey, treat and retard additional stormwater that results from development, including a Developer Contributions Plan (DCP) administered by SGSC and a Development Services Scheme (DSS) administered by Melbourne Water. The funding approach for major drainage works should be determined in discussions with Melbourne Water.

14. RECOMMENDATIONS

14.1 General

1. SGSC consider adopting the Nyora SMP.

14.2 Flood modelling

The following recommendations are made with respect to flood modelling at Nyora:

2. SGSC consider undertaking floor level survey to further inform the hydraulic modelling and associated flood risk within the catchment.
3. SGSC consider undertaking a climate change investigation to inform the likely impacts of climate change at Nyora.
4. SGSC consider using the results of the flood modelling to inform development approvals.

14.3 Flood mitigation works

The following recommendations are made with respect to the proposed flood mitigation works that are presented in **Section 5.3**.

5. The impact of the Glovers Road flood mitigation works requires further consideration given the potential impact of the works on Giant Gippsland Earthworm habitat and significant vegetation.
6. Onsite detention for future development at Yannathan Road could be required to mitigate peak 1% AEP flows to the 18% AEP event by way of onsite detention. This would not eliminate the requirement to undertake pipe upgrades and intersection regrading works at Yannathan and Davis Street. However it may provide an alternative to lowering Yannathan Road.
7. Further investigation and discussion with landowners regarding the existing flooding and proposed mitigation solution at the north end of Hatchs Road.

14.4 Stormwater quantity

8. Retarding basins that were located in areas covered by the provisional GGEO were assumed to require headwalls rather than being in-cut. It is recommended that SGSC undertake further consultation with Melbourne Water to determine whether this design approach is appropriate and whether there are any special design approaches that could be adopted to reduce the impact of proposed retarding basins to existing GGE populations.
9. The risk of dam break for retarding basin headwalls should be further considered in accordance with ANCOLD principles.
10. Constructed waterways will require works within the GGEO and it is recommended that further investigations be undertaken to determine whether alternative works can

be undertaken to reduce the impact to the Giant Gippsland Earthworm. For example whether the provision of additional retarding basins located upstream of the proposed constructed waterways would result in the habitat values of the Giant Gippsland Earthworm being preserved and enable the constructed waterways to be converted to waterway corridors

11. As part of the development of this SMP with the Nyora Development Strategy (Planisphere, 2016), the option of a possible green East-West connection was identified for Precinct B. The provision of a constructed waterway at this location was not investigated but is considered to be a potentially viable alternative to the pipes and road approach documented in this SMP.

14.5 Stormwater quality

12. The water quality plan has sized assets to achieve Best Practice Environmental Management targets. The more stringent (but non-legally binding) Schedule F8 targets for Western Port Bay should be considered by SGSC in consultation with Melbourne Water for this area.
13. Rainwater tanks could provide hydrological benefits by reducing development flow volumes which could be beneficial to reduce the impact of development on the Giant Gippsland Earthworm (GGE). It is recommended that the implementation of rainwater tanks on all development areas is considered further by SGSC in consultation with GGE specialists and Melbourne Water river health team.
14. End of line wetlands located offline from waterways were considered where catchment areas were considered large enough for a sustainable wetland to be implemented. These locations were Precinct C (within RB1), Precinct F (RB9). Wetlands were ultimately not adopted at these locations as it was considered that the earthworks required would impact negatively on the GGE. Given offline wetlands in these locations could reduce the maintenance burden associated with the distributed network of sedimentation and bioretention basins that is currently proposed, it is recommended that further investigation into the viability of constructing wetlands is undertaken in consultation with the river health team at Melbourne Water and GGE specialists.

14.6 Administration

15. In lieu of implementing planning overlays to control development in flood prone areas, it is recommended that SGSC further consider the practical implementation and internal processes required for assessing development applications in flood prone areas, and how the flood modelling undertaken for this SMP could be used to inform this process.
16. It is recommended that SGSC discuss the mechanisms for managing development contributions in the form of a Development Service Scheme (DSS) with Melbourne Water.

15. QUALIFICATIONS

a. In preparing this document, including all relevant calculation and modelling, Engeny Water Management (Engeny) has exercised the degree of skill, care and diligence normally exercised by members of the engineering profession and has acted in accordance with accepted practices of engineering principles.

b. Engeny has used reasonable endeavours to inform itself of the parameters and requirements of the project and has taken reasonable steps to ensure that the works and document is as accurate and comprehensive as possible given the information upon which it has been based including information that may have been provided or obtained by any third party or external sources which has not been independently verified.

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g. This report does not provide legal advice.

16. REFERENCES

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APPENDIX A

Drainage Investigations Report

South Gippsland Shire Council

ENGENY WATER MANAGEMENT

South Gippsland Shire

Nyora Development Precinct

Drainage Investigations Report




July 2016

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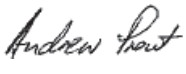
Signatures					

EXECUTIVE SUMMARY

This report

This report presents the findings of drainage investigations undertaken to inform the stormwater management strategy for the town of Nyora, located in West Gippsland, including:

- background investigation
- data review
- the results of the existing conditions flood mapping undertaken for the 18% AEP and 1% AEP events using a 1D/2D TUFLOW hydrodynamic model and RORB hydrological model.
- identification of existing flooding hotspots
- identification of existing stormwater issues and opportunities that are to be addressed by the stormwater management plan
- development of the stormwater management strategy framework
- next steps for the development of the stormwater management strategy.

Existing conditions flood modelling

Flood modelling and mapping were undertaken in accordance with Melbourne Water standards as described in the November 2012 Flood mapping guidelines and technical specifications. Modelling methodologies were also informed by the DRAFT March 2015 Flood mapping guidelines and technical specifications where appropriate.

Flood modelling was undertaken using the combination of a RORB hydrological model to generate rainfall excess catchment flows and a 1D/2D TUFLOW hydraulic model to route flows, and estimate flood depths and velocities. The extent of both models covered the entire future development area for Nyora.

The 18% AEP event and 1% AEP events were modelled as these events represent the objective design capacity of the minor and major drainage systems respectively.

The results of the existing conditions flood modelling and mapping are presented in the table below. Refer to **Section 4.6** for a definition of minor and major flooding.

Location	18 % AEP	1 % AEP
Properties with minor flooding	61	98
Properties with major flooding	2	28
Roads with minor flooding	3	6
Roads with major flooding	0	2
Railway	0	2
Railway with major flooding	0	0

The two roads subject to major flooding are Walters Road and Glovers Road.

The two properties subject to major flooding for the 18% AEP event are located on the corner of Henley and Hewson Street and on Yannathan Road respectively.

Issues and Opportunities

The stormwater management strategy for Nyora has the opportunity to address existing flooding problems and set a strategic direction for implementing best practice, multifunctional stormwater assets that achieve the primary water quality, drainage and flood mitigation objectives and also provide environmental, public amenity and other benefits to the community.

A number of strategic stormwater issues have been identified and used as a basis for developing objectives for the stormwater management strategy, including:

- existing flooding problems
- development in flood-prone areas
- legal issues regarding drainage outlet permission
- downstream impacts to existing landowners and the environment
- increased pollution in stormwater runoff from urbanisation
- reduced annual rainfall due to climate change resulting in increased pressure on the potable water supply
- increased rainfall intensity due to climate change resulting in increased flooding
- poor public amenity due to intrusive drainage infrastructure development

- damage to the environment as a result of future drainage infrastructure.

Further discussion is presented in **Section 5.2.**

Documentation of specific opportunities and issues is presented in **Section 5.3** followed by a framework for the Nyora stormwater management plan and the next steps for developing the plan.

Engeny Water Management (Engeny) was engaged by Planisphere Pty Ltd. on behalf of South Gippsland Shire to undertake the stormwater management plan and drainage investigations for the Nyora Development Strategy.

CONTENTS

Appendices

Glossary

The following definitions are from the Infrastructure Design Manual (version 4.4.2).

Annual Exceedance Probability (AEP) The long-term average probability that the defined magnitude will be exceeded in any given year.

Average Recurrence Interval (ARI) The long-term average interval elapsing between successive events of the defined magnitude.

The stormwater industry is transitioning towards adopting the AEP terminology over other terminologies (including ARI) for consistency and simplicity across projects. The use of AEP is recommended in the new AR&R guidelines, which were in draft form at the time of reporting, and has been adopted for the Infrastructure Design Manual.

The following table relates ARI to AEP.

ARI (years)	AEP (%)
1	63
2	39
5	18
10	10
20	5
50	2
100	1

ASCII American Standard Code for Information Interchange (a common simple GIS file format)

AHD Australian Height Datum

DEM Digital Elevation Model

GIS Graphical Information System

IFD Intensity Frequency Duration

Hydraulic Modelling The representation of the passage of flood waters across the DEM by computational means. Hydraulic

	modelling for the Nyora Stormwater Management Plan was undertaken in TUFLOW.
LiDAR	Light Detection And Ranging (used to gather data to develop a DEM of large areas)
Long Term	A timeframe for the implementation of development works at Nyora of greater 20 years into the future (>2035).
Medium Term	A timeframe for the implementation of development works at Nyora of between 10 to 20 years into the future (2025 - 2035).
Nuisance Flooding	Minor flooding to roads and properties that occurs frequently for events smaller than or equal to the 18% AEP.
RORB	RORB is a general runoff and streamflow routing program used to calculate flood hydrographs from rainfall and other channel inputs
Short Term	A timeframe for the implementation of development works at Nyora of between 5 to 10 years into the future (2020- 2025).
TUFLOW	TUFLOW is a computational engine that provides one-dimensional (1D) and two-dimensional (2D) solutions of the free-surface flow equations to simulate flood and tidal wave propagation.
1D	One Dimensional – Refers to modelling of pipes, culverts and waterways which are modelled using one dimensional methods.
2D	Two Dimensional – Refers to hydraulic modelling of overland flows using two dimensional methods.

1. INTRODUCTION

1.1 This report

Engeny Water Management (Engeny) was engaged by Planisphere Pty Ltd on behalf of South Gippsland Shire to undertake the stormwater management plan and drainage investigations for the Nyora Development Strategy. Nyora is a town of approximately 1300 people and is located in West Gippsland.

This report presents the findings of drainage investigations undertaken to inform the stormwater management strategy for the town of Nyora, located in West Gippsland, including:

- background investigation
- data review
- the results of the existing conditions flood mapping undertaken for the 18% AEP and 1% AEP events using a 1D/2D TUFLOW hydrodynamic model and RORB hydrological model.
- identification of existing flooding hotspots
- identification of existing stormwater issues and opportunities that are to be addressed by the stormwater management plan.
- development of the stormwater management strategy framework
- next steps for the development of the stormwater management strategy.

2. BACKGROUND

2.1 Previous studies

The following reports and investigations have been undertaken for Nyora and were used to inform this study.

- Nyora Structure Plan (Planisphere, 2013)
- Nyora Structure Plan Submission (Beverage Williams, 2011)
- Development forecasts for Nyora (Nott and More, 2010)
- Strategy & audit for social community infrastructure 2014 -2029 (South Gippsland Shire Council)
- Flood Management Plan for South Gippsland Shire Council, Melbourne Water and West Gippsland CMA (prepared in collaboration, 2013).

Melbourne Water has undertaken a number of stormwater investigations as part of preparing a development services scheme for Nyora. The scheme was not completed and was put on hold whilst the provision of sewer infrastructure for the town was determined by other authorities. The following surface water reports that were undertaken for the scheme were provided by Melbourne Water and used to inform this study:

- Nyora Development Services Scheme Summary Report (Alluvium, 2009)
- Water Quality Report (BMT WBM, 2009).

2.2 Catchment Conditions

Nyora is located amongst undulating hills in the fertile west Gippsland region. The average annual rainfall for Nyora is 1026 mm based on the 45 year rainfall data record from the Nyora Post Office (Bureau of Meteorology station 086281) and the region surrounding the town contains a mix of agricultural and forested land (refer to **Figure 2.1**).

Figure 2.1 View north east from Glovers Road showing the agricultural and forested land located to the North of Nyora.

The Nyora development strategy is encompassed by eight (8) catchments totalling an area of approximately 580 hectares. The catchments discharge into three (3) major waterways, Little Lang Lang River, Bass River and Adams Creek, which all ultimately discharge into Western Port. The headwaters of six (6) of the largest catchments are located near the town centre which results in a pattern of major flow paths radiating outwards in different directions from the town. A plan showing the major flow paths and catchment boundaries is presented in **Figure 2.2**.

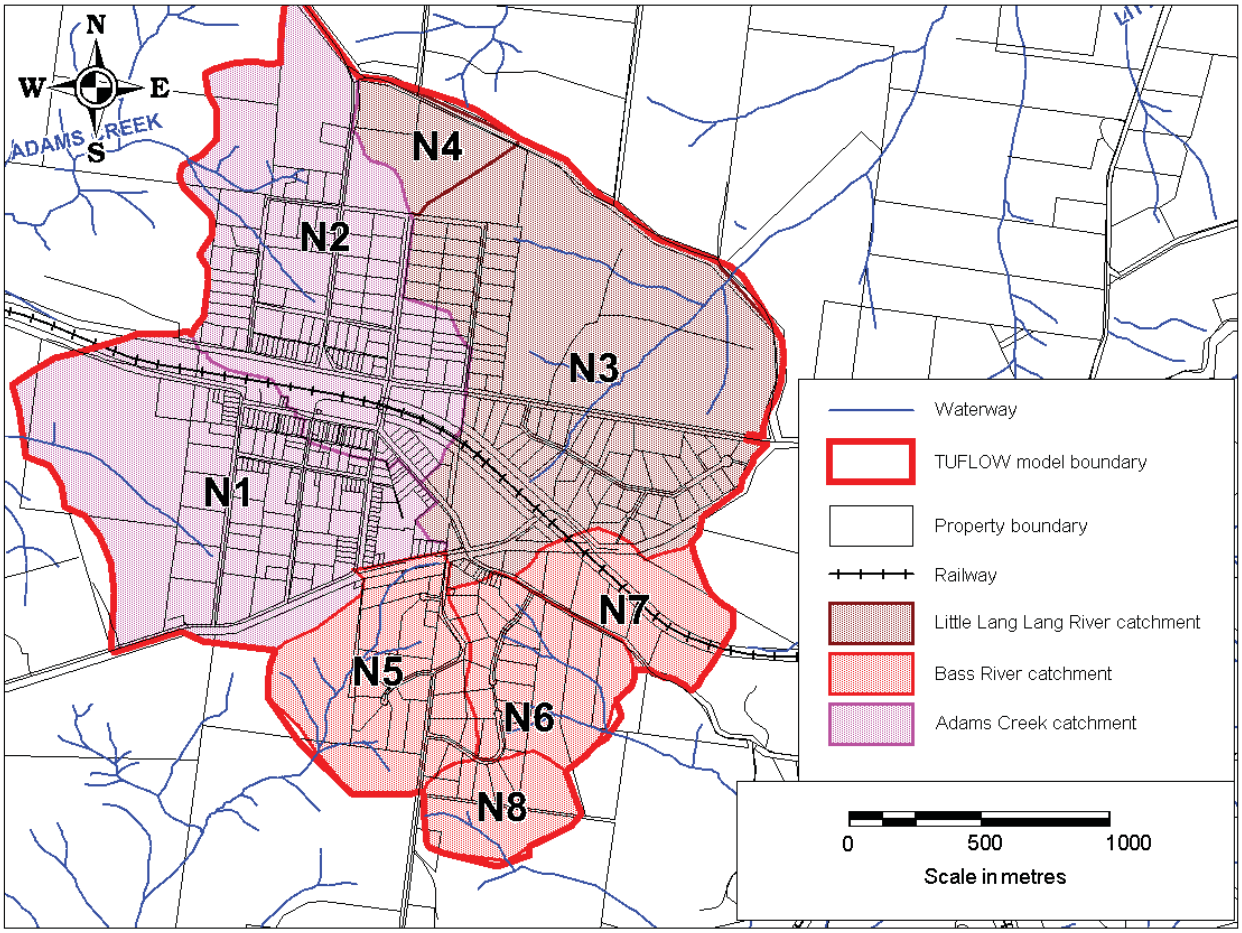


Figure 2.2 Nyora catchments

The region's waterways have been characterised by the Development Services Scheme Summary Report (Alluvium, 2009) as being largely intact and in good geomorphic condition. Waterways are generally of moderate to steep longitudinal grade with grades of 2-3 % in the north east and north west catchments(N2 and N3), a slightly gentler grade in the south west (catchment N1). The steepest grades occur in the south east (catchments N5, N6 & N8) where waterway slopes exceed 5 % in some locations.

Roads within the area generally lack a kerb and channel system and the minor drainage flows are conveyed within open channels, with the exception of a central drainage network near Mitchell Street and in the Henry Street area in south Nyora.

The existing development in Nyora contains a mix of traditional lot sizes (750 – 800 m^2) and large low density lot sizes (8,000 – 12,500 m^2), with the higher density areas typically located closer to the town centre near Mitchell Street. An area of light industrial development is located on the north side of the Nyora – Wonthaggi Rail line.

The Nyora-Wonthaggi Rail line bisects the town and acts as a major control to the distribution of overland flows in some locations.

3. DATA

3.1 Base data

The data presented in **Table 3.1** was provided by South Gippsland Shire Council (SGSC) Council and was used as a basis for the hydraulic and hydrological modelling that was undertaken to estimate the existing and future flood conditions at Nyora. Some of the data provided by Council is understood to have been sourced from the Department of Land Water and Planning (DEWLP) and Melbourne Water Corporation (MWC).

Table 3.1 Base data

Data	Format	Description
Stormwater_Pipes	.tab	Council stormwater drainage pipes
Stormwater_Pits	.tab	Council stormwater drainage pits
TableDrains_InProgress	.tab	Council table drains
Nyora_FASTLOOK_12Apr2012 _RGB_10cm_MGA55	.ecw	Aerial photograph
Stockyard Rise Estate, Nyora Stages 3,4 & 5 Plans	.pdf	Plans showing the drainage system and layout for the development in the Eagle Rise / Carlisle Close area
Gambrae Park Estate, Nyora – Stage 5 Plans	.pdf	Plans showing the drainage system and layout for the development on Follett Drive
Proposed Road Reconstruction Henrys Road, Nyora – Stage 1	.pdf	Plans showing the road reconstruction and drainage plans for Henrys Road
PLAN_ZONE	.tab	Planning zones
PLAN_OVERLAY	.tab	Planning overlays
e3xxn57xx_Desalination_Corridor_10cm	.xyz	LiDAR tiles

3.2 Site Visit

Engeny undertook a site visit to Nyora with Council and other members of the development strategy team on the 26th of October, 2015. The site visit was used to inform our understanding of the catchment and existing drainage system characteristics.

Photographs taken on the site visit are presented below.

Figure 3.1 View south near the railway crossing on the east side of Davis Street

Figure 3.2 View west towards the station from near the railway crossing at Davis Street.

Figure 3.3 View north to Adams Creek from Patman Drive

Figure 3.4 View north on Walters Road near the low point between Hewson Street and the Lang Lang - Poowong Road

Figure 3.5 View north to the inlet of the 2 no. 1200 mm wide by 600 mm high box culverts located under Follett Drive

Figure 3.6 View north east across the Nyora Speedway from Grundy Avenue

Figure 3.7 View west to new side entry pit and kerb and channel on Henrys Road near the intersection with Eagle Rise.

Figure 3.8 View north on Henrys Road showing new kerb and channel and road reconstruction works

Figure 3.9 View west on Hewson Street

3.3 Data review

A review was undertaken to determine any deficiencies in the drainage data before modelling was undertaken. The review included the following checks of the pipe drainage system:

- pipe diameters:
  - All 166 pipes had diameters.
  - A number of pipes had non-standard diameters including, twenty one (21) pipes with diameters of 400 mm, four (4) pipes with diameters of 500 mm and three (3) pipes with a diameter of 325 mm. These pipe diameters were not changed as it is understood that some pipes may be imperial sizes and modification of the pipes was considered unlikely to make a significant difference to the flow capacity of the network.
- pipe direction:
  - Pipe directions were reversed where the direction was found to be opposite to the direction of flow.
- snapping pipes together:
  - Pipes were snapped together where gaps were found between pipes.

- invert levels:
  - Invert levels were based on the depth of the upstream and downstream pits (as per Stormwater_pits.tab layer provided by Council). Where invert levels were not available the following equation was used to set the invert level:
  - Ground level RL – 600mm (pipe cover) – pipe diameter.

Following the site visit and an initial model run, missing Council, VicTrack and VicRoads drainage data was identified. VicTrack and VicRoads data was not available in time for use in this study, however Council undertook a field survey of thirteen (13) culverts identified by Engeny as missing from the drainage system data. The additional culverts are presented in **Table 3.2.**

Table 3.2 Additional culvert data collected by Council and included in the hydraulic model

Culvert No	Size (mm)	Type	Location	Notes
1	450	CP	Under railway line near station – invert 1.5 m below ballast	Extends for over 40 m into flat land
2	750	CP	Under railway line near station – invert 1.5 m below ballast	Extends for 40 m into flat land
3	300	CP	Under road the Lang Lang - Poowong Road – invert 1 m below road	Discharges into open drain along south side of rails
4	900	RCP	Under road the Lang Lang - Poowong Road – invert 2.5 m below road	Very deep
5	375	CP	Under the Lang Lang - Poowong Road – invert 3.5 m below road	Very deep – no discernible low point though has rock beaching on HS
6	2x 1200x 600	BC	Under Follett Drive – invert 900 mm below road	
7	900x 450	BC	Under Follett Drive – invert 600 mm below road	
8	600	RCP	Under railway line near Speedway – invert 1.2 m below ballast	Appears to be newer pipe taking discharge from reserve
9			Within private property north of the Nyora – Poowong Road	Subject to proposed Wallis Watson subdivision
10	900	CP	Under railway line near the south east development boundary – invert 3 m below ballast	Very old & very deep. Could not find inlet.
11	375	CP	Under Yannathan Road – invert 1.5 m below road	Very poor condition
12	300	CP	Under Glovers Road – invert 600 mm below road	
13			Within private property north of the Nyora – Poowong Road	Subject to proposed Wallis Watson subdivision

In addition to the drainage data surveyed by Council, pipe drainage systems in Follett Drive, Henrys Road and Eagle Rise were included in the modelled pipe drainage system. The locations, diameters and inverts of these pipe drainage systems were manually digitised using the plans provided by Council as a basis (refer to **Section 3**).

3.4 Assumptions and Limitations of Data

While all possible care has been taken to ensure the accuracy and robustness of this study there are some underlying limitations in the data that may reduce the accuracy of the flood mapping results in some locations:

- The pipe data provided by SCSC did not contain all pipe inverts. Where inverts where not available it has been assumed that all pipes have 0.6 m of cover and that they all grade downhill towards the outfall.
- The LiDAR data was captured between 2007 and 2009, since this time it is possible that the topography of some areas within Nyora has been locally re-shaped. In these areas the LiDAR data may not correctly represent the current topography and therefore flood conditions may be miss-represented.

4. EXISTING CONDITIONS FLOODING

4.1 Approach

Existing flooding conditions were modelled to determine the performance of the existing drainage system and identify flooding hotspots.

The flood modelling and mapping was undertaken in accordance with Melbourne Water standards as described in the *November 2012 Flood mapping guidelines and technical specifications*. Modelling methodologies were also informed by the *DRAFT March 2015 Flood mapping guidelines and technical specifications* where it was considered appropriate.

Flood modelling was undertaken using the combination of a RORB hydrological model to generate rainfall excess catchment flows and a 1D/2D TUFLOW hydraulic model to route flows, and estimate flood depths and velocities. The extent of both models covered the entire future development area for Nyora.

The 18% AEP event and 1% AEP events were modelled as these events represent the objective design capacity of the minor and major drainage systems respectively.

4.2 Hydrology

4.2.1 RORB hydrologic modelling

Engeny developed an undiverted RORB hydrological model to estimate catchment flows across the Nyora development area for the 18% AEP and 1% AEP events. The RORB model was used to produce rainfall excess hydrographs that were input to the TUFLOW hydraulic model.

Subareas were delineated within the RORB model and assigned impervious fraction value. The method employed in delineating subarea boundaries was based on a combination of the following considerations:

- 1% AEP overland flooding behaviour
- separation of areas dependent on underground drainage pipes from those where no underground drainage exists
- existing land use types based on identified planning zones
- proposed land use type based on future precinct areas.

4.2.2 Intensity-Frequency-Duration Data

Intensity-Frequency-Duration (IFD) data for Nyora was sourced from the Bureau of Meteorology using the online IFD tool (AR&R 1987 methodology) and used to estimate catchment rainfall excess hydrographs in RORB.

The adopted IFD parameters are presented in Table 4.1

Table 4.1 IFD parameters for Nyora

Parameter	Value
Intensity - 1 hour duration, ARI = 2 years ($^{2}I_{1}$)	17.89
Intensity - 12 hour duration, ARI = 2 years ($^{2}I_{12}$)	3.96
Intensity - 72 hour duration, ARI = 2 years ($^{2}I_{72}$)	1.15
Intensity - 1 hour duration, ARI = 50 years ($^{50}I_{1}$)	33.31
Intensity - 12 hour duration, ARI = 50 years ($^{50}I_{12}$)	7.2
Intensity - 72 hour duration, ARI = 50 years ($^{50}I_{72}$)	2.21
Skew (G)	0.39
F_2	4.25
F_{50}	15.01

4.2.3 RORB model parameters

The RORB model adopted a runoff coefficient model with parameters consistent with Melbourne Water flood modelling methodology, including:

- Filtered Temporal patterns
- Uniform spatial patterns
- Siriwardena and Weinmann areal reduction factor
- m = 0.8
- Initial loss = 15 mm
- 18% AEP runoff coefficient = 0.25
- 1% AEP runoff coefficient = 0.60.

4.2.4 Fraction Impervious

Fraction impervious values were assigned by land use type for the Nyora township area as presented in **Table 4.2**. All values depicted are based on typical values suggested by Melbourne Water guidelines and verified by inspecting aerial photography with adjustments made as necessary. The table was used to assign a fraction impervious value to all existing land use polygons. In some instances, a polygon was split to vary the fraction impervious based on aerial observations. A fraction impervious for each RORB subarea was then determined based on the fraction impervious values applied to the land use polygons within each subarea.

Table 4.2 Fraction impervious by land use type

Plan Zone	Land Use	Existing conditions Fraction Impervious
PUZ1	Service and Utility	0.2
LDRZ	Low Density Residential Zone	0.25
PPRZ	Public Park and Recreation Zone	0.1
PUZ4	Transport	0.3
PUZ3	Health and Community	0.2
C1Z	Commercial 1 Zone	0.7
PUZ2	Education	0.7
GRZ1	General Residential Zone (Schedule 1)	0.35
FZ	Farm Zone	0.1
PUZ5	Cemetary / Crematorium	0.15
IN3Z	Industrial Zone 3	0.45
PUZ6	Local government	0.1
RDZ2	Secondary and Local road	0.6
RLZ	Rural Living Zone	0.15

4.3 Hydraulics

4.3.1 TUFLOW hydraulic modelling

Engeny developed a two-dimensional hydraulic model for the Nyora township catchments, which have been utilised to determine design flood levels and extents for the 18% and 1% AEP events.

The model adopted a grid size of three meters, which allows for appropriate definition of the catchment terrain and is consistent with recommendations in Melbourne Water's Flood Mapping Guidelines.

4.3.2 1-D Network data

Engeny has modelled all assets identified in Council's GIS as well as those identified in Engeny's site visit to the township, with the exceptions of culverts located under private driveways. The removal of these culverts from the model is not considered to have a significant impact on the results for the events modelled.

Council provided Engeny with concept and detailed plans of pipe alignments not already depicted within Council's GIS layer. Further discussion on the data used and the methodology used to check and the base data is provided in **Section 3.3**

Information regarding the type of each existing stormwater pit was included within Council's GIS pit layer. Side entry and grated pits were modelled as weir type pit inlets to ensure no restriction of flow due to inlet capacity, whilst end walls where modelled as a boundary condition which transfers stormwater into/out of the two-dimensional domain from a 1-dimensianal element (pipe). Junction pits were not modelled.

4.3.3 Pipe and Pits Losses

Tuflow has the ability to automatically determine pit losses. A manhole layer is automatically created and used to apply the losses to the pits. The losses are based the Englehund Method. This method recalculates losses at each time step using the angle of the entry and exit pipes, water levels and flow distributions. Engeny checked the losses calculated by this automatic approach to ensure they are reasonable and flow patterns have been checked to ensure that the pit losses have not resulted in any unexpected surcharges.

4.3.4 Open Channels/Waterways

Within the modeling area there a number of waterways, including several unnamed waterways and Adams Creek, which is located to the north west of the town centre.

Review of the LiDAR found that it provides a satisfactory definition of the waterways and as such it was determined that the waterways can be effectively modelled in the 2-D domain.

Inverts of the waterways, roadside drains along Yannathan Rd and within the railway reserve north of Mitchell Street, and all drainage channels contained with Council's Drainage channel GIS layer were represented in the TUFLOW model using breaklines.

4.3.5 Retarding Basins

There are no formal retarding basins located within the Nyora area, however a number of depressions located upstream of major roads or the railway act as defacto retarding basins and provide varying degrees of attenuation to catchment flows.

4.3.6 Private dams

Over 60 dams were identified within the area covered by the Nyora TUFLOW model. The capacity of these dams to provide retention to flood storage varies and is based on the difference between the dam water surface level (that was picked up by the LiDAR data when the survey was flown) and the surrounding land surface. Given the farm dams are not designated flood storage assets and could be removed by the private land owner at any time, a sensitivity analysis was undertaken with all dams filled to determine the effect of the dams on catchment flows and the flood extent.

The sensitivity analysis found that in most catchments, removal of the dams resulted in an increase in peak 1% AEP flood flows of 5% - 15%. The largest increase in peak flows was found in the north east catchment where removal of a large dam results in a 40% increase in the peak 1% AEP flood flow.

The existing conditions flood maps presented in **Appendix A** represent flooding conditions where dams are included. However the adoption of pre-development conditions flood flows based on conditions where dams are removed requires further discussion with Melbourne Water and other stakeholders.

4.4 Verification

Verification of the existing conditions 1% AEP flood modelling flows was undertaken against the rural rational method. The rural rational method in Victoria adopts Adam's formula to estimate the catchment time of concentration (T_c) based on catchment size, and a 10 year ARI[1] runoff coefficient (0.14 adopted). The method is described in Section 5.4.3. of AR&R (1987). The results of the verification are presented in **Table 4.3**.

[1] ARI terminology as per the AR&R 1987 guidelines. Refer to the Glossary for the definition of this term.

Table 4.3 1% AEP TUFLOW peak flow verification against the rural rational method

Catchment	Receiving Waterway	Area (ha)	Rural Rational (m^3/s)	TUFLOW - dams not filled (m^3/s)	Difference
N1	Adams Creek	129.7	3.05	5.31	74%
N2	Adams Creek	122.3	2.92	4.46	53%
N3	Little Lang Lang River	172.0	3.76	4.78	27%
N4	Little Lang Lang River	18.5	0.69	0.63	-9%
N5	Bass River	53.8	1.56	2.76	77%
N6	Bass River	57.2	1.18	2.05	73%
N7	Bass River	29.3	1.00	1.27	27%
N8	Bass River	20.2	0.76	N/A	N/A

The verification results presented in **Table 4.3** show that the TUFLOW modelled flows are generally between 20 and 80 % higher than the rural rational method. This result is not an unexpected result as all the catchments except N4 and N7 have some low density residential development within them which is likely to increase catchment flows. Catchment N4 was the only catchment where it was found that the TUFLOW model flow was lower than the rural rational method estimate. This result is considered to be due to the attenuation of flow by the defacto detention storage upstream of Glovers Road.

A flow comparison was also undertaken between the existing 1% AEP flows from TUFLOW and the flows from *Nyora Development Services Scheme Summary Report* (Alluvium, 2009). The Development Services (DS) methodology utilised a diverted RORB model to estimate catchment flows for the Adams Creek catchment that incorporates precincts B and C (Engeny catchment N1), and the Little Lang Lang River catchment that incorporates precincts F and G (Engeny catchment N3). The flows for these catchments are presented in **Table 4.4** together with the Engeny TUFLOW results for the base case scenario where existing dams were represented by the LiDAR data and the sensitivity analysis where existing dams are filled.

Table 4.4 Existing conditions 1% AEP event peak flow comparison

Catchment	TUFLOW - base case (m^3/s)	TUFLOW - dams filled (m^3/s)	DS RORB flow (m^3/s)
N1	5.31	5.44	6.1
N2	4.46	4.53	-
N3	4.78	6.68	8.9
N4	0.63	0.65	-
N5	2.76	3.03	-
N6	2.05	2.37	-
N7	1.27	1.44	-
N8	N/A	N/A	N/A

The comparison presented in **Table 4.4** shows the increases in the 1% AEP existing conditions flows between the base case and dams filled scenarios for the various catchments. It also shows that the TUFLOW model flows are lower than the RORB model flows produced for the DS scheme. In both cases it is considered that the difference is predominantly due to the additional (and explicit) accounting of catchment storage that the TUFLOW model provides. This is particularly evident in the Little Lang Lang River catchment (N3) where significant existing defacto detention storages exist upstream of the Lang Lang – Poowong Road and upstream of the Nyora – Wonthaggi Railway.

1% AEP existing conditions flood extents, developed for the Nyora DS scheme, were provided by Melbourne Water and compared to the Engeny TUFLOW model results. A 1D HEC-RAS model is understood to have been used to develop the DS extents. **Figure 4.1** and **Figure 4.2** present a comparison between the two extents for the major flow paths in catchments N3 and N1 respectively.

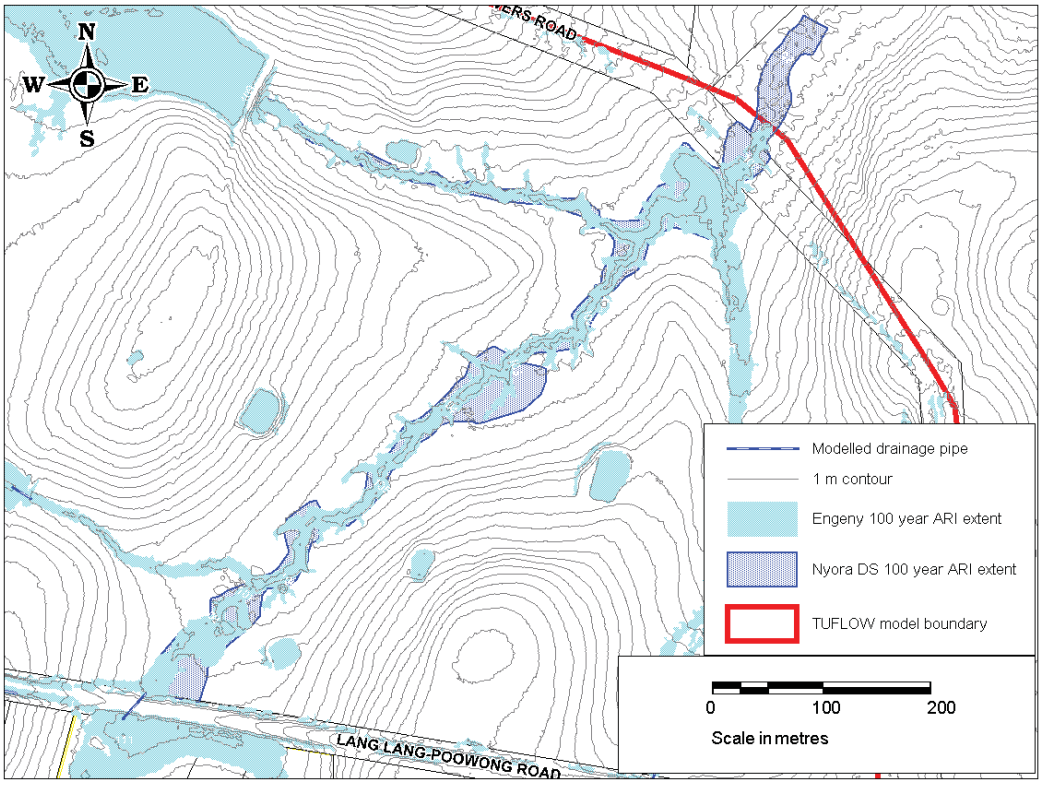


Figure 4.1 Catchment N3 flood extent comparison

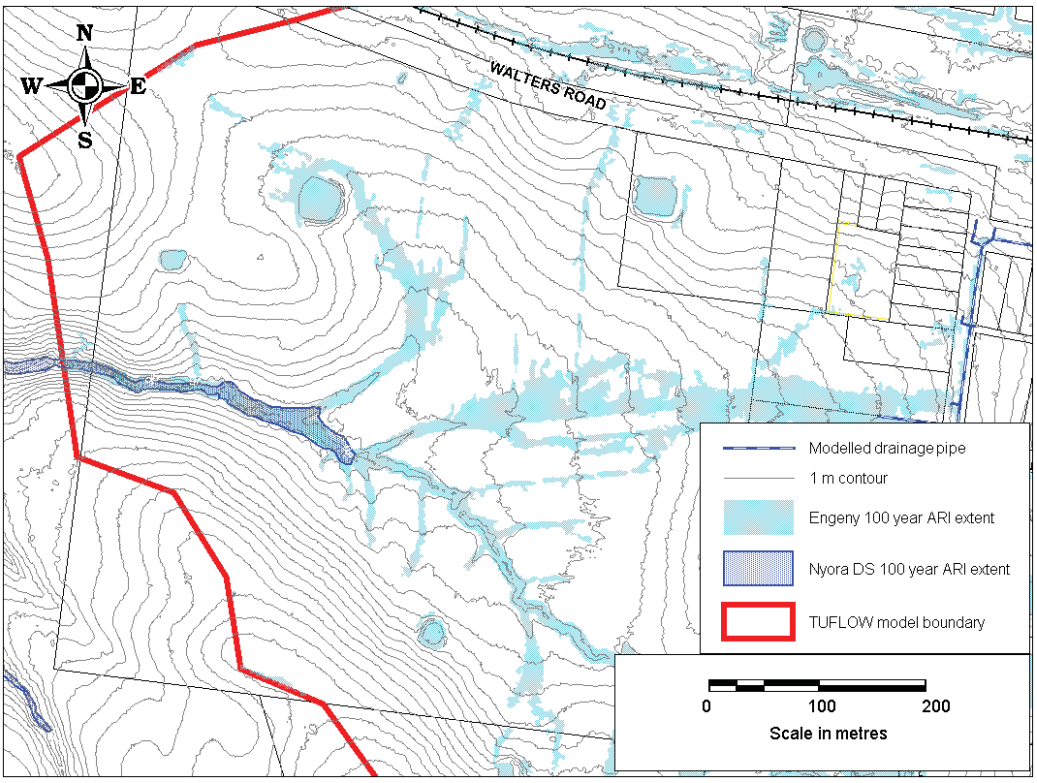


Figure 4.2 Catchment N1 flood extent comparison

Figure 4.1 and **Figure 4.2** show that the existing conditions flood extents generated by the two studies are consistent in most locations and highlight the improved flood shape definition that the 2D TUFLOW flood model provides.

Additional verification of the flood modelling results was attempted with the South Gippsland Flood Management Plan, however the flood maps presented in the report provided insufficient detail to make a meaningful comparison and the background data was not available.

4.5 Existing conditions flood maps

The preliminary flood modelling results for existing climate and development conditions at Nyora are presented for the 1% AEP and 18% AEP events in **Appendix A.**

4.6 Flooding Hotspots

4.6.1 Properties and Roads

The results indicate that significant flooding within private property and inundation of some buildings occurs for existing climate conditions. Locations that have been identified as particularly vulnerable to flooding include the area of low density development south of Hewson Street, the light industrial area near the intersection of Watts Road and Yannathan Road and on the south side of Follett Drive.

Existing flooding was categorised into minor or major flooding with the definitions provided properties, roads and the railway below:

- **Minor** Flooding:
  - properties containing a main flow path as indicated by a flood extent that forms a continuous connection to a waterway
  - roads or railway where flooding is to a depth of ≥ 50 mm.
- **Major** Flooding:
  - properties where flood waters on main flow paths inundates building footprints to a depth of ≥ 100 mm
  - roads or railway where flooding is to a depth of ≥ 200 mm or the velocity depth exceeds 0.35 m^2/s.

The flooding assessment criteria were applied for the 18% and the 1% AEP events to determine the impact of flooding for each event. The number of properties and locations where roads and railways were subject to minor or major flooding for these events is presented in **Table 4.5**.

Table 4.5 Categorisation of existing flooding

Location	18% AEP	1% AEP
Properties with minor flooding	61	98
Properties with major flooding	2	28
Roads with minor flooding	3	6
Roads with major flooding	0	2
Railway with minor flooding	0	2
Railway with major flooding	0	0

The two roads subject to major flooding are Walters Road and Glovers Road.

The two properties subject to major flooding for the 18% AEP event are located on the corner of Henley and Hewson Street and on Yannathan Road respectively.

Resolving the flooding at these locations and the large number of properties subject to major flooding for the 1% AEP event and roads that are inundated are key issues to be addressed by the stormwater management strategy.

Figure 4.3, **Figure 4.4** and **Figure 4.5** show the 1% AEP flooding in the Walter Street, Yannathan Road and Follett Drive areas respectively. The figures also show properties affected by major flooding for the 1% AEP and 18% AEP events.

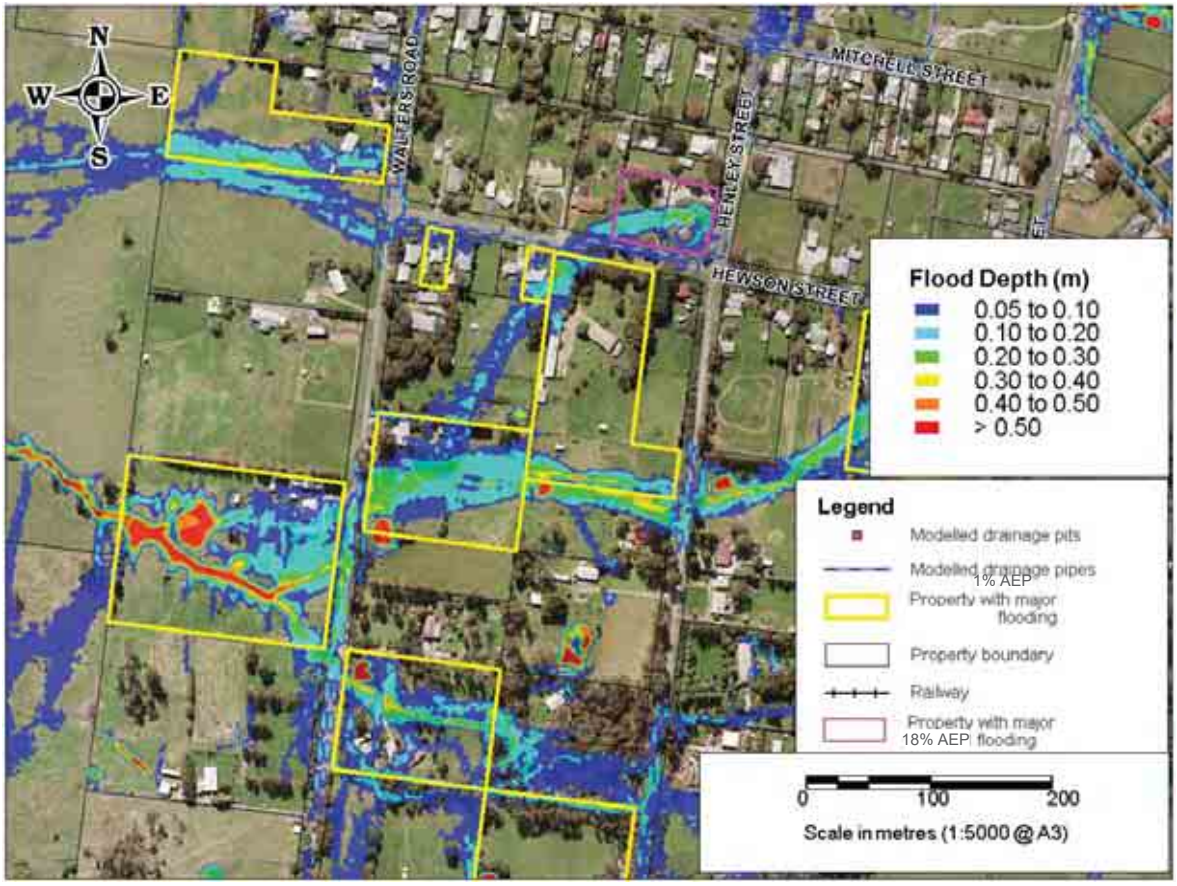


Figure 4.3 1% AEP flooding in the Walter Street area

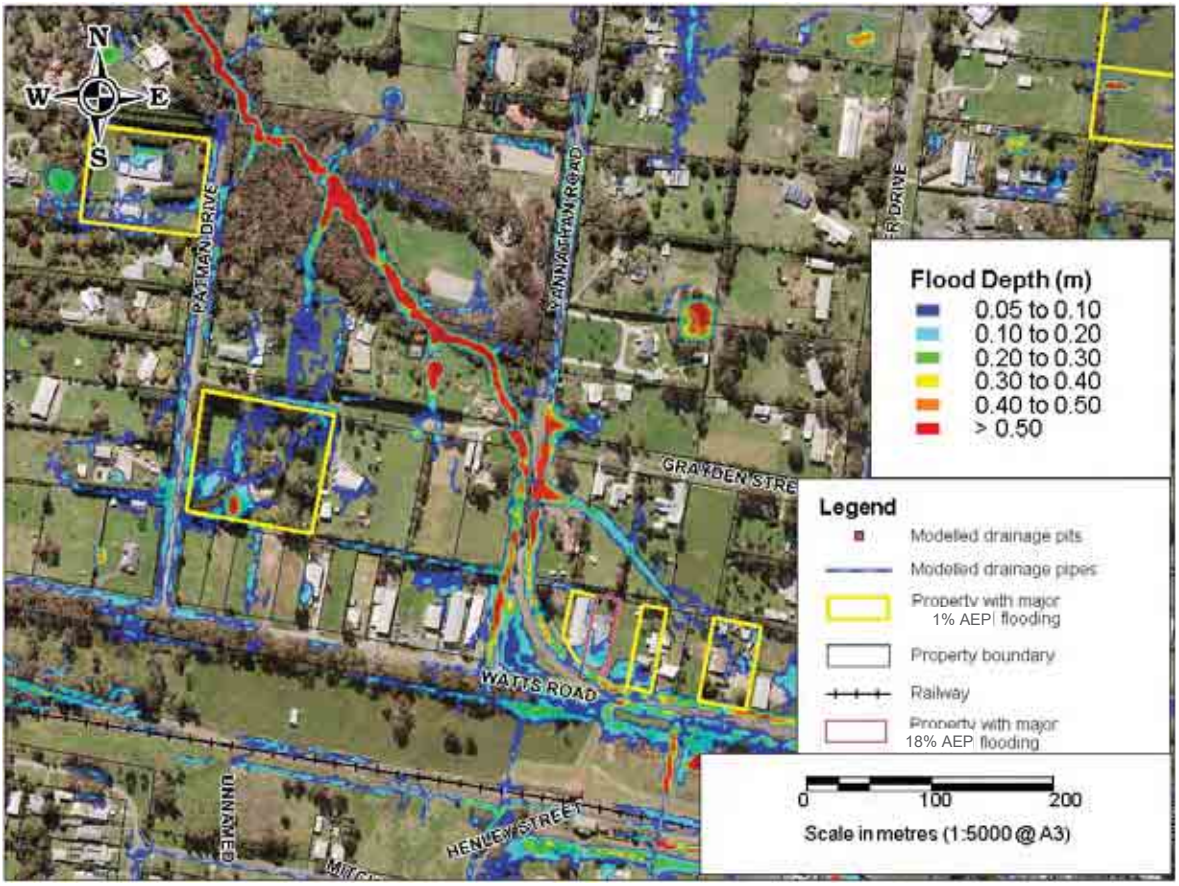


Figure 4.4 1% AEP flooding in the Yannathan Road area

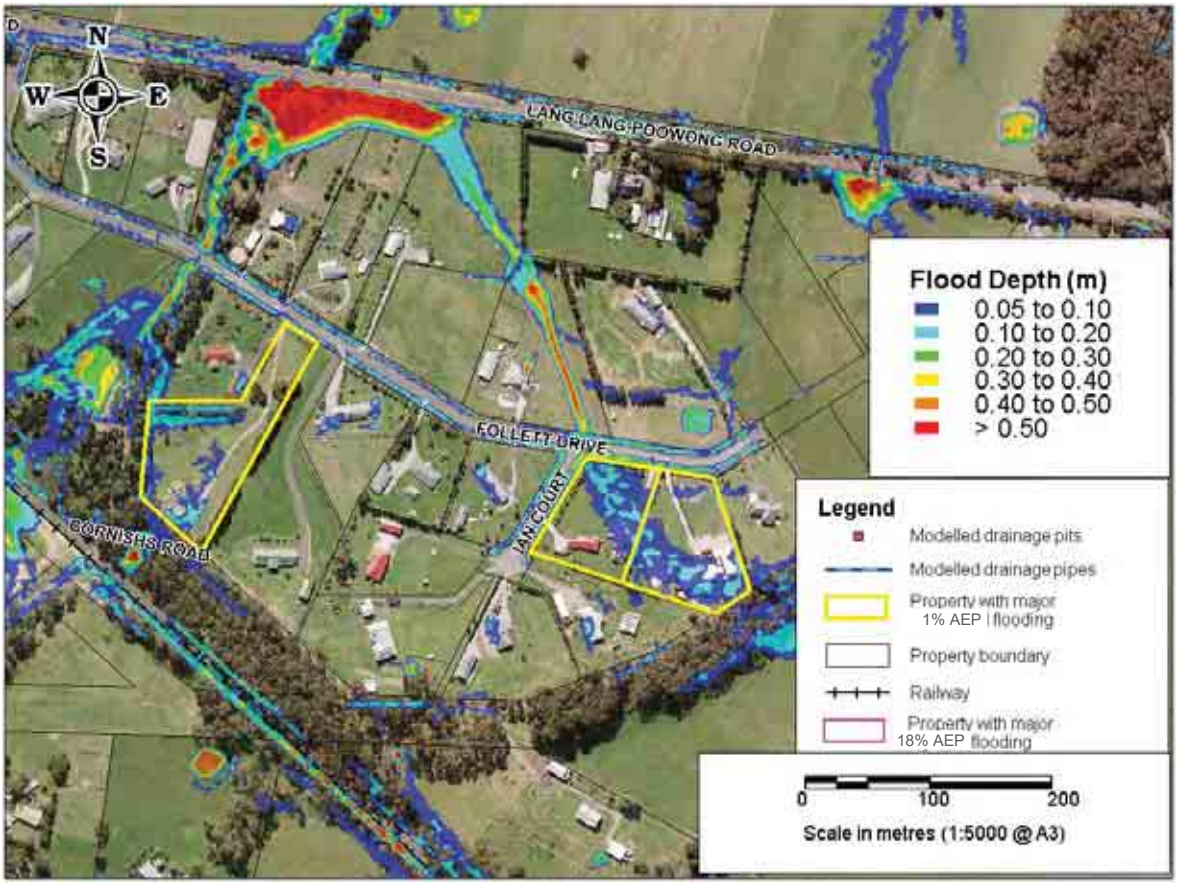


Figure 4.5 1% AEP flooding in the Follett Drive area

4.6.2 Pipe drainage system capacity

With the exception of the approximately 320 m long reach of pipe that starts at Mitchell Street and continues west before entering Walter Street and joining the Hewson Street pipe system, all underground pipe systems have a standard of less than the 18% AEP.

4.6.3 Open channel drainage system capacity

The modelling indicated that the open channel drainage system is generally able to convey the 18% AEP event with only minor local flooding occurring to road shoulders.

5. ISSUES AND OPPORTUNITIES

5.1 Strategic Opportunities

The stormwater management strategy for Nyora has the opportunity to address existing flooding problems and set a strategic direction for implementing best practice, multifunctional stormwater assets that achieve the primary water quality, drainage and flood mitigation objectives and also provide environmental, public amenity and other benefits to the community.

Liveability and resilience should be incorporated into all new developments. With respect to stormwater management, this involves utilising the stormwater as an asset for the community whilst ensuring fundamentals such as flood protection, safety with respect to flow management and water supply security are maintained. This can be achieved through incorporation of best planning practices for stormwater management during the development of the urban structure.

Nyora is located within Melbourne Water management zone and some of the stormwater assets proposed as part of the strategy may ultimately be managed and maintained by Melbourne Water. As a key stakeholder it is therefore intended that Melbourne Water is involved in the strategy development (please refer to Section 6 for further discussion).

5.2 Strategic Issues

A number of strategic stormwater issues have been identified and used as a basis for developing objectives for the stormwater management strategy:

- Existing flooding problems:
  - Resolve or identify flooding at all existing properties affected by major flooding for events up to the 1% AEP by upgrading the existing pipe system and implementing planning controls such as LSIO where appropriate.
  - Use structural measures such as pipe and road upgrades to resolve flooding at all roads affected by major flooding for events up to the 1% AEP and minor flooding for events up to the 18% AEP event.
  - Determine an appropriate planning mechanism that fairly apportions the cost of resolving existing flooding.

- Development in flood-prone areas:
  - Propose structural and non-structural measures to prevent future development being subject to flooding or increasing flooding elsewhere in the catchment.
  - Structural measures include appropriate planning for the major and minor drainage system to the standards required by Melbourne Water and the Infrastructure Design Manual (IDM).

- Non-structural measures include drainage easements, planning overlays and developer contribution schemes.

- Legal issues regarding drainage outlet permission:
  - Identify discharge locations for properties and parcels.
- Downstream impacts to existing landowners and the environment:
  - Determine appropriate discharge criteria to apply to future developments.
- Increased pollution in stormwater runoff from urbanisation:
  - Develop a water quality strategy that meets or exceeds the best practice environmental management water quality treatment objectives.
  - Propose assets that achieve best practice water quality requirements.
- Reduced annual rainfall due to climate change resulting in increased pressure on the potable water supply:
  - Build in resilience against climate change by investigating opportunities for stormwater and rainwater harvesting.
- Increased rainfall intensity due to climate change resulting in increased flooding:
  - Propose further investigations to identify the impact of increased rainfall intensity on climate change.
- Poor public amenity due to intrusive drainage infrastructure development:
  - Strategy should propose stormwater assets that are in keeping with and enhance public amenity and the natural environment.
- Damage to the environment as a result of future drainage infrastructure:
  - Protect key waterways and locations where the Giant Gippsland Earthworm and other protected species exist. Piping existing open channels and constructing other drainage infrastructure in locations where Giant Gippsland Earthworms are known to exist could have a detrimental impact to their survival. This should be carefully considered as part of the final drainage strategy.

5.3 Precinct based issues and opportunities

5.3.1 Precinct A – Town Centre

- The station area could be utilised to construct a detention storage to provide attenuation for development flows from the catchment located approximately east of Henley Street that discharges north across the railway. Depending on the future development plan for this area, the detention storage could be underground or an

above ground retarding basin. There is potential that the storage could be sized to attenuate existing catchment flows to provide some flood relief for properties on the north side of the railway. However further investigation is required to determine the effectiveness of this solution given the relatively small upstream catchment area. There is also potential that a storage located here could be utilised for stormwater harvesting.

- Back of kerb bioretention basins and tree pits could be utilised on Mitchell Street to provide water quality treatment.
- Pipe upgrades on Henley Street and Mitchell Street are required to provide 18% AEP standard for existing and future development.
- Water quality treatment for the catchment draining south west could be provided by an end of line wetland located in Precinct C or vegetated swales, bioretention basins and treepits depending on the development timing of the Precinct C development.
- Rainwater harvesting opportunities to be considered as part of redevelopment strategy to contribute towards the water quality objectives in this area.

5.3.2 Precinct B – Nyora Central

- Future road alignments or a drainage corridor should be aligned to convey the two main overland flowpaths if possible.
- Main trunk drains should be sized to convey the future 18% AEP fully developed flow and located under the main overland flow paths.
- Preferred water quality treatment and flow control is by end of line wetland and retarding basin located in Precinct C. However given precinct is likely to be developed after Precinct B locations for vegetation swales and bioretention basins adjacent to road sides and within public open spaces should be considered.

5.3.3 Precinct C – Nyora West

- Future major and minor drainage system to service development area.
- Water quality treatment by end of line wetland which could potentially be used to treat flows from the upstream precinct areas.
- Establish a waterway corridor with appropriate buffers around existing waterway.
- Look for opportunities for stormwater and rainwater harvesting.

5.3.4 Precinct D – Nyora North

- Isolated catchment that can be constructed at any time and independently to other precincts.
- Future major and minor drainage system to service development area.
- End of line wetland and retarding basin
- Look for opportunities for stormwater and rainwater harvesting.

5.3.5 Precinct E – Low Density Residential 1

- Drainage easement to convey flows into Precinct F at the north east corner of Hatchs Road.
- Underground pipe network construction to replace open channels with priority given to upgrading the underground pipe drainage system on Yannathan Road and the Lang-Lang Poowong Road.
- No end of line option is available within the development area therefore treatment provided in vegetated roadside swales and bioretention basins.
- Stormwater harvesting/detention storage should be considered at the Pony club as an alternative to mandating onsite detention.
- Consider implementation of an LSIO on Adam's creek.

5.3.6 Precinct F – Nyora East

- End of line retarding basin and wetland subject to proposed Wallis Watson subdivision

5.3.7 Precinct G – Low Density Residential 1

- Opportunity to mitigate flooding in precinct G and harvest stormwater for use on the Nyora Primary School by converting the existing storage located north of the railway and formalising the upstream flowpath. Modification to this storage could be undertaken provide at least a partial offset of the increase inflows resulting from future infill development
- Additional attenuation of development flows could be undertaken by formalising the defacto storage upstream of the Lang-Lang Poowong Road. However it is noted that this this may impact the habitat of the Giant Gippsland Earthworm and may require the procurement of private property.
- Consider negotiating with Precinct F development to enlarge wetland and retarding basin to cater for fully developed flows and treatment requirements from this

precinct. This could potentially be undertaken in combination with an upgrade of the culvert capacity under the Lang Lang – Poowong Road which would alleviate flooding and increase the developable land in this location.

- Consideration should be given to constructing a retarding basin to mitigate future development flows either immediately upstream of the Lang Lang – Poowong Road or further up on the main drainage land. Both options could potentially

- Construct a drainage easement containing a shallow open channel on the east side of Ian Court to intercept upstream catchment flows causing flooding to existing properties.

- Depending on resolution regarding Precinct F water quality treatment, bioretention basins and vegetated swales could be adopted to provide water quality treatment.

5.3.8 Precinct H – Rural Lifestyle

- No change.

6. STORMWATER MANAGEMENT STRATEGY DEVELOPMENT

6.1 Drainage

The drainage system should be designed to ensure no flooding of private property occurs in events up to the 1% AEP and that the stormwater runoff can be safely conveyed through the development to the receiving waterway. To achieve this a minor / major drainage system philosophy is proposed.

The following provides a basis for the development of the stormwater management strategy Based on the further investigations undertaken will cement these strategies.

6.2 Minor Drainage System

The minor drainage system will consist of a subsurface pipe network designed to capture and convey all stormwater runoff generated from the catchment for rainfall events up to and including the 18% AEP design storm.

6.3 Major Drainage System

The primary objective of the major drainage system is to provide flood protection for the allotments from the 1% AEP storm event and to ensure the overland flow can be safely conveyed through the development. This will be via overland flow paths contained within road reserves prior to discharging into a drainage or waterway reserve.

6.4 Retarding Basins

In some locations retarding basins will be required to mitigate the increase in catchment flows that will occur with development.

Further discussion with Melbourne Water is recommended to determine whether flows estimated with or without the presence of the dams should be adopted.

6.5 Waterway Corridors

The preservation of existing waterway corridors will be driven by environmental, public amenity and other factors together with consideration of stormwater requirements such as the grade and flow capacity requirements.

Waterway corridors may need to be augmented to protect them against increased flows from the development that may enter the waterway before retardation can occur. Alternatively distributed measures such as on-site detention considered to reduce inflows to the waterway and reduce the need for protection works.

6.6 Water Sensitive Urban Design (WSUD)

The State Environment Protection Policy (Waters of Victoria) defines the required water quality conditions for urban waterways. Section 56.07-4 of the Victorian Planning Provisions set the stormwater treatment targets required for residential development in Victoria in order to comply with SEPP and the Planning Scheme. The aim of stormwater quality treatment is to reduce typical pollutant loads from urban areas to Best Management Practices as defined in the following targets:

Table 5.1 Best Practice Pollutant Reduction Targets

Pollutant	Performance Objective
Total Suspended Solids (TSS)	80% reduction from typical urban load
Total Phosphorous (TP)	45% reduction from typical urban load
Total Nitrogen (TN)	45% reduction from typical urban load
Gross Pollutants (GP)	70% reduction from typical urban load

Source: Urban Stormwater: Best Practice Environmental Management Guidelines – Victorian Stormwater Committee, 1999.

End of line wetlands are the preference for providing water quality treatment at Nyora. As well as providing the required water quality treatment, wetlands will provide habitat value, visual amenity and are considered to be more aligned with the existing environmental character than other treatment measures. However the viability of constructing a large online wetland that treats runoff from multiple precincts will depend on the suitability of the terrain and development timeframes. In many precincts, particularly the infill development areas such as precincts E, G and B distributed water quality measures such as bio-retention basins, swales is likely to form a key part of the strategy.

A summary of the water sensitive urban design elements that will be considered for the water quality strategy is presented in **Appendix B**.

7. WHERE TO NEXT

The following summarises the next steps for the development of the Nyora stormwater strategy:

- Meet with Melbourne Water to discuss the findings of the existing conditions modelling work and the proposed strategies for each precinct. Determine appropriate existing conditions flow attenuation parameters for each waterway.
- Adopt existing conditions flood modelling results subject to approval by Council.
- Workshop the results of the drainage investigation to determine an appropriate development strategy for each precinct including staging of development and works.
- Identify the appropriate mechanism for procuring funding for stormwater assets for each catchment.
- Model fully developed conditions to determine catchment flows for sizing of the major and minor drainage system and retarding basins.
- Undertake MUSIC water quality modelling to determine the redevelopment strategy.
- Develop a stormwater management plan in accordance with Infrastructure Design Manual requirements including preliminary cost estimates for proposed assets.

8. QUALIFICATIONS

a. In preparing this document, including all relevant calculation and modelling, Engeny Water Management (Engeny) has exercised the degree of skill, care and diligence normally exercised by members of the engineering profession and has acted in accordance with accepted practices of engineering principles.

b. Engeny has used reasonable endeavours to inform itself of the parameters and requirements of the project and has taken reasonable steps to ensure that the works and document is as accurate and comprehensive as possible given the information upon which it has been based including information that may have been provided or obtained by any third party or external sources which has not been independently verified.

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g. This report does not provide legal advice.

9. REFERENCES

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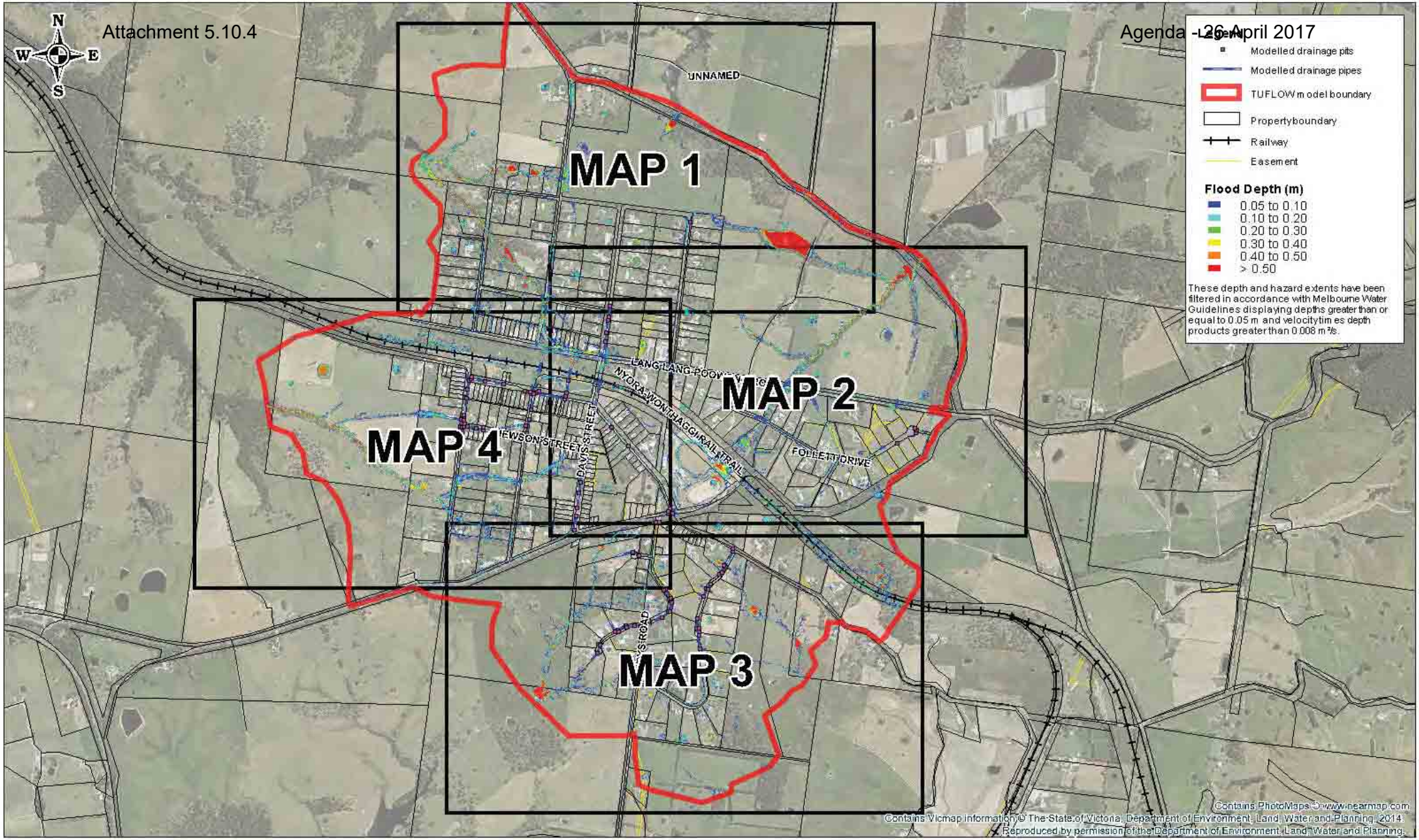
APPENDIX A

Existing Conditions Flood Maps



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Scale in metres (1:15000 @ A3)

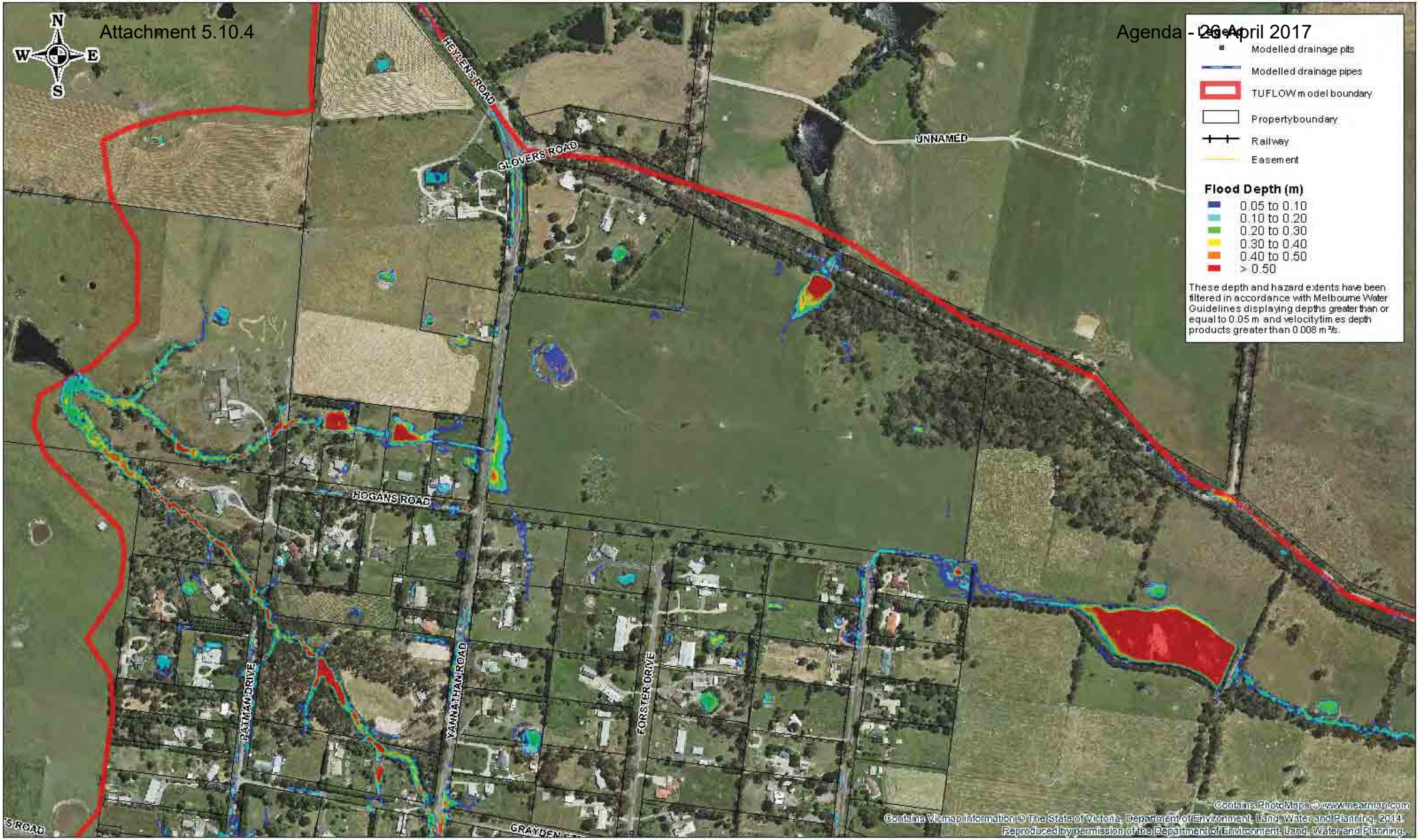
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994, (GDA94)
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

Nyora Development Strategy

18% AEP Existing Conditions Flood Map

Key Map

Job Number: V1128_001
Revision: 0
Drawn: MM
Checked: NEA
Date: 13 January 2016



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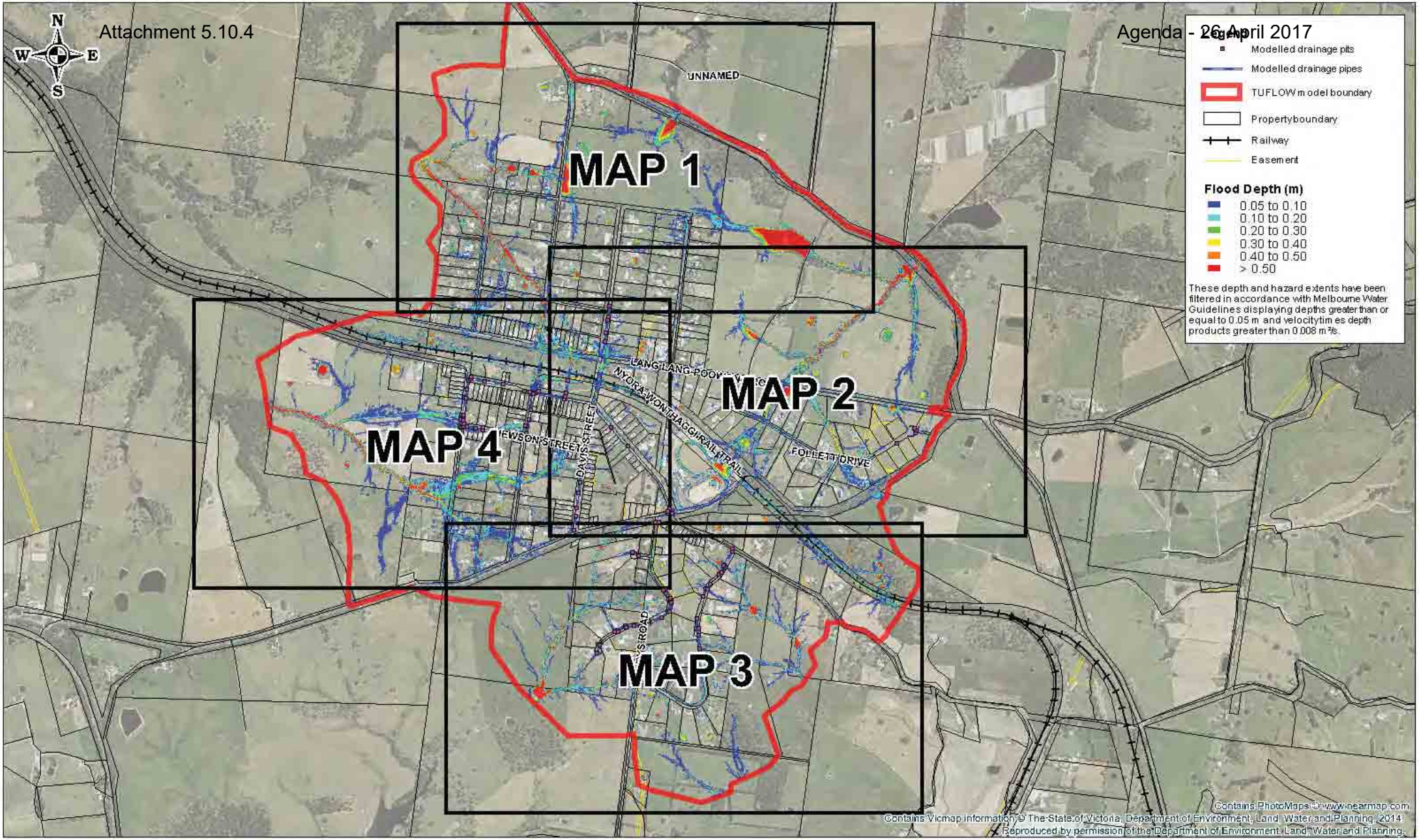

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1% AEP Existing Conditions Flood Map

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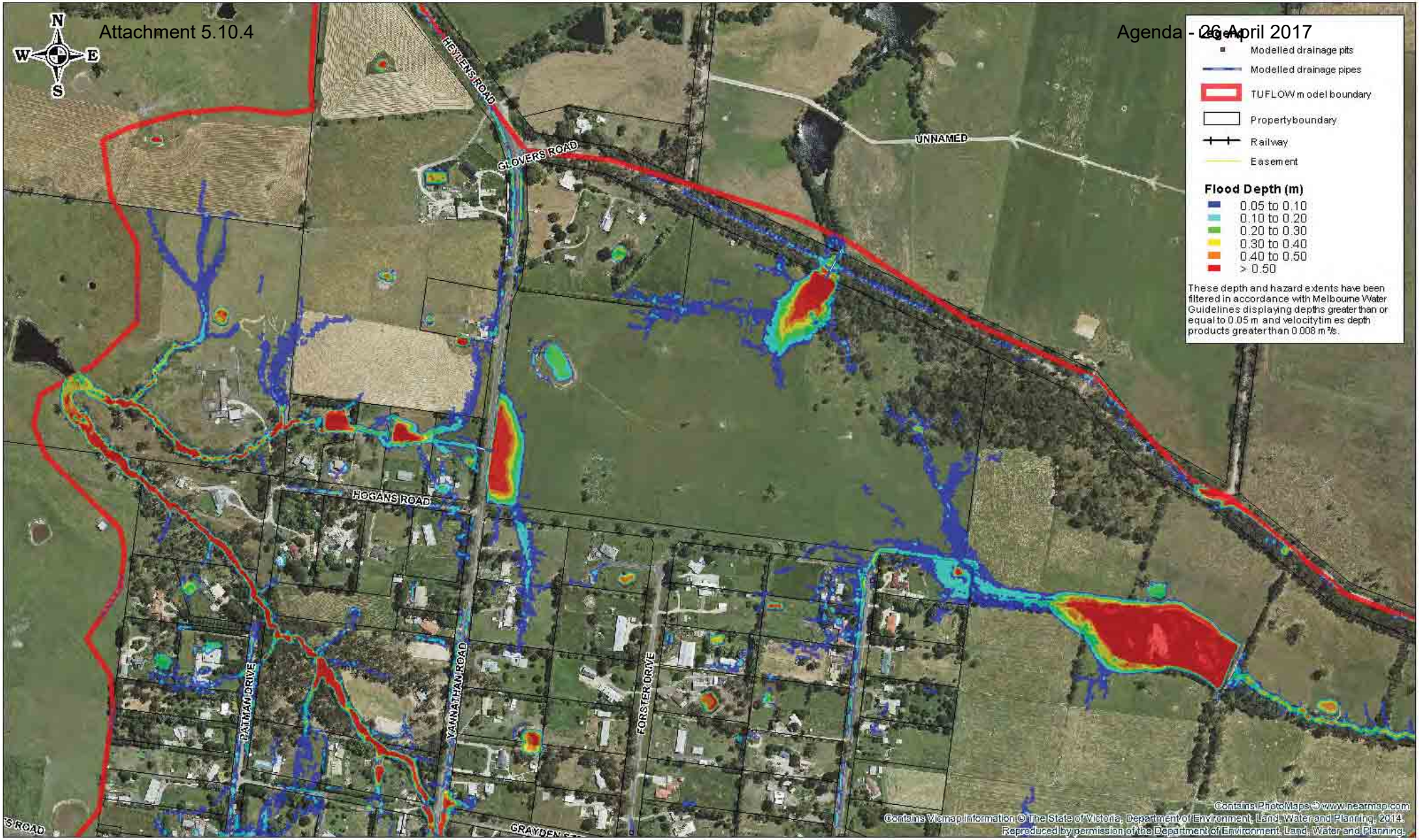

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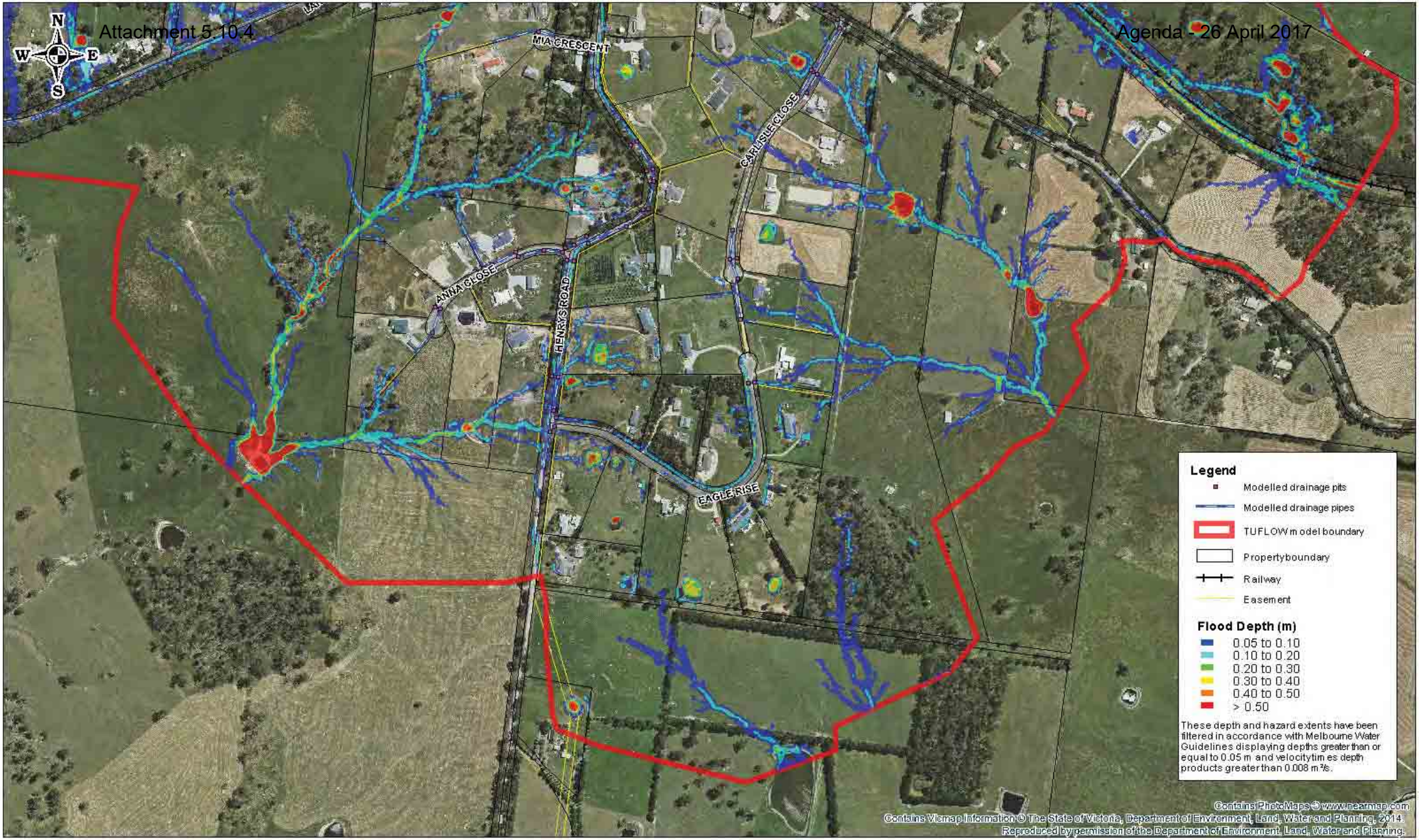

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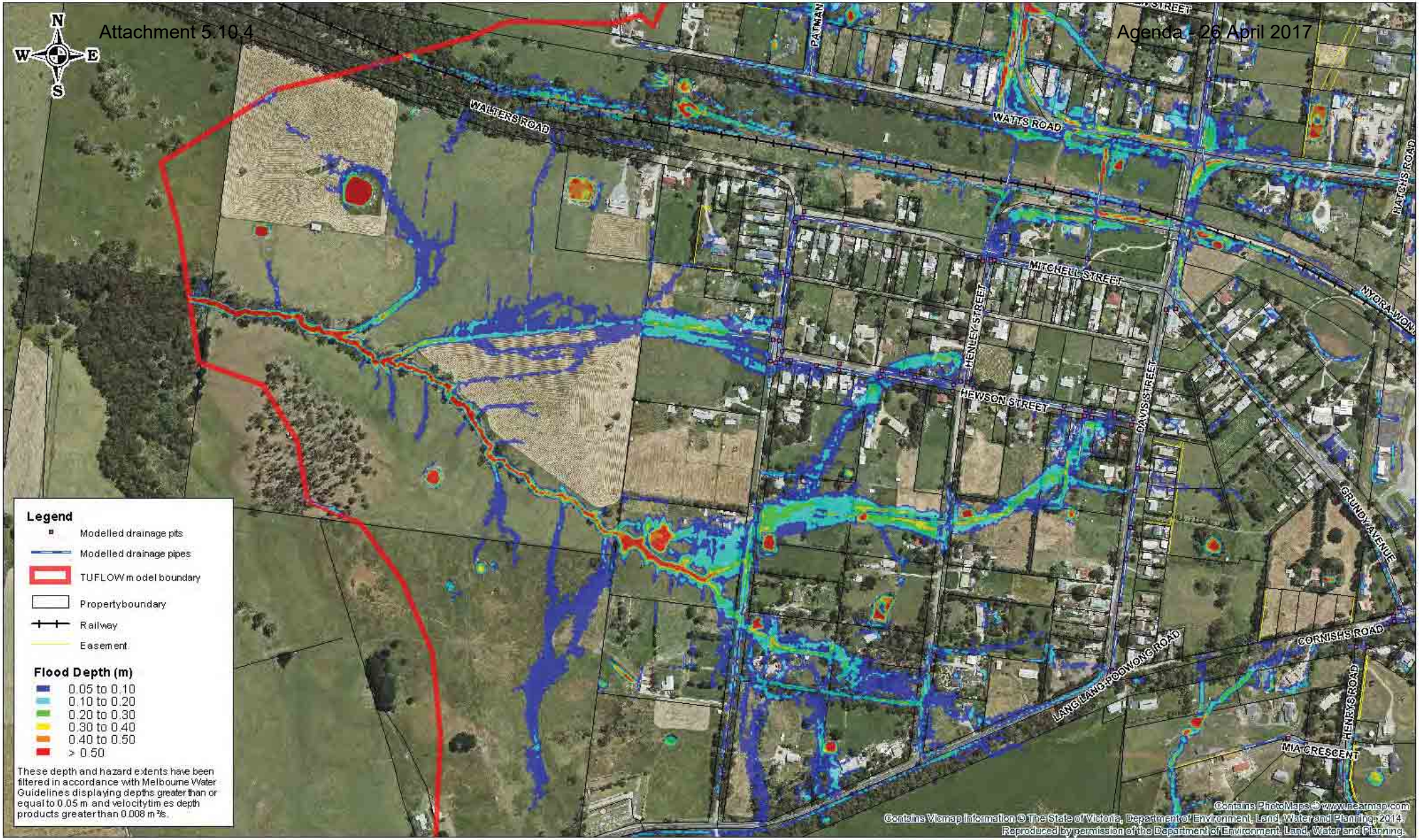

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1% AEP Existing Conditions Flood Map

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APPENDIX B

Water Sensitive Urban Design Elements

Rain Gardens

Rain gardens, otherwise known as bio-retention basins, are specifically designed to integrate gardens into the stormwater management systems of the site. Bioretention systems treat stormwater by percolation through a vegetated soil media (typically sandy loam). A rain garden will offer a landscape component to the site.

Bioretention Planter Box

Bioretention planter boxes are simply rain gardens, but in a planter box instead of flush with the ground. A planter box can create a nice aesthetic for a building, and can combine with a contemporary sculpture that conveys water from a downpipe to the box to add an architectural value.

Roof Garden

Roof gardens, also referred to as green roofs, are simply gardens or areas of greenery on roof tops. Since roof tops are 100% impervious area, roof gardens act to capture and filter stormwater, reducing the amount of runoff generated by a roof top and subsequently removing the pollutants associated with the stormwater.

Roof gardens can also assist to create a more energy efficient building. Reducing the amount of concrete or impervious area on a roof top effectively reduces the heat absorption and hence,

reducing the overheating effect of the roof top. The roof gardens provide a form of insulation for the building which may lead to substantial energy savings.

Implementation of roof gardens would need to be considered in the planning stage of buildings as the roof must be designed to cater for the additional loads generated by the gardens and the temporary storage of stormwater in these gardens.

Permeable Pavements

Permeable pavements promote infiltration of stormwater runoff to either the soil below or to a water storage reservoir below.

The structure of permeable pavements is relatively simple. They consist of the pavers, laid with a gap in between each paver, on a sand or fine gravel base with a layer of geotextile fabric between the base and a sub base of coarse aggregate. Pervious concrete and pervious gravel can also be considered a form of permeable pavements.

There are 2 main advantages of permeable pavements over traditional pavements; improved water quality through filtering, interception and biological treatment and flow attenuation through infiltration and storage.

The concept of permeable pavements is enticing, but careful design is required if the pavement requires vehicular traffic. Also, installation of permeable pavements alone will not meet the best practice targets for pollutant reductions as specified in the *Urban Stormwater: Best Practice Environmental Management Guidelines* (Victorian Stormwater Committee, 1999)

Rainwater Tanks

Rainwater tanks are used for harvesting stormwater for reuse. They capture stormwater runoff, primarily from roof tops, and store it for reuse. Applications of reuse include garden watering and toilet flushing. This effectively reduces the demand on reticulated potable water, while reducing the volume of stormwater runoff and the pollutants associated with the runoff.

Water reuse for a site is becoming increasingly popular with the uncertainties surrounding climate change. A rainwater tank can add value to this development, but alone will not meet the best practice targets for pollutant reductions.

Wetlands

Constructed wetland systems are an end of pipe solution to water quality. The primary function of wetland systems is to remove pollutants associated with fine particulates and dissolved contaminants. Wetlands are constructed to mimic a natural habitat and are generally located immediately upstream of a receiving waterway.

Whilst wetlands are effective at pollutant removal and provide an aesthetic water feature, they also have the largest footprint of all the above mentioned treatments.

Gross Pollutant Traps (GPT)

Gross pollutant traps (GPT) are used as a primary treatment measure to remove litter, debris and coarse sediments.

GPT's are advantageous in that they can be located underground in the form of a large drainage pit. They do, however, only remove a small portion of total phosphorous and total nitrogen from the runoff, only that which is attached to the coarse sediments being retained in the trap.

GPT's require regular manual maintenance to clean out the litter and debris, but are an ideal treatment for removal of unsightly gross pollutants as they have a very small footprint.

Vegetated Swales

Grass swale (Photo courtesy of Melbourne Water)

Vegetated swale conveying road runoff

(Photo courtesy of Melbourne Water)

Swales are linear depression of channels that provide for stormwater collection and conveyance. Swales may simply be grass-lined or more densely vegetated and/or landscaped. While swales provide for stormwater conveyance, they also lend to the screening or removal of gross pollutants, such as litter and coarse sediment, from stormwater runoff.

Swales are often used pre-treatment of stormwater at a streetscape level in lieu of the conventional piped drainage network. They are generally located in the nature strips or the central medians of roads. Swales are not a new concept however as they are often used instead of kerb and channel and can appear as a typical road verge in low density residential areas, on rural roads and highways.

Sedimentation Basins

Sedimentation basins are basins specifically designed to remove medium to coarse sized suspended solids via a settling process. Sedimentation basins use temporary detention to promote sediment settling and reduction of velocities. These basins can either be permanent or used as a temporary measure during construction.

Infiltration Trenches

Lynbrook Estate Infiltration Trench (Photo courtesy of Melbourne Water)

An infiltration trench is a shallow, excavated trench filled with gravel or rock, through which run-off drains. The purpose of infiltration trenches is to remove particulate and soluble contaminants from stormwater by passing the runoff through a filter medium. The effectiveness of the pollutant removal is determined by the type of filter medium used in the trench.

Infiltration trenches offer a recharge to ground water however are susceptible to clogging and do have the potential to cause ground water contamination.

APPENDIX B

TUFLOW model results

1% AEP developed conditions with **no** mitigation works

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0 100 200
Scale in metres (1:5000 @ A3)

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994, (GDA94)
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

Nyora Storm Water Management Plan

100yr ARI Developed Conditions Flood Map

Map 1 of 4

Job Number: V1128_001
Revision: 0
Drawn: NEA
Checked: AP
Date: 22 Jun 2016

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0 100 200
Scale in metres (1:5000 @ A3)

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994, (GDA94)
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Grid: Map Grid of Australia, Zone 55

Nyora Storm Water Management Plan

100yr ARI Developed Conditions Flood Map

Map 2 of 4

Job Number: V1128_001
Revision: 0
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Date: 22 Jun 2016

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0 100 200
Scale in metres (1:5000 @ A3)

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994, (GDA94)
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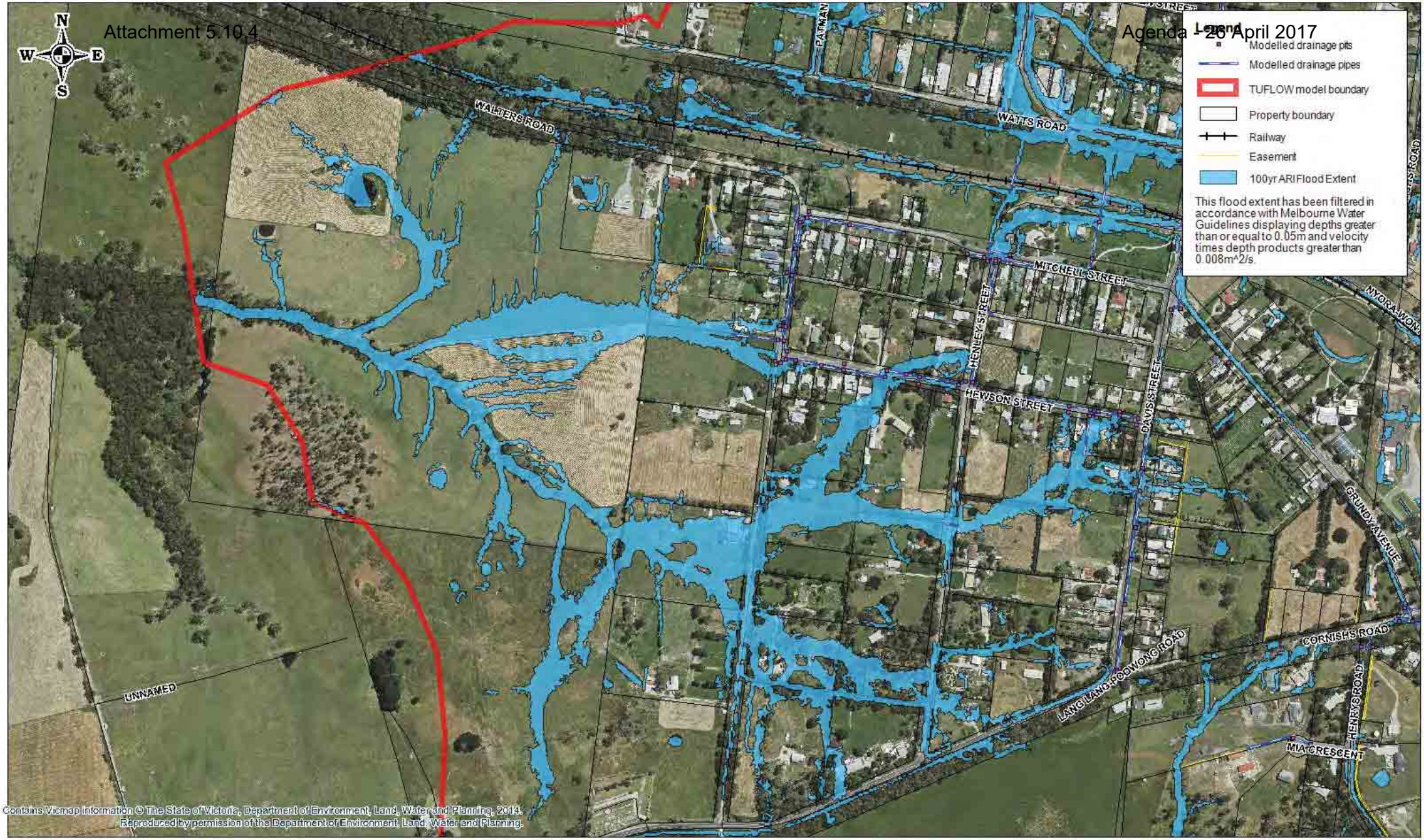
Grid: Map Grid of Australia, Zone 55

Nyora Storm Water Management Plan

100yr ARI Developed Conditions Flood Map

Map 3 of 4

Job Number: V1128_001
Revision: 0
Drawn: NEA
Checked: AP
Date: 22 Jun 2016



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0 100 200
Scale in metres (1:5000 @ A3)

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994, (GDA94)
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

Nyora Storm Water Management Plan

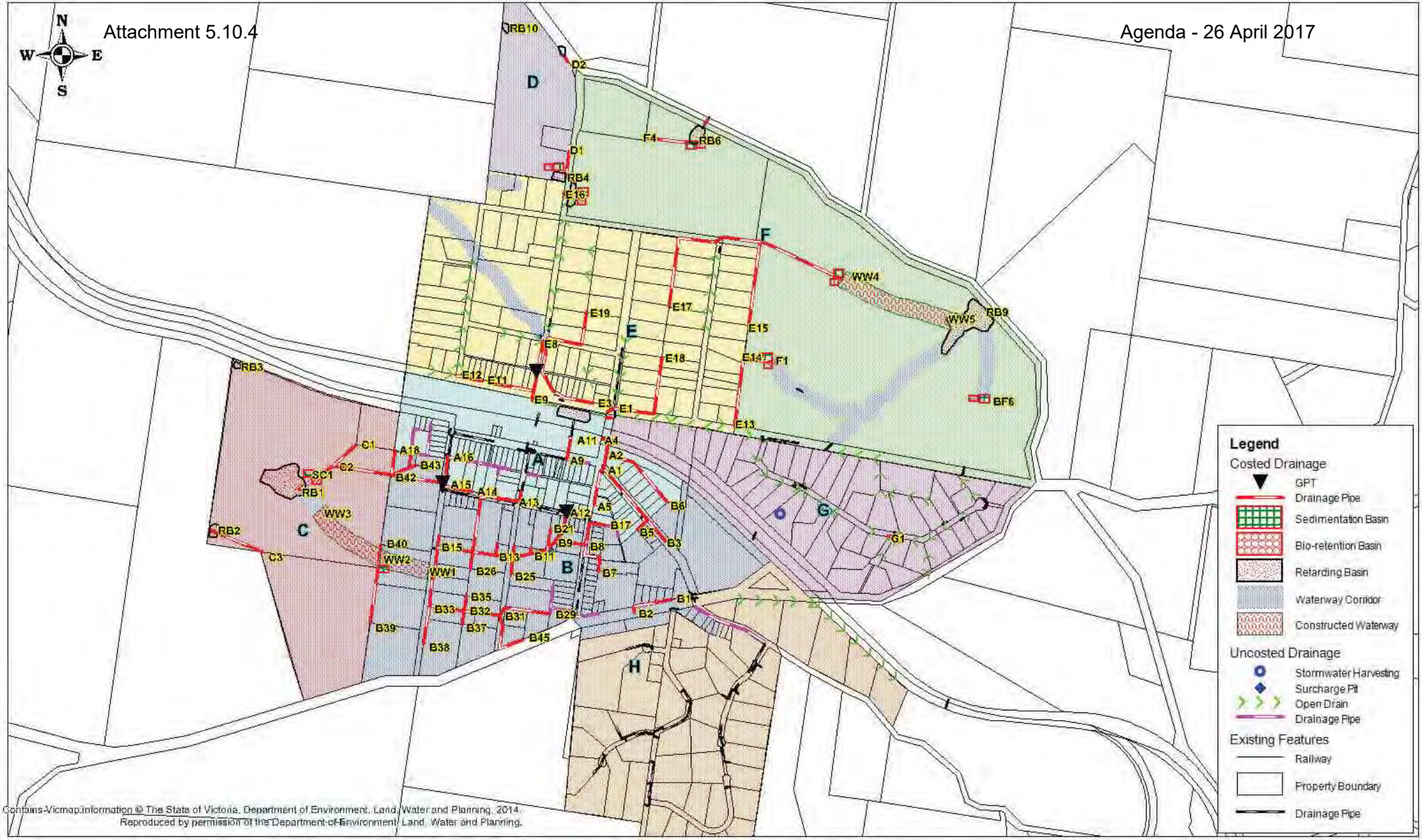
100yr ARI Developed Conditions Flood Map

Map 4 of 4

Job Number: V1128_001
Revision: 0
Drawn: NEA
Checked: AP
Date: 22 Jun 2016

APPENDIX C

Ultimate Stormwater Management Plan



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Scale in metres (1:12500 @ A3)

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994, (GDA94)
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

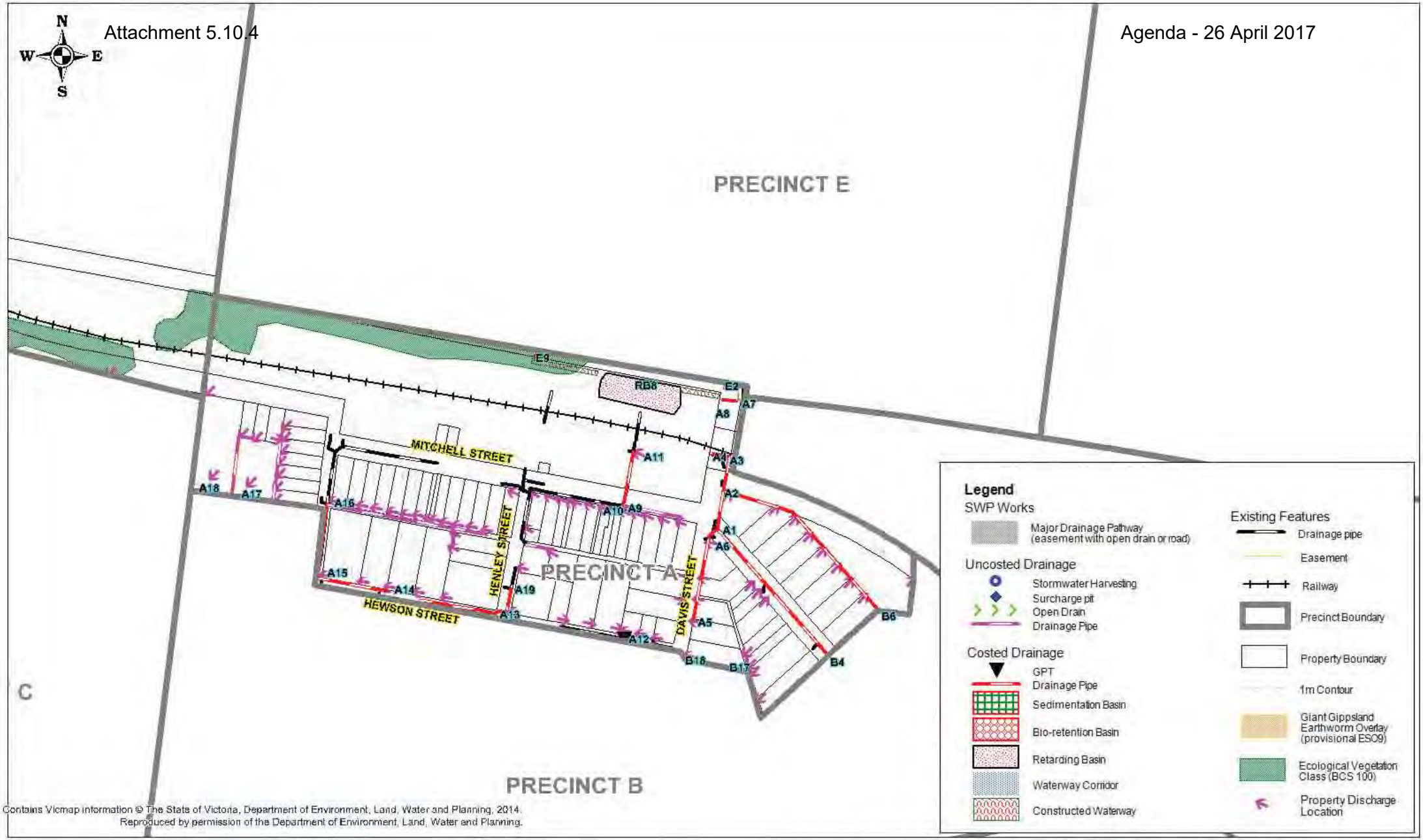
Nyora Storm Water Management Plan

OVERVIEW

Job Number: V1128_001
Revision: 0
Drawn: NEA
Checked: AP
Date: 10 Jun 2016

APPENDIX D

Stormwater management by precinct



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0 100 200
Scale in metres (1:5000 @ A3)

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994, (GDA94)
Vertical Datum: Australia Height Datum
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Nyora Storm Water Management Plan

PRECINCT A

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Revision: 0
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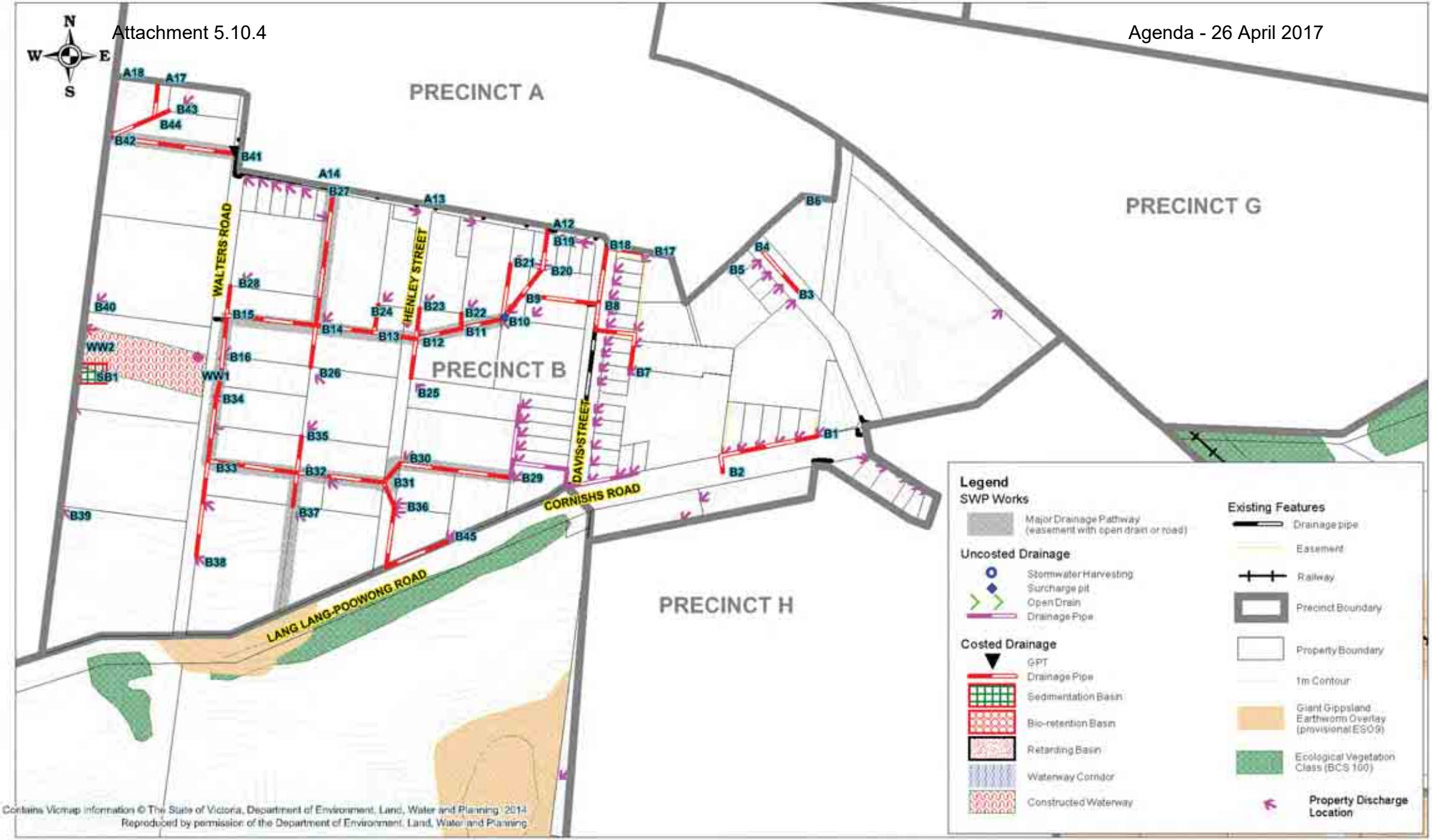
Date: 10 Jun 2016



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Scale in metres (1:5000 @ A3)

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Horizontal Datum: Geocentric Datum of Australia 1994 (GDA94)
Vertical Datum: Australia Height Datum
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Nyora Storm Water Management Plan

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Revision: 1
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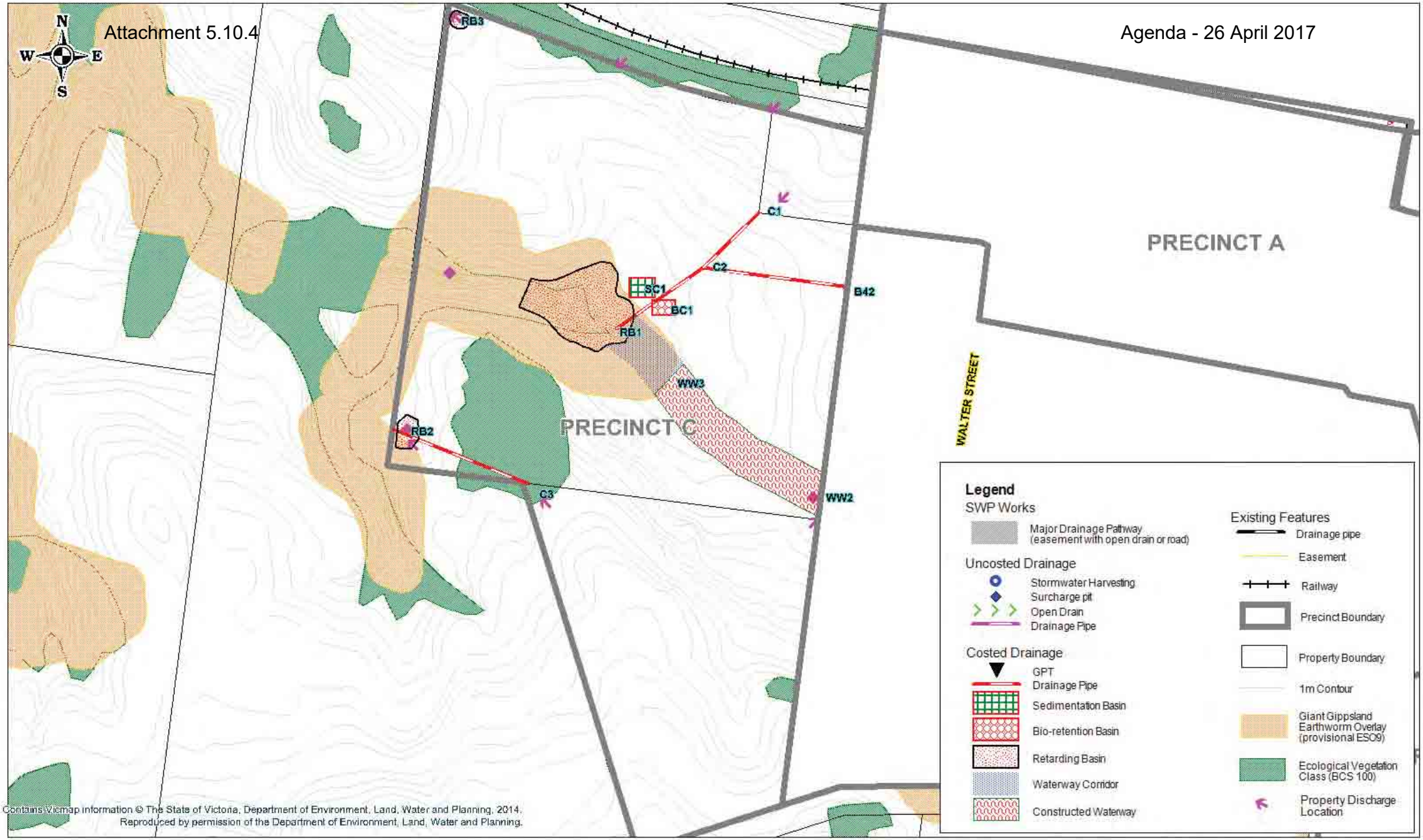
Date: 18 Jul 2016



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0 100 200
Scale in metres (1:5000 @ A3)

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Vertical Datum: Australia Height Datum
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Nyora Storm Water Management Plan

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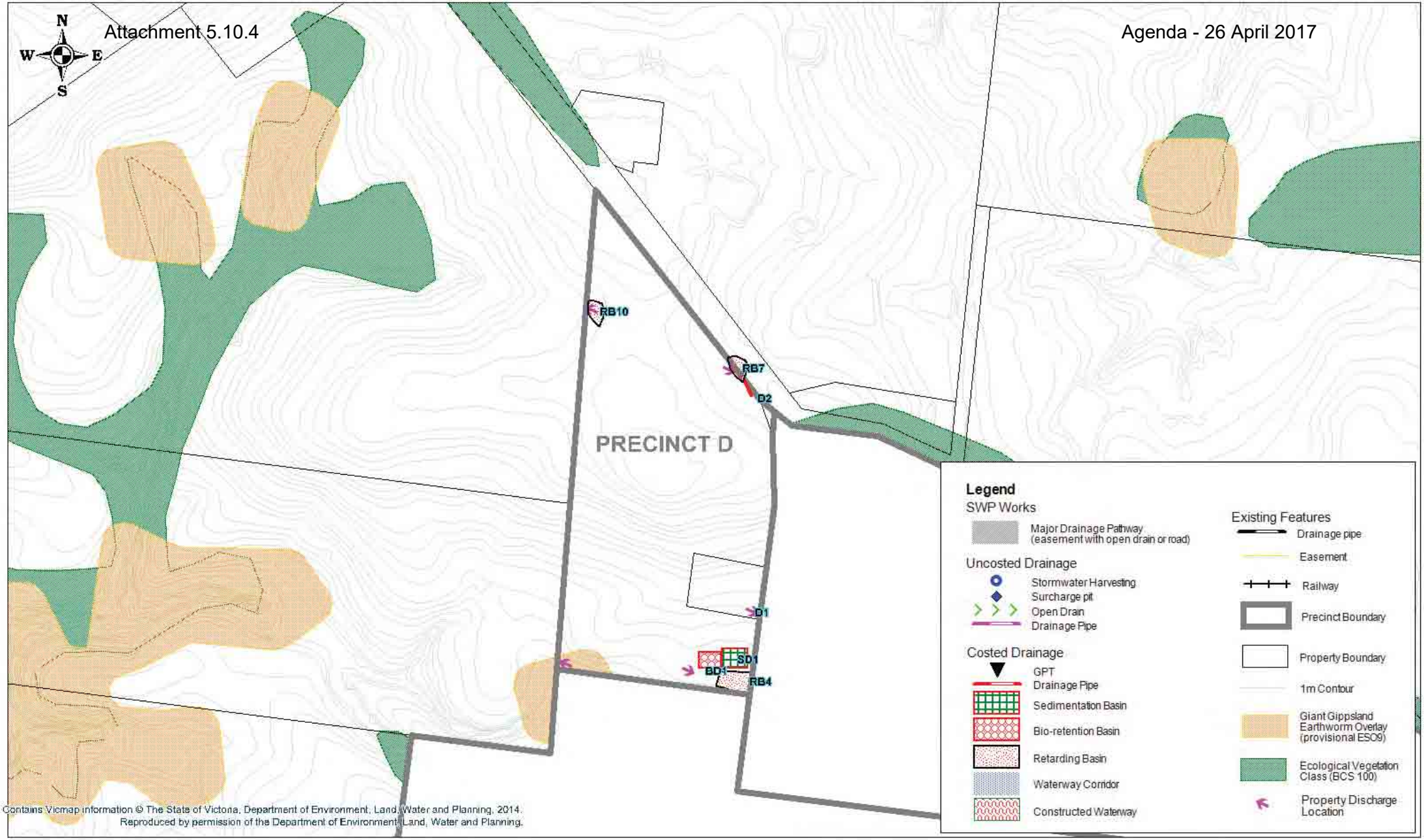

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0 100 200

Scale in metres (1:5000 @ A3)

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994, (GDA94)
Vertical Datum: Australia Height Datum
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Nyora Storm Water Management Plan

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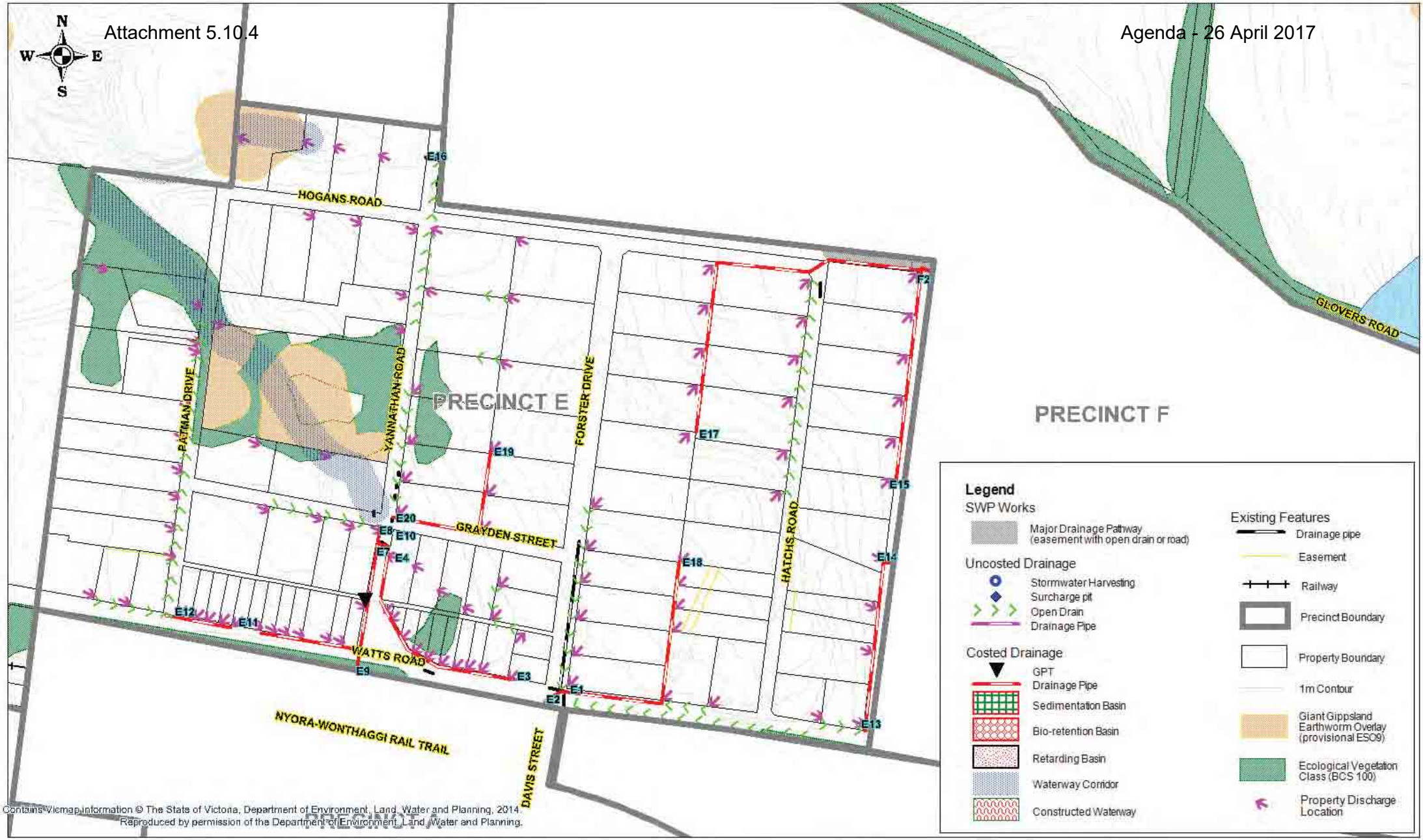

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Scale in metres (1:5000 @ A3)

Map Projection: Transverse Mercator
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Vertical Datum: Australia Height Datum
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Nyora Storm Water Management Plan

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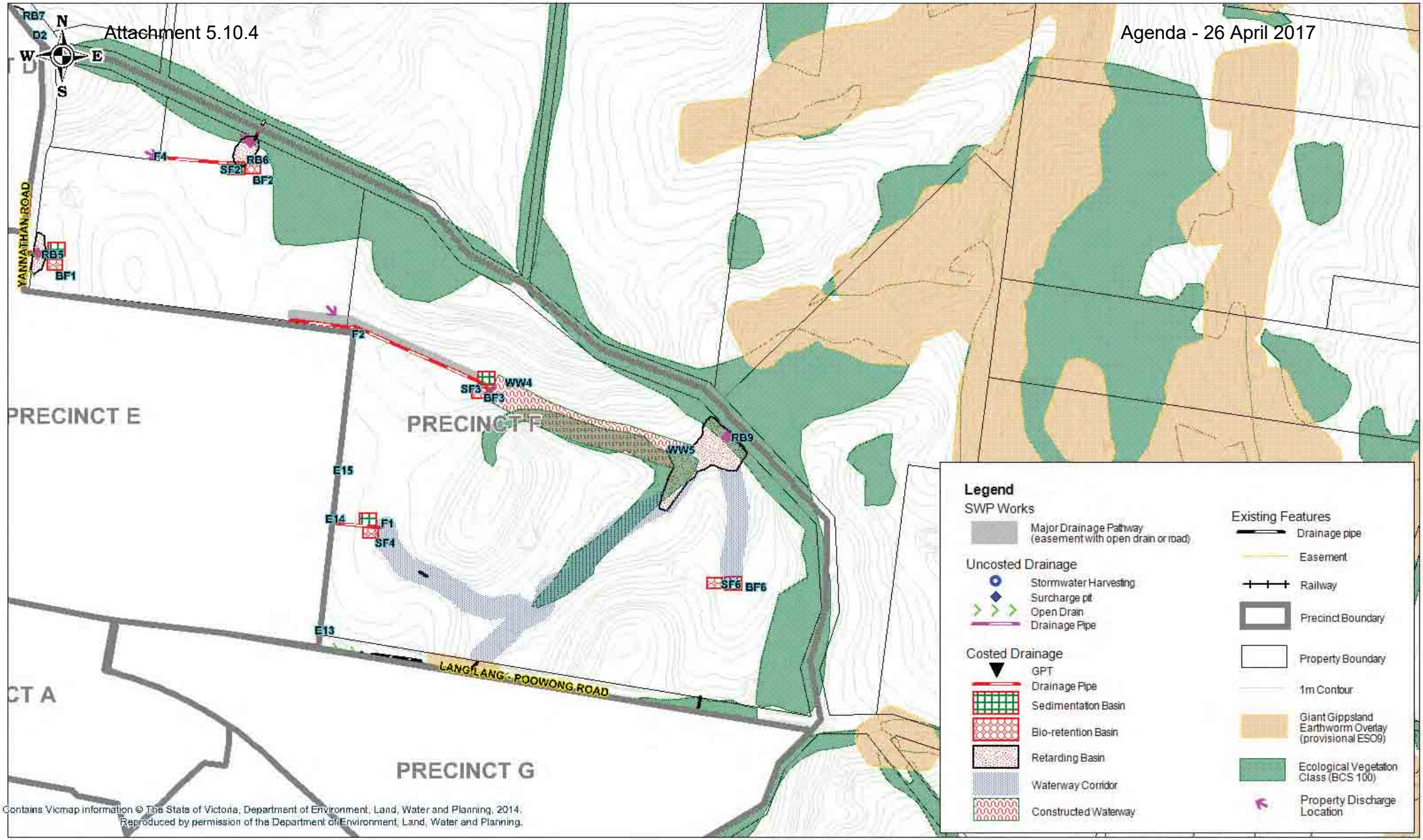

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Nyora Storm Water Management Plan

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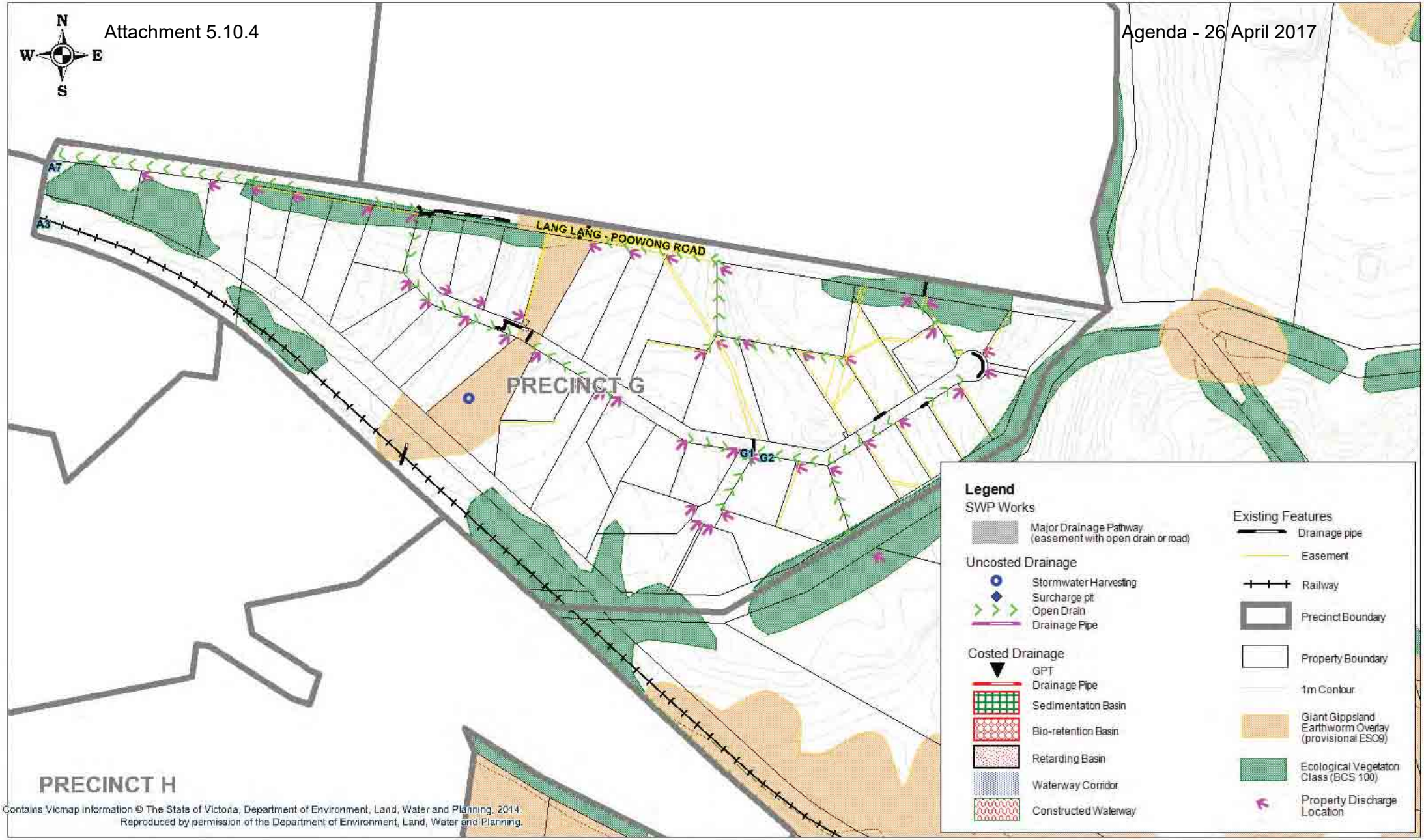

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0 100 200
Scale in metres (1:5000 @ A3)

Map Projection: Transverse Mercator
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Vertical Datum: Australia Height Datum
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Nyora Storm Water Management Plan

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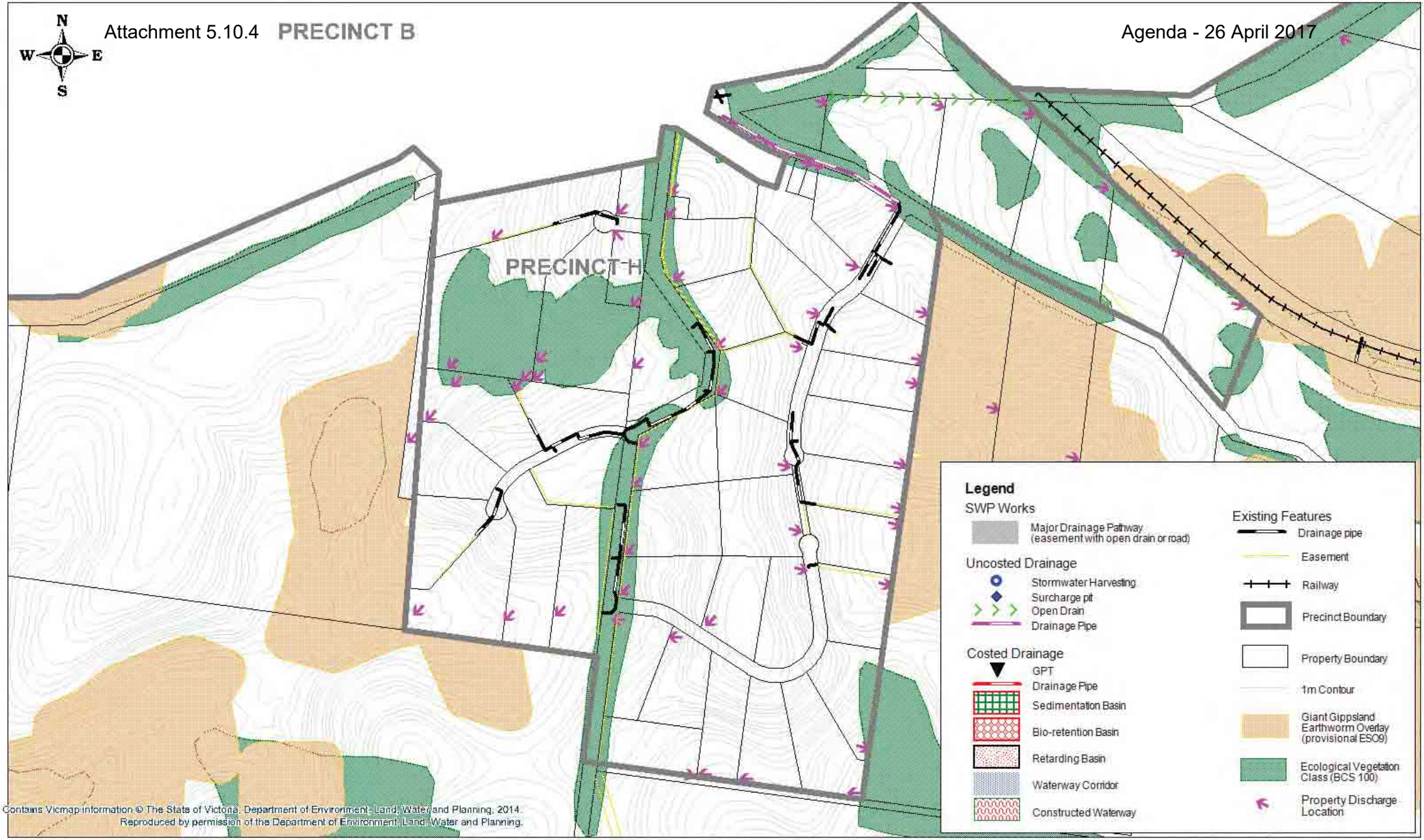

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0 100 200

Scale in metres (1:5000 @ A3)

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994, (GDA94)
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

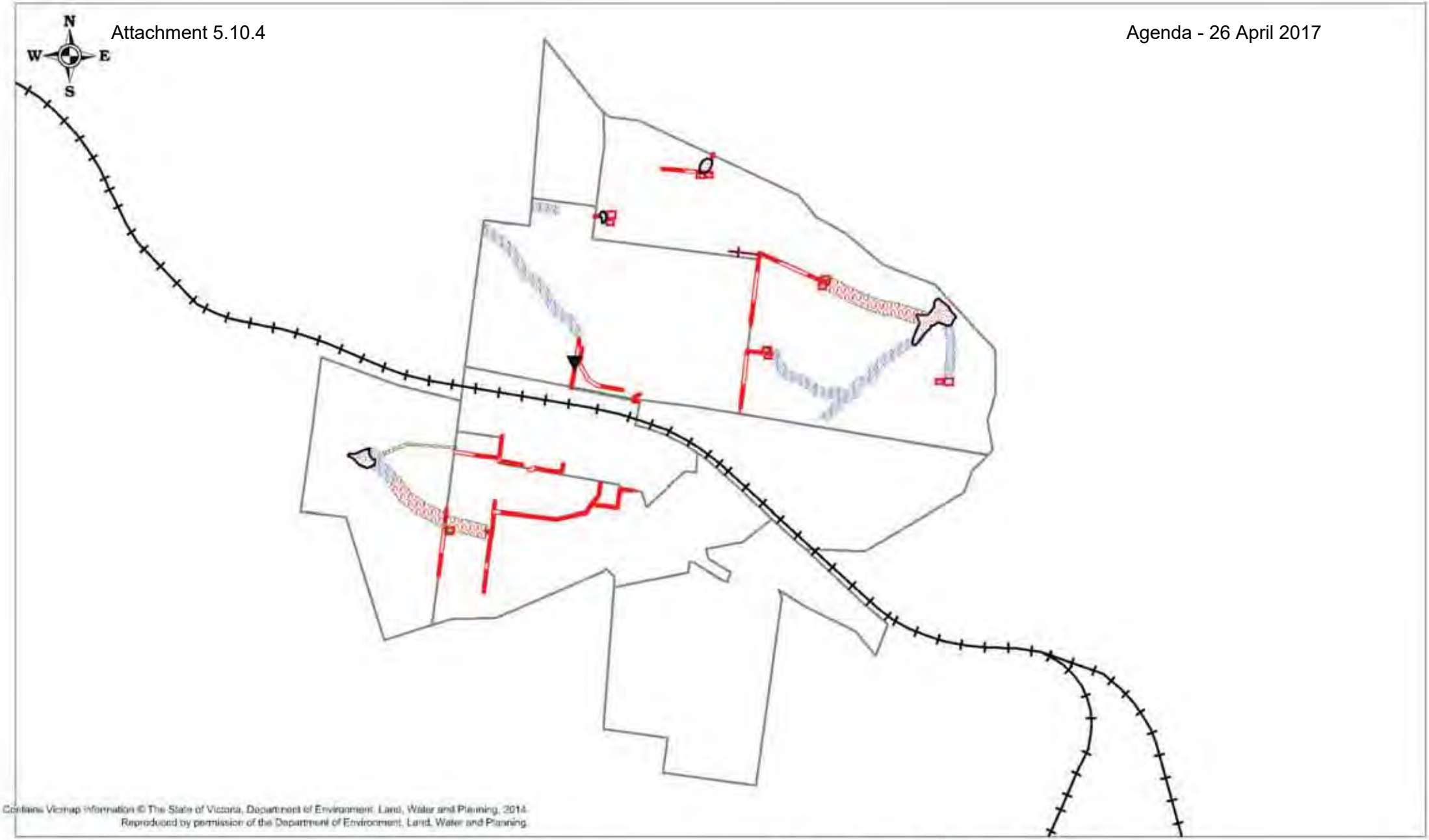
Nyora Storm Water Management Plan

PRECINCT H

Job Number: V1128_001
Revision: 0
Drawn: NEA
Checked: AP
Date: 10 Jun 2016

APPENDIX E

Staged stormwater management



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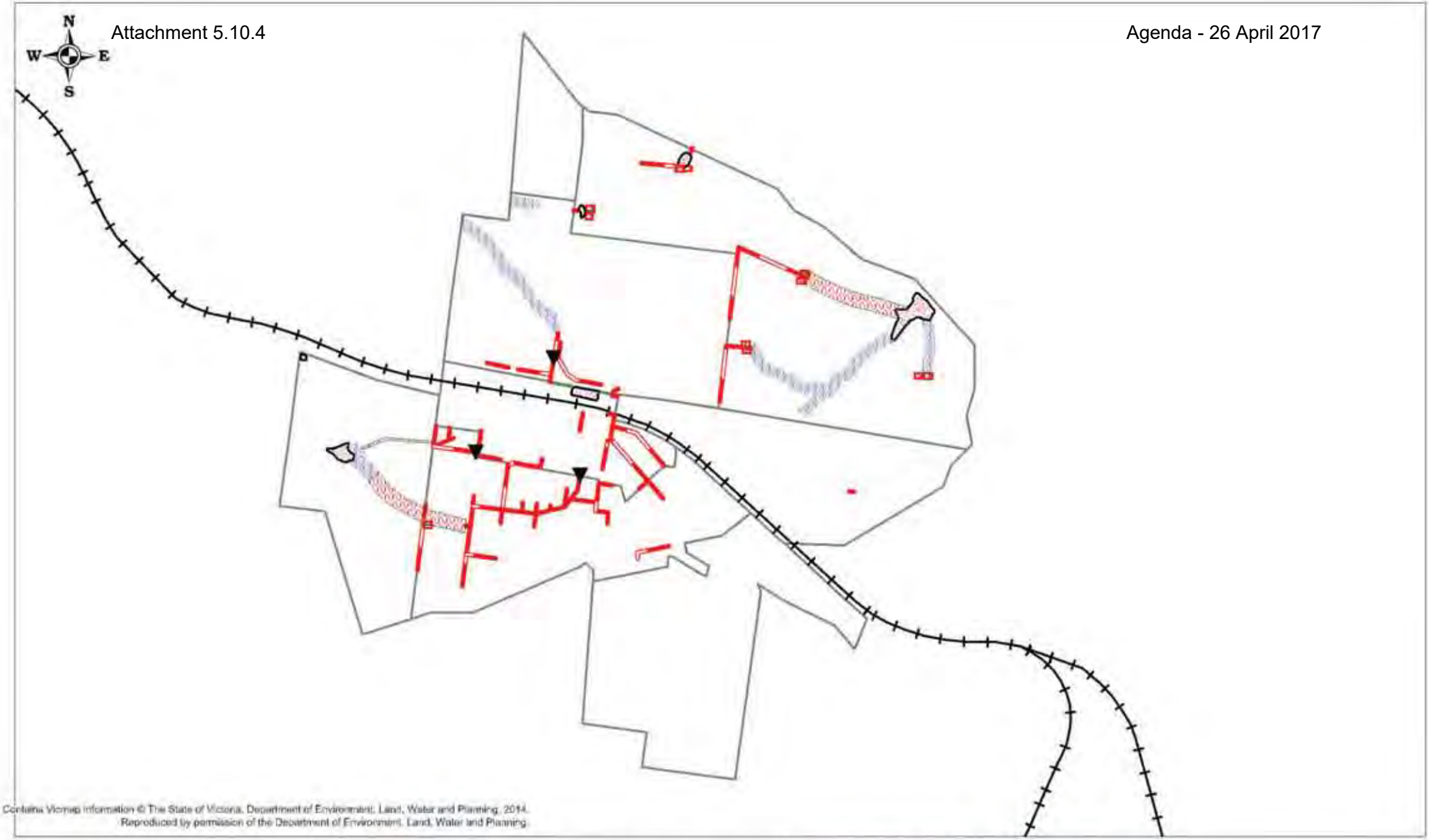
Scale in metres (1:15000 @ A3)

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994 (GDA94)
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia_Zone 55

Nyora Storm Water Management Plan

SHORT TERM STORM WATER MANAGEMENT WORKS (5 -10 YEARS)

Job Number: V1128_001
Revision: 0
Drawn: NEA
Checked: AP
Date: 10 Jun 2016



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South Gippsland Shire Council

0 300 600
Scale in metres (1:15000 @ A3)

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994 (GDA94)
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia_Zone 55

Nyora Storm Water Management Plan

MEDIUM TERM STORM WATER MANAGEMENT WORKS (10 - 20 YEARS)

Job Number: V1128_001
Revision: 0
Drawn: NEA
Checked: AP
Date: 10 Jun 2016

F

APPENDIX F PROPERTY & ECONOMIC REPORT