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ARMSTRONG CREEK
URBAN GROWTH AREA

HORSESHOE BEND PRECINCT (HBP)

STORMWATER MANAGEMENT STRATEGY (SWMS)

(FINAL-Version 8)

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1. INTRODUCTION

This paper follows on as the final document in a series of reports prepared since October 2011, regarding the provision of main drainage services across the Horseshoe Bend Precinct (HBP) and into the receiving drainage/floodplain systems in Sparrovale Farm and Hospital Swamps. These prior reports are referenced as follows:

- Armstrong Creek Urban Growth Area, Horseshoe Bend Precinct (HBP), Stormwater Management Strategy (SWMS), Discussion Paper, 31 October 2011;

- Armstrong Creek Urban Growth Area, Horseshoe Bend Precinct (HBP), Stormwater Management Strategy (SWMS), Sparrovale Wetland Option, Discussion Paper 2, 12 February 2012;

- Armstrong Creek Urban Growth Area, Horseshoe Bend Precinct (HBP), Stormwater Management Strategy (SWMS), Sparrovale Wetland Option, Discussion Paper 3, 10 May 2012;

The various precincts that comprise the Armstrong Creek Urban Growth area are shown on Figure 1. The acronyms used throughout this report are as follows:

HBP-Horseshoe Bend Precinct
MP-Marshall Precinct
NEIP-North East Industrial Precinct
ACEP-Armstrong Creek East Precinct
MAC-Major Activity Precinct
ACWP-Armstrong Creek West Precinct

This paper:

- consolidates primary outcomes of the previous discussion papers;

- presents information regarding existing catchments and flooding conditions across the HBP;

- presents a summary of the various recent studies that have been carried out to determine critical environmental flow/ecology requirements for the Lower Barwon Wetlands system which receive the surface runoff from the Armstrong Creek and HBP catchments;

- corrects previous erroneous spelling of Sparrovale to Sparrovale throughout, in accord with recent directions from Council;

- adopts inclusion of the wetland area in Sparrovale Farm as part of the overall Armstrong Creek Growth Area stormwater management system;

- incorporates the impacts of the proposed MAC railway corridor excavation;
- adopts current preliminary design proposals for the Ring Road 4D corridor which will enable formalising of the road corridor as the catchment boundary divide between the HBP and surrounding precincts (NEIP, MP and ACWP) as well as the Southeast Grovedale/Trifilos Drain catchment north of the Railway;
- incorporates diversion of the Reserve Road subcatchment in the HBP (west of the 4D corridor) away from the Marshall precinct and back into the Sparrovale catchment;
- incorporates partial diversion of flows in the Trifilos Drain (Reserve Road) catchment across the Ring Road 4D corridor and back into the Sparrovale Farm wetlands via the proposed HBP main drainage system;
- provides a confirmed functional design of the overall stormwater system through application of the RORB[1] hydrologic model and MUSIC[2] water quality model;
- incorporates and integrates responses/edits arising from comments provided during discussion meetings and on the previous version documents by City of Greater Geelong (CoGG) Engineering Services.

2. EXISTING CATCHMENTS AND FLOODING CONDITIONS

Existing flooding conditions have been investigated and modelled using a two-dimensional hydraulic model in two studies; (a) by Water Technology (Armstrong Creek Urban Growth Plan Flooding and Drainage Study, 24 February 2006), and (b) by Bonacci Water (Stormwater Management Strategy for Armstrong Creek, July 2008).

Both studies produced similar results and there is no need to redo this task.

There are two primary catchments draining land in the HBP and the extents and levels of flooding derived for the 100 year Average Recurrence Interval (ARI) flood event have been determined by Water Technology (2006).

[1] RORB is the name given to an industry-standard Runoff Routing Model originally due to Laurenson EM and Mein RG. It is an interactive runoff and streamflow routing program that calculates catchment losses and streamflow hydrographs resulting from rainfall events and/or other forms of inflow to channel networks. It is used for flood estimation, spillway and retarding basin design and flood routing.

[2] MUSIC is the acronym used for the Model for Urban Stormwater Improvement Conceptualisation software developed by the Cooperative Research Centre for Catchment Hydrology to model urban stormwater quality management schemes.

Figure 2 (Sheet 1 of 2) shows the HBP catchment area and flooding extents abutting the railway line and draining northwards across Reserve Road, primarily via Trifilos Drain, but also partly as shallow overland flow. This is part of the overall South East Grovedale catchment. It is referred to herein as the Reserve Road catchment.

The bulk of the HBP drains northeasterly and easterly across Barwon Heads Road to Sparrovale Farm and is referred to as the Sparrovale catchment. Figure 2 (Sheet 2 of 2) refers. Flood extents shown on this figure assume local catchment runoff conditions only. Higher flood levels apply for Barwon River inundation (2.00 m/3.00 m AHD for 10/100 years ARI respectively).

Along the southerly boundary of the Sparrovale catchment the HBP boundary straddles the catchment boundary. Small pockets of land within the HBP thus drain south into the ACEP as indicated on Figure 2 (Sheet 2 of 2). Due to small catchment areas, higher elevation and greater slope, none of these small areas is affected by waterway or floodplain inundation.

Downstream of Sparrovale Farm the receiving environments of the Lower Barwon River Wetlands, especially Hospital Swamps, are dominant considerations for surface drainage planning. Figure 3 shows the wetland system layout with key reference points for water control structures including the farm levee and river offtakes.

Figure 4 (Sheets 1 and 2) are nearmap.com extracts showing conditions in the area downstream of the HBP during the drought (August 2009), and most recently in October 2011. Under existing catchment conditions extensive areas of the farm are subject to prolonged inundation, unrelated to Barwon River flooding but clearly linked to high water levels in Hospital Swamps effectively impeding drainage of water through the levee via the drain/regulator.

It is clear from Figures 2-4 inclusive that Sparrovale Farm is and has historically been subject to extensive inundation from both its local catchment and the Barwon River.

Development of the HBP lands will further increase volumes and frequency of surface runoff discharging to the farm area which is of critical concerns for the affected landowners.

3. RECEIVING ENVIRONMENT FLOW REGIMES

3.1 General

Urbanisation inevitably leads to increased discharge of surface runoff and reduced accessions to groundwater and losses to evapotranspiration.

In round figures mean annual runoff for the Armstrong Creek area under existing conditions can be expected to average 1.3 ML/ha/year (obtained using the MUSIC model and Geelong rainfall for the 1980-89 period). After residential development at average imperviousness of 50% (ie., impervious surfaces will account for 50% of total catchment area), mean annual runoff will rise to about 2.6 ML/ha/yr from the same rainfall. This equates to a 200% increase in mean annual runoff.

For average imperviousness of 60%, mean annual runoff will rise to about 2.9 ML/ha/yr (220% increase). Since the average imperviousness of the bulk of the HBP development area will be 60%, existing conditions (mean annual) runoff will be at most about 45% of future runoff.

While annual runoff patterns will still be strongly seasonal there is no doubt that significant increases in surface runoff will occur in the summer/autumn periods. Short duration rainfall which produces little runoff under existing rural conditions will produce significant runoff from large impervious areas.

Infiltration losses cannot offset any of this increase (unless costly pressure injection schemes are found to be feasible and can be economically implemented), simply because potential infiltration areas are markedly reduced by sealing of land surfaces and construction of roofs.

The only practical ways to make some offsets against the impacts of increased surface runoff regimes are (a) reuse of water instead of discharging it, and/or (b) bypassing excess “development” flows around sensitive receiving environments directly into the Barwon River, if possible. The latter approach could for example, involve construction of levee-banked drains around the Sparrovale wetlands with flood-gated connections to the river to prevent backflow.

Normally a primary opportunity is reuse of roofwater (via raintanks before it is contaminated by pavement runoff) and at the lot scale.

> *(Note: It is stressed that reuse is considered as an effective measure for reducing volumetric runoff but it is not effective as a peak flow rate mitigation measure.)*

However Class A recycle water supply is to be provided in the HBP by Barwon Water. The Class A supply effectively competes for the same demand uses as roofwater and stormwater. In the ACEP, Barwon Water set conditions on development that mandated connection of all lots to the Class A recycle supply and actively discouraged the effective reuse of roofwater. Such conditions are expected to be applied across the HBP and other precincts as well.

As it is a "free water supply" unlike the Class A recycle supply, it is likely that voluntary uptake of rainwater tanks by future residents will prove significant over time and such action is to be encouraged through the SWMS in order to assist with further improving stormwater management outcomes and reducing potable water supply demands for the development. Regrettably however the Barwon Water conditions rule out storage and reuse of stormwater, at the allotment scale, as a formal integrated part of the SWMS (ie., it cannot be incorporated into water quality and quantity modelling as a guaranteed offset).

The Barwon Water conditions leave reuse on a precinct or regional scale as the only possible alternatives for water reuse to be incorporated into the HBP SWMS. The main opportunity within HBP will be at the downstream (eastern) end for the purposes of irrigation of the regional open space (ROS) facilities located in the HBP and to the south in the ACEP.

Lesser opportunities may be afforded within HBP by extraction from wetland systems. However constraints on extraction must be imposed to protect dependent aquatic plantings so that wetlands have limited ability to support extraction in dry times of the year when demand is highest.

As was concluded in the ACEP and ACWP SWMS reports, there also remains the opportunity for the water authority (Barwon Water) to enter the picture and install a larger scale stormwater reuse system from a terminal wetland/storage system east of Barwon Heads Road. That opportunity is very significant, given that Barwon Water could use water generated at high reliability in winter/spring periods from HBP as well as both ACEP and ACWP lands when ROS irrigation is offline.

However as an external opportunity, it is beyond the scope of this SWMS to further quantify and no further consideration is made in this report.

In light of the above constraints and unknowns regarding reuse opportunities, the adopted strategy for HBP must incorporate alternative measures which are able to be guaranteed outcomes, robust and sustainable.

> *(Note: It is stressed that reuse is not ruled out as part of the SWMS. The opportunity to reuse stormwater is strongly encouraged.)*

The SWMS must therefore focus on evaporation and flow diversion systems to protect Sparrovale Farm and Hospital Swamps from the increased seasonal inflow volumes that will follow on with urbanisation of the catchment.

> *(Note: If Sparrovale Farm were to come under public ownership then major opportunity is afforded for regional wetlands to be established in the farm areas which are currently subject to regular inundation and waterlogging.)*

3.2 Hospital Swamps Flow/Ecology Requirements

Constraints posed to Hospital Swamps environments are significant but not so clear cut or understandable as impact of increased surface runoff on the private land holdings of Sparrovale Farm.

There have been many major investigations and reports issued on management of the Swamps and downstream estuarine/marine environments in recent years. Those most relevant to the Armstrong Creek Urban Growth Area are:

- Lower Barwon Wetlands Flow Ecology Relationships Final Report (Lloyd Environmental et al, September 2011 for CCMA;

- Barwon River Lower Breakwater Management Options, Water Technology et al, June 2010 for CCMA;

- Lower Barwon Wetlands Hydraulic Modelling for the Environmental Entitlement, Water Technology, July 2011 for CCMA;

In regard to Hospital Swamps the reports can be briefly summarised as follows:

- Hospital Swamps comprises 5 basins which receive water from both the Barwon River and from local runoff;

- Three of the basins are at 0.5 m AHD, with the other two at 0.20 m AHD;

- As well as alternating between a flooded and a dry state on a seasonal basis, the main basin alternates between saline and fresh conditions. Hospital Swamps is adjacent to the Mt Duneed lava flow which has high groundwater salinities ranging from 20,000 EC at the western end of Hospital Swamps to 50,000 EC in the east. Saline groundwater contributes to high wetland salinities in summer and autumn when surface water levels are low. Inflows in winter and spring will flush accumulated salts and suppress groundwater discharge, creating seasonally fresh conditions.

- The hydrology of Hospital Swamps was modified in 1983 by the installation of regulators and a water supply channel from the Barwon River;

- Prior to these works Hospital Swamps would only hold water temporarily after heavy winter rain or when flooded by the Barwon River, due to drainage works many years ago;

- In the early 1980’s Hospital Swamps held water for most of the year;

- The wetland complex is separated from the estuary by a bund.

- Water is diverted into the wetlands via a regulated channel through Sparrovale Farm which has an invert of 0.30 m AHD;

- Other unregulated channels become active when the Barwon River water level exceeds 1.40 m AHD;

- The bed of the wetlands lies at 0.0 m AHD;

- The inlet regulator from the Barwon River is opened when river levels exceed 0.70 m AHD;

- Barwon River water levels greater than 0.90 m AHD allow Hospital Swamps levels to reach 0.50 m AHD which is the normal top water level;

- The Hospital Swamps overflow to Lake Connewarre when levels exceed 0.50 m AHD;

- Hospital Swamps can be drained using a regulated pipe with an invert of 0.20 m AHD;

The water management cycle for Hospital Swamps which has operated over the last 25 years (with no changes in vegetation over that time) is in summary:

- Fills in spring;
- Drops to 0.30 m AHD in January;
- Usually dry by end of summer.

Vegetation, waterbird and fish-based ecological objectives and hydrological requirements for Hospital Swamps are listed in Lloyd et al (2011).

The threats to Hospital Swamps are mainly derived through potential future changes to water regime. These may come about from:

- stormwater inflows from Armstrong Creek (developments upstream are likely to produce increasing amounts of run-off);

- changes to inflows from Barwon River (these need to be secured through the bulk entitlement and access rights across the land to the Swamp through ownership or management agreements); and/or

- additional environmental flows from upstream (these would need to be managed to prevent additional inflows).

Hospital Swamps are vulnerable to a water regime that increases inflows over summer and autumn. Low flows or no flows in this period are important in creating saline conditions in the wetland bed which exclude emergent macrophytes and maintain a diverse community of plants that tolerate a variety of saline environments. Summer inflows will suppress groundwater discharge to the wetland and dilute surface water salinities. They may lead to an increase in the extent of reeds and a loss of a variety of salt-tolerant herbs, sedges and shrubs. In addition, nutrient run-off from stormwater, recreational ovals and irrigation upstream may change the nutrient status of the Swamp and therefore the vegetation community and the rest of the ecosystem through trophic cascades.

The specific recommendations for water regime for Hospital Swamps were listed in Table 18 of Lloyd et al, 2011. The table is repeated on the following pages for ease of reference.

In regard to potential increase in freshwater volumes from the Armstrong Creek Urban Growth Area, the emphasis for surface water management design must focus on maintaining essentially the same summer/autumn conditions as have persisted for the last 25 years. Increase in volumetric throughputs in winter/spring periods would be expected to have little detrimental impact based on the writer's understandings of the flow/ecology reports.

As concluded in the previous section the SWMS must focus on evaporation and flow diversion systems to protect Hospital Swamps from the increased seasonal inflow volumes that will follow on with urbanisation of the catchment.

Council have emphasised the need for responsibility to be properly defined for securing the rights to flows from the Barwon, across private land as well as the allocation.

Table 18: Water Regime Recommended for Hospital Swamps to meet Ecological and Management Objectives. While the whole water regime is required to meet the overall ecological outcomes, the coloured highlighting indicates the priority of each objective: Orange indicates the highest priority hydrological objectives, Green the second priority objectives and Blue indicates the third priority objectives.

Season	Typical Hydrological Environment	Hydrological Objective	Frequency	Environmental Objective
Early Winter (May to September)	Low flows in the Barwon with the possibility of minor freshes. Minor inflows from Armstrong Creek	Allow wetland to fill in sympathy with flows in Barwon River. - inlet regulator open - outlet regulator closed	9 years in 10	• Initiate *Stuckenia* and *Chara* growth • Initiate decomposition of organic matter on wetland bed • Dilute accumulated soil and surface water salts • Create habitat and invertebrate populations • Stimulate fish and waterbird breeding • Allow fish to colonise wetland from the river
Spring High Flow Period (September to November)	High flows in the Barwon River. Overbank flows occur intermittently. Storm flows from Armstrong Creek	Fill Hospital Swamps with main wetland filled to 0.5m AHD. - inlet regulator open - outlet regulator closed	9 years in 10	• Continuous flushing of salt from deep wetland basins • Inundation of reedbeds and *Bolboschoenus* beds fringing the main basin • Sustain growth of *Stuckenia* and *Chara* • Promote growth of *Myriophyllum* in southern part of main basin • Waterlog *Gahnia filum* sedgelands • Stimulate fish and waterbird breeding • Stimulate increase in invertebrate populations and biomass • Create nesting habitat colonial and other waterbirds
Spring High Flow Period (September to November)	Flow freshes in the Barwon River. Storm flows from Armstrong Creek	Flow freshes used to surcharge (to 0.7m AHD) and flush the wetland. - inlet regulator open - outlet regulator closed	9 years in 10	• Continuous flushing of salt from deep wetland basins • Inundate shallow wetland basins and promote growth of *Ruppia* • Inundate *Gahnia filum* sedgelands • Create additional fish and waterbird habitat and

Extract from Lloyd et al 2011

Season	Typical Hydrological Environment	Hydrological Objective	Frequency	Environmental Objective
				invertebrate populations • Trigger fish spawning • Provide connecting flows to the river and between wetlands
Early Summer Drawdown Period (December to January)	Moderate flows in the Barwon. Overbank flows less frequent. Intermittent minor flows from Armstrong Creek.	Drain Hospital Swamps to a level of less than 0.3 m AHD by the end of January. - inlet regulator closed - outlet regulator open	9 years in 10	• Increase wetland salinity as groundwater discharge increases in proportion to surface water • Shallow wetland basins exposed (creates open water habitat upon refilling) • Restart wetland processes • Allow eggbanks to be produced and laid • Provide waterbird food supply from access to tubers, seeds and invertebrates in shallow water
Late Summer – Autumn (February to March/April)	Low flows in the Barwon. Overbank flows rare. Inflows from Armstrong Creek rare.	Allow wetland bed to dry. - inlet regulator closed - outlet regulator open	9 years in 10	• Soil salinity increases in shallow wetland basins and deep wetland basin • *Chara* and *Stuckenia* die back • Limited colonisation of wetland bed by annual herbland plants • Reeds and other emergent macrophytes become dormant • High soil salinity excludes reeds • Expose mudflats for waterbird feeding • Allow nutrient re-cycling • Control carp populations
All year	Very low flows in Barwon and Armstrong Creek	Wetland bed dry or shallow flooding Salinisation of the wetland bed and limit extent of flushed soil conditions	1 year in 10	• Maintain vegetation structure

Extract from Lloyd et al 2011

3.3 Barwon River Flood Hydrology

The main conclusions from the Lower Barwon Wetlands hydraulic modelling are as follows:

- Hydrodynamic modelling and subsequent validation from water level records available during an overbank flooding event that occurred in January 2011, determined that a flow rate of approximately 3,500ML/d initiated sustained overbank flooding into Reedy Lake and Hospital Swamps. This is far less than the 1 year ARI peak flow of 10,800 ML/d.

- Analysis of long term historical streamflow time series for the Barwon River at Geelong provided estimated annual overbank flow frequencies of approximately 3 events per year.

- The frequency of overbank flow events over the last approximate 10 years has however been well below the long term average.

- The total annual duration of overbank flows into Reedy Lake and Hospital Swamp has been estimated as 10 days historically. Overbank flow events are strongly concentrated over the months of July through to October.

- Historically, sub-overbank flow spells greater than 365 days occur on average, once every 5 years.

- The height of the natural banks separating Lake Connewarre and Hospital Swamps are approximately 0.5m AHD. Based on the analysis of the storm surge planes for Lake Connewarre, these banks would be overtopped on average once per year or greater to a depth of 0.1m. This would potentially enable significant inundation of these wetlands and in particular the northern most two basins of Hospital Swamp from Lake Connewarre.

- The natural banks separating Lake Connewarre from Reedy Lake are at their lowest point approximately 0.9m AHD. Significant overbank inundation from Lake Connewarre into Reedy Lake is considered unlikely and would be an extremely rare occurrence.

- The outlet channels and regulator sill levels of both Reedy Lake and Hospital Swamps are below mean high water in Lake Connewarre and inundation to a level of approximately 0.4m AHD in these wetlands could theoretically be achieved by operation of the regulators to allow the ingress of estuarine water from Lake Connewarre into these wetlands.

Water Technology also assessed the potential impact that removal of the Sparrovale Farm levee could have on the hydrology of the Farm and Hospital Swamps. It was found that without the levee, inundation of the Farm area would commence at a flow rate of 1,728 ML/d.

Complete inundation would occur when the flow reaches 3,456 ML/d. This flow approximates the current threshold of protection against flooding of Hospital Swamps from the Barwon River.

3.4 Sea Level Rise Predictions

In compiling recommendations for future water regimes for Hospital Swamps, the flow/ecology reports have all assumed current tidal regimes in Lake Connewarre are continued into the future.

This would seem to be at odds with predictions for mean sea level rise from 0.0 m AHD to 0.25 m AHD by 2030 and to 0.80 m AHD by the year 2100. If such predictions do eventuate then Hospital Swamps will be effectively permanently saline and inundated above 0.5 m AHD with this outcome being realised for the lower two basins by 2030.

It would follow that increased freshwater runoff from the catchments to Hospital Swamps would then be of little practical relevance within a couple of decades.

3.5 Implications for HBP SWMS

3.5.1 Sparrovale Farm Retained in Private Ownership

Despite the dire longer term threats posed to Hospital Swamps if sea levels rise as predicted, the pressing need as far as the HBP SWMS is concerned is to deal with protection of Sparrovale Farm from increased runoff, in a manner which complies as far as practicable with the defined flow regime requirements for protection of Hospital Swamps.

This constraint effectively rules out increased discharge of water to Hospital Swamps in the dry times of the year.

Given that the existing farm levee bank will need to be retained to protect the farm from frequent river flooding the only feasible options are to either pump water over the levee, or to construct an alternative levee-banked/flood-gated outfall to the River around the north side or possibly even through the farm, to mitigate the threat of prolonged inundation within the farm.

Council have advised that a dependence on pumping is not considered an acceptable option and it has not been considered further as part of the SWMS.

3.5.2 Sparrovale Farm Transferred to Public Ownership

If Sparrovale Farm is transferred into public ownership then the area currently subject to prolonged inundation would be able to be converted to a freshwater wetland system, with the existing Barwon River levee retained.

The Normal Top Water Level (NTWL) of the wetland would be set at or close to 1.00 m AHD (as is the case for the terminal linear wetland chain in the ACEP) so as to facilitate effective gravity drainage connection out to the River for most of the year and especially in the summer/autumn periods, using the existing farm drainage channel outlets.

The extra runoff volumes generated from development in the HBP then also present an additional source of supply of freshwater for Hospital Swamps when required.

It would be a simple matter to then also link the ACEP wetland system through Sparrovale Farm to allow all low flows from the wider Armstrong Creek catchment to be diverted around Hospital Swamp in the summer/autumn period.

This solution then offers the opportunity to reduce size and land take for surface water management assets within the HBP and relocate residual management capacity needs into Sparrovale Farm.

With the Sparrovale wetland NTWL also being above the longer term sea level rise predictions, this solution is sustainable beyond the year 2100. It is also the most technically robust option for management of Hospital Swamps over the next few decades at least.

3.5.3 Recommendation

Conversion of the Sparrovale Farm lowlands into a major freshwater wetland system should be incorporated as a fundamental building block for the HBP SWMS.

4. SURFACE WATER MANAGEMENT STRATEGY

4.1 Objectives

The proposed strategy for management of stormwater peak flows and quality in the HBP is an integrated approach considering both quality and quantity. It is based first and foremost on ensuring:

- stormwater quality from the HBP land is treated to contemporary best practice objectives, as measured/referenced at the precinct outfall boundaries;

- no significant change to stormwater discharges for critical storm durations up to 100 years Average Recurrence Interval (ARI) events, as measured/referenced at the precinct outfall boundaries and taking into account other external catchments;

- as far as practically feasible, protecting Hospital Swamps from the impacts of altered hydrology arising from urbanisation. The primary focus will be on maintenance of existing summer/autumn drying periods.

In determining the most appropriate form and location of management assets the strategy assumes that the Sparrovale Farm lowlands will be converted to a freshwater wetland system managing runoff from development areas in the HBP.

The SWMS has also considered the following objectives:

- integration of surface water management features with open space;

- staged implementation constraints associated with differing land ownership across the HBP;

- rationalisation of subcatchment boundaries to optimise the strategic stormwater management value offered by integration of the Sparrovale lowland as a major freshwater wetland system treating runoff from the HBP catchments;

- creation of stormflow mitigation storages that avoid the use of high embankments (safety and cost grounds);

- protection of key flora/fauna habitat areas and sites of cultural heritage value;

- consolidation of drainage management assets wherever possible to minimise ongoing maintenance costs;

- encouragement for reuse of stormwater.

4.2 Incorporating The Sparrovale Wetland

When the inundated areas of Sparrovale Farm are transferred into public ownership then the area currently subject to prolonged inundation would be converted to a freshwater wetland system, with the existing Barwon River levee retained.

The permanent fixed crest of the Barwon River barrage is 0.85 m. After consideration of the 0.5 m contour data on Figure 5 (Sheet 1 of 2), the Normal Top Water Level (NTWL) of the wetland would be set at or close to 0.95 m AHD so as to facilitate effective gravity drainage connection out to the River barrage pondage for most of the year and especially in the summer/autumn periods, using the existing farm drainage channel outlets. <u>There would be no need to pump water to the Barwon River</u>.

The wetland area that would be created at NTWL of 0.95 m is some 220 ha. With such a vast surface area, evaporation losses will be extensive during the summer/autumn periods and water levels can be expected to drop below NTWL at such times and with the flat topography the margins of the wetland will contract and expand over significant distances.

Extended detention depth (above NTWL) associated with use of this wetland for stormwater quality and quantity management will only be of the order of 50-100 mm.

The flood storage volume available above NTWL and below a level of say 1.2 m is some 330,000 m^3 which is 3-4 times that required to fully mitigate impact of increased peak flow discharges from the HBP.

The Sparrovale Wetland area is more than sufficient to provide best practice water quality and quantity treatment outcomes for the entire HBP in its own right. Therefore other assets located within the HBP can be scaled back to minimums required to suit ultimate drainage line form.

On this basis it is considered that the land area required for surface water management purposes associated with development of the HBP can be set generally as the area below 1.2 m AHD.

This does not mean that land above 1.2 is available for development-all lands below 3.00 m AHD are subject to inundation in the 100 year ARI flood in the Barwon River.

Figure 5 (sheet 2 of 2) shows the recommended minimum extent of land that should be set aside for management of catchment runoff for the Sparrovale Wetland with full catchment development in place:

- the west boundary is approximated by a northwards extension of Charlemont Road;
- the south boundary is approximated in part by Groves Road;

- the balance boundaries are set by the alignment of the Barwon River levee and the 1.20 m AHD contour.

The total area of land within these boundaries is estimated to be 300 ha.

Figure 5 (sheet 2 of 2) also shows a linear sedimentation basin to be constructed within the boundaries on the existing inlet drainage line. This would be formed as an over-excavation of the existing drainage line and would have a water surface area of not less than 7,000 m^2 at NTWL.

The easterly end of the wetlands area contains remnant modified coastal salt marsh vegetation. Ecological advice indicates it would be desirable for this vegetation to be retained and protected from altered hydrology due to urbanisation. As the identified area is generally between 0.5-1.0 m AHD the wetlands proposal would result in virtually complete and permanent inundation of the vegetation by freshwater, unless protected by an embankment of sufficient height to separate it from the main wetlands.

The extent of works depicted on Figure 5 (sheet 2 of 2), in conjunction with ongoing weed management, is very much the minimum required to achieve the desired longer term outcome of an extensive freshwater wetland system, whilst protecting the remnant modified coastal salt marsh.

There are many other enhancements that could be implemented as part of the project to address possible other objectives including:

- recreational and landscape values;
- design to zone residual stormwater capacity for the HBP close to the wetlands inlet so as to maximise water quality values across the balance wetlands area;
- flora/fauna and cultural/heritage values.

Such enhancements, whilst considered desirable over the longer term, are not required to achieve the SWMS outcomes for management of HBP stormwater.

They would more properly be evaluated/designed/completed by the body/bodies responsible for long term operation and management of the new freshwater wetland system as an integrated component of the wider Lower Barwon Wetlands area. As such they should not form part of the Development Contributions Plan.

4.3 Rationalisation of HBP Subcatchment Drainage Systems

Definition of subcatchment drainage systems has evolved during the course of investigations, in response to emerging flora and fauna and cultural heritage constraints, constraints posed by existing and proposed infrastructure, and in accord with evolution of overall precinct development planning.

4.3.1 Basic Assumptions

Basic assumptions that have been made in deriving the final subcatchment layout are as follows:

- Existing drainage crossings of the Railway line and the pipeline exiting from the ACWP at Surf Coast Highway (Trifilos Drain), are the only external catchment flow inputs to the HBP.

- Existing land north of the Railway line and west of Surf Coast Highway (South East Grovedale) is assumed to retain its current outfall system via Trifilos Drain to Reserve Road (as shown on Figure 6) and be confined west of the future east-west 4D road corridor so that it will be effectively excluded from the HBP drainage systems.

- The proposed 4D road corridor reservation is treated as rural land for the purposes of sizing of water quality and urban trunk drainage systems. Only that part of the corridor south of Reserve Road is considered as part of the HBP drainage system. The balance corridor along Reserve Road will continue to drain north across Reserve Road into the Marshall Precinct.

- The future MAC land will incorporate its own surface water management facilities such that existing rural flows and water quality will be effectively maintained for all events up to and including 100 years ARI.

- Piped drainage connections will be provided to all separate titles within the HBP with overland flows to be conveyed in roads or reserves depending on flow magnitudes and road floodway safety guidelines. In regard to the latter the relevant guideline that has been followed is Appendix A of the Melbourne Water Land Development Manual.

- Subcatchment and piped drainage system layouts have attempted to follow land ownership and existing road boundaries as far as practicable having regard to the natural fall of the land, so as to simplify as much possible, future implementation of works.

- The small pockets of land in the HBP which drain south into the ACEP will be required to meet best practice conditions for stormwater quality treatment and maintain existing rural runoff peak flows (for all events up to and including 100 years ARI) prior to discharge over the HBP boundary.

4.3.2 Adopted Existing Drainage Catchments

Figure 7 shows the adopted HBP subcatchment boundaries and primary drainage lines. The subcatchment references accord with the setup used in the RORB hydrologic model for existing catchment conditions, as discussed in Section 5.

The subcatchment boundaries also accord with the assumption that the Trifilos Drain (South East Grovedale) catchments are separated from the HBP system by the 4D reservation.

4.3.3 Diversion of Reserve Road Catchment

Adoption of the Sparrovale Wetland option presents an opportunity for improved management of drainage within the Marshall Precinct, through diversion of drainage flows from the Reserve Road HBP catchment eastwards and back into the Sparrovale North catchment. The advantages are that:

- peak discharges into the Marshall Precinct could be significantly reduced;
- the estimated landtake for a WLRB within the HBP at Reserve Road could be significantly reduced.

Hydrologic modelling completed in this report confirms that it is feasible to divert the 100 year ARI flow to the Sparrovale outfall system, eliminating any need for connection of drainage north across the 4D corridor into the Marshall Precinct at the proposed Drews Road extension.

This option is adopted in the SWMS.

4.3.4 Impact of the 4D Vertical Alignment

Preliminary design details have been provided on the vertical alignment of the 4D road (Cardno Revision P3 4 April 2012). The proposal is for the road to pass under Surf Coast Highway, return to existing surface and then dip again to pass under the future rail extension to the MAC. The road would emerge from cut before reaching the Reserve Road area, maintain a lowpoint in the longitudinal profile very close to that for existing conditions at Drews Road, and then rise to a highpoint about 1 m above natural surface around Horseshoe Bend Road then dip back to natural surface east to Barwon Heads Road. The latter will be formed as an overpass to the 4D alignment.

This design proposal is consistent with drainage planning constraints in the HBP and no special fill requirements are created in the HBP as a consequence of the 4D alignment. The 4D alignment is thus confirmed as the northwest and north catchment boundary for the HBP.

4.3.5 Impact of the MAC Rail Corridor

The Cardno 4D preliminary design plans also consider the vertical alignment of the rail corridor extension to the MAC. The rail line maintains levels close to existing conditions where the HBP drainage line will cross parallel to the 4D alignment at Barwarre Road. To the south the rail line is cut well below natural surface across Boundary Road and into the MAC. This severs surface drainage connectivity across the rail corridor and creates a need to divert drainage both within and around the MAC.

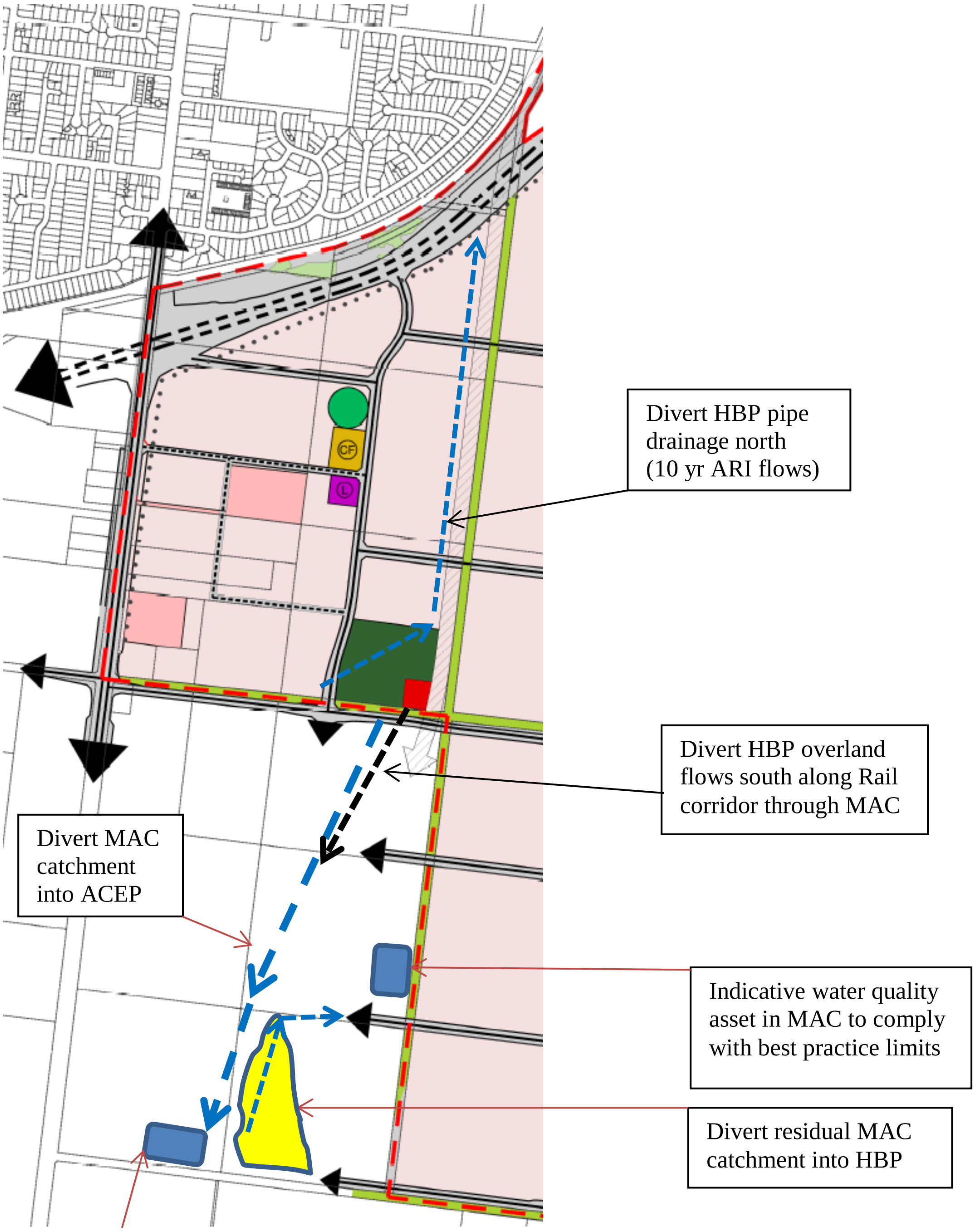
Whilst it may be possible for pipe drainage lines to pass over the rail cut, this is not considered desirable. Instead pipe drainage for land upslope of the rail corridor would best be piped either north or south to avoid the need for crossings.

Within the HBP on Boundary Road west of the rail corridor, along the northern frontage of the MAC, it is feasible to divert pipe drainage northwards into the Reserve Road catchment, without the need for any special storages or treatment on Boundary Road.

The alternative to this diversion is to provide a suitable WLRB on Boundary Road and pipe south into the MAC at existing rural discharge rates. It is assumed that this option will not be attractive from a development yield or asset management viewpoint so the northern diversion option has been adopted.

Within the MAC itself the rail corridor cut requires diversion of drainage for lands to the west which naturally drain eastwards into the Sparrovale catchment. The diversion must be to the south into the Armstrong Creek (ACEP) catchment. A small area on the east side of the rail corridor in the south part of the MAC which drains naturally south into the ACEP must be diverted east into the HBP for similar reasons.

The following sketch illustrates the adjustments to drainage patterns in and around the MAC and rail corridor, that have been adopted as part of the HBP SWMS.



Adopted drainage works in and around the MAC and the Rail Corridor

Indicative WLRB or equivalent in MAC to maintain existing flows and best practice water quality into ACEP

4.3.6 Impact of the Main Sewer

The main sewer is 1650 mm in diameter and constructed in a north-south direction through the HBP paralleling and crossing Barwon Heads Road in two locations as shown on Figure 1.

As-built level information shows the sewer to be a critical control on drainage levels in both the Sparrovale subcatchments, but especially at the waterway crossing in the Sparrovale South catchment just north of Boundary Road.

In the Sparrovale North catchment the large flat area west of the sewer has existing surface levels of 8.0-8.5 m AHD with the sewer invert at 4.0 m AHD. To maintain cover of at least 1 m to the sewer with the outfall pipe or waterway, the lowest NTWL that can be created in a wetland is 6.75 m AHD. Effective drainage of this land without forcing major filling of the land requires a linear wetland system to extend west of the sewer to at least the 8.50 m contour as depicted on Figure 8.

An additional outfall is proposed in the northeast corner of this catchment under the 4D road corridor intersection with Barwon Heads Road. Design information shows a culvert is to be provided at invert level of 7.0 m AHD with maximum capacity of 0.68 m^3/s. The level constraint means that the primary drainage direction for the Sparrovale North catchment (wetland NTWL of 6.75 m) must be eastwards across Barwon Heads Road to Sparrovale Road. The capacity constraint will likely mean that drainage connected to this outfall will be limited to the 4D reservation only. This outfall has therefore been excluded from the HBP SWMS.

In the Sparrovale South catchment the sewer is actually partly exposed at the waterway crossing as shown in the aerial photo below (nearmap.com). Actual sewer invert level is 3.60 m with Barwon Heads Road formation just below 6.0 m at the lowpoint.

This sewer crossing structure will likely need to be retained as part of the ultimate drainage system so the effective waterway invert/wetland NTWL will match the existing pool at about 4.0 m. (Detail survey of this structure will be required to confirm all levels).

In turn this implies that with the minimal grade available, the wetland system upstream of the sewer will need to straddle Barwon Heads Road with a partly submerged culvert system under the road. A similar setup is currently under construction in the ACEP on Armstrong Creek at Barwon Heads Road in the Warralily Estate.

4.3.7 Adopted Drainage Layout for the SWMS

Figure 8 shows the adopted subcatchment boundaries and main piped and open waterway drainage lines for full development in the HBP, with the various drainage diversions in place.

Adjustments to the subcatchment structure have been made in the RORB hydrologic model to account for these changes, as discussed in Section 5.

4.3.8 Primary Drainage Management Assets-Sparrovale Catchments

The primary assets shown on Figure 8 and overlaid on the proposed urban structure plan on Figure 9 are sediment basins/retarding basins (SBRB's) and wetland/retarding basins (WLRB's) linked by open waterways and/or pipelines.

> *(Sediment basins will also need to be incorporated at other significant pipe outfalls to open waterways. Locations of these outfalls will be dependent on future subdivisional design and cannot be confirmed at this time. For this reason those additional assets will not be included in the Development Contribution Plan).*

Wetlands and sediment basins provide the required water quality treatment function and create the most land-efficient retarding storage in the airspace overhead. They also maximise evaporation losses in summer/autumn periods as is desirable for management of downstream impacts. Open waterways slow down runoff responses and encourage infiltration losses to similar effect.

These assets are first and foremost sized to ensure sediment management across the HBP is adequate for the purposes of protection of proposed open waterways within the HBP. A minimum treatment performance standard of 70% removal of Total Suspended Solids (TSS) is arbitrarily set in the MUSIC model to determine the minimum water surface area required for each asset to comply with this target.

The two assets at the two main sewer crossings are designed as linear waterbodies to overcome flat drainage gradient issues. Consequently these have larger water surface areas than required to achieve the 70% TSS removal criteria. The water surface areas are determined by length of the storage and average water surface width of 20 m.

Section 5 summarises the hydrologic and water quality modelling results for the Sparrovale catchments and sizing and design levels for the main drainage assets.

4.3.9 Asset Sizing-HBP South Boundary Areas

Due to conflicts between natural topography, property boundaries and precinct boundaries, three small areas of land within the HBP along the south boundary cannot be serviced by the Sparrovale catchment drainage systems and must discharge south into the ACEP drainage systems.

These small areas must also comply with the specified best practice requirements for quality and quantity/rate of stormwater discharge. However the opportunity may arise for co-operative agreement with ACEP landowners to amalgamate drainage assets further downstream within the ACEP. Such cross-precinct co-operative arrangements, if they eventuate, should be encouraged by Council as it will reduce the number and cost of drainage assets required to be maintained into the future.

For the purposes of the current HBP SWMS no assumptions can be made in regard to potential cross-precinct arrangements, so three WLRB's are included as shown on Figures 8 and 9.

Sizing of the assets required to service these small areas is based on the estimating relations derived in a previous detailed RORB modelling exercise completed in 2007 for the Sparrovale North catchment, as well as the recent ACEP/ACWP SWMS modelling.

The adopted estimates are as follows:

- retarding storage capacities = 300 m^3/ha of developable catchment area;
- wetland water surface areas = 2% of developable catchment area;
- Maximum active flood storage depth = 1.5 m above wetland NTWL;
- Asset land take for WLRB's = 2.2* wetland water surface area.

Table 1 summarises the estimates adopted for the SWMS. Future detailed modelling may allow some refinement of these quantities but they are adequate for the purposes of Development Contribution Plan preparation.

TABLE 1 Asset Sizing for South Boundary Catchments

Asset	Catchment (ha)	Flood Storage Capacity (m3)	Wetland Area (ha)	Land Take (ha)
WLRB South A	8.4	2,520	0.168	0.370
WLRB South B	15.0	4,500	0.300	0.660
WLRB South C	8.7	2,610	0.174	0.383

5. STORMWATER MODELLING-SPARROVALE CATCHMENTS

5.1 Peak Flows-Existing Conditions

5.1.1 Model Parameter Values

A RORB hydrologic model was prepared for existing catchment conditions as shown diagrammatically on Figure 7.

The model was run with Geelong Airport rainfall data, the "filtered" pattern option selected, with areal reduction factors as by Siriwardena and Weinmann, and using the following storage and rainfall model parameter values:

Storage Model: Kc=3.60, m=0.80,
Rainfall Loss Model: as per Table 2.

TABLE 2 Rainfall Loss Model Parameters for Armstrong Creek

ARI (years)	Initial Loss (mm)	Pervious Area Runoff Coefficients
1	20	0.56
2	20	0.56
5	20	0.59
10	20	0.63
20	20	0.67
50	20	0.73
100	20	0.79

(Note: The ratio Kc/Dav obtained by the CCMA for modelling of Armstrong Creek catchment was used to estimate the new catchment Kc value for HBP (T Jones pers. comm.).

This ensures the relative storage for each reach in HBP remains the same as that used in the wider Armstrong Creek catchment. (Dav = Average flow length for all sub areas with respect to the model outlet).

For Armstrong Creek Kc/Dav = 14.0/6.50 = 2.154.
*Dav for the HBP existing conditions structure shown on Figure 1 is 1.66 (generated by the model). Hence Kc= 2.154*1.66=3.6 with m=0.8.)*

5.1.2 RORB Model Results

Model results are summarised in Table 3.

TABLE 3 RORB Model Results (Model: HBP Exist.cat)							
Location	**ARI (yrs)**	**Peak Discharge (m3/s)**	**Critical Duration (hrs)**	**Location**	**ARI (yrs)**	**Peak Discharge (m3/s)**	**Critical Duration (hrs)**
Horseshoe Bend Road South	1	0.8	30	Horseshoe Bend Road North	1	0.2	30
	2	1.0	30		2	0.3	12
	5	1.5	48		5	0.5	12
	10	2.0	9		10	0.6	9
	20	2.8	9		20	0.9	9
	50	3.9	9		50	1.2	9
	100	5.1	9		100	1.5	9
Batten Road	1	1.0	30	Barwon Heads Road North	1	0.8	30
	2	1.3	48		2	0.9	12
	5	2.0	36		5	1.4	12
	10	2.4	12		10	1.9	12
	20	3.3	9		20	2.5	9
	50	4.7	9		50	3.2	9
	100	6.1	9		100	4.7	9
Barwon Heads Road South	1	1.0	30	Sparrovale North catchment at Sparrovale Road	1	0.9	30
	2	1.4	48		2	1.1	12
	5	2.1	36		5	1.7	12
	10	2.5	12		10	2.2	9
	20	3.4	12		20	3.1	9
	50	4.9	12		50	4.2	9
	100	6.3	12		100	5.5	9
Sparrovale South catchment at Charlemont Road	1	1.0	30	Reserve Road catchment at Barwarre Road	1	0.2	30
	2	1.4	48		2	0.3	12
	5	2.2	36		5	0.4	12
	10	2.6	24		10	0.6	9
	20	3.6	12		20	0.8	9
	50	5.2	12		50	1.2	9
	100	6.7	12		100	1.5	9
				Reserve Road catchment outfall at Reserve Road/Drews Road	1	0.5	30
					2	0.6	48
					5	0.9	12
					10	1.1	9
					20	1.5	9
					50	2.2	9
					100	2.9	9

5.2 Peak Flows and Levels-Fully Developed Conditions

5.2.1 Parameter Adjustments

The RORB hydrologic model was adjusted to suit proposed future developed catchment conditions and drainage diversions, as shown diagrammatically on Figure 8.

The Kc value was again adjusted to suit the amended structure and additional subareas east of Barwon Heads Road. Dav for the setup shown on Figure 8 is 2.16, so Kc=2.154*2.16 = 4.70, with m=0.8. Rainfall parameters are unchanged.

Percentage imperviousness for each subarea was set according to the current proposed masterplan layout:

- 60% impervious for conventional residential development;
- 70% impervious for schools;
- 80% impervious for medium density areas;
- 90% impervious for the MAC;
- 65% impervious for residential areas abutting the MAC.

5.2.2 Primary Drainage Management Assets

In addition to the subarea and reach data derived from Figure 8, the stage-storage characteristics of the four major proposed stormwater management assets were also input to the model.

These assets are first and foremost sized to ensure sediment management across the HBP is adequate for the purposes of protection of proposed open waterways within the HBP. A minimum treatment performance standard of 70% removal of Total Suspended Solids (TSS) is arbitrarily set in the MUSIC model to determine the minimum water surface area required for each asset to comply with this target.

The two storages designed as linear waterbodies to overcome flat drainage gradient issues at the two main sewer crossings have larger water surface areas than required to achieve the 70% TSS removal criteria. These water surface areas are determined by length of the storage and average water surface width of 20 m.

Table 4 summarises the stage-area-storage relations and the hydraulic controls adopted for each asset after trial and error modelling in RORB and MUSIC. The Normal Top Water Levels (NTWL's) have been determined using the 0.5 m contour data plus as-built levels along the Barwon Water main sewer.

TABLE 4	**Stage-area-storage-discharge characteristics for key retarding storages**				
Storage	**NTWL (m)**	**Stage (m)**	**Area (m2)**	**Storage (m3)**	**Outlet Controls**
Horseshoe Bend Road South SBRB (1.0 ha reserve)	16.00	16.00	5,000	0	0.3 weir
		16.50	5,460	2,615	2.0 m weir
		17.00	7,475	5,849	
		18.00	9,780	14,477	20 m overflow weir
		18.50	11,000	19,672	
Barwon Heads Road South SBRB (2.25 ha reserve)	4.00	4.00	8,500	0	0.5 m weir
		4.50	9,600	4,525	2.5 m weir
		5.00	15,395	10,775	
		6.00	20,350	28,650	20 m overflow weir
		6.50	22,500	39,360	
Reserve Road SBRB (1.6 ha reserve)	8.50	8.50	5,500	0	0.3 m weir
		9.00	6,244	2,936	0.6 m weir
		9.50	9,320	6,827	
		10.50	12,740	17,857	
		11.00	16,000	25,040	20 m overflow weir
Sparrovale North (sewer crossing) SBRB (2.25 ha reserve)	6.75	6.75	10,250	0	0.5 m weir
		7.25	11,564	5,453	5.3 m weir
		7.75	17,000	12,595	
		8.25	19,865	21,810	20 m overflow weir
		8.75	22,725	32,458	

Note: Detail design of each asset may result in adjustments to the NTWL's. The current proposal for the Sparrovale North (sewer crossing) SBRB provides for a 1m clearance between NTWL and the top of the sewer. As this selection has great significance for fill volumes across the surrounding lands, it is expected that detail design will endeavour to reduce the clearance and lower the whole stage-storage relation accordingly. Final decisions will be subject to the approval of Barwon Water.)

5.2.3 RORB Model Results

The RORB model results summarised in Table 5 show that:

- Peak 10 year ARI discharges in the HBP at Boundary Road/Rail Crossing are 3 m^3/s and this is the minimum flow to be diverted north into the Sparrovale North catchment.

- The full 100 year ARI discharge from the Reserve Road SBRB can be diverted south-easterly into the Sparrovale North catchment without flood levels at the 4D boundary exceeding natural surface.

- Consequently, peak 100 year ARI discharges into the Marshall Precinct at Reserve Road are reduced by 2.9 m^3/s compared with existing conditions.

- Peak 100 year ARI flows east of Horseshoe Bend Road in the Sparrovale North waterway are 7.3 m^3/s into the Sparrovale North (Sewer Crossing) SBRB, rising to 10.5 m^3/s across the sewer and Barwon Heads Road.

- Peak 100 year ARI discharges in the Sparrovale South waterway east of Horseshoe Bend Road can be maintained between 9 and 10.6 m^3/s to Charlemont Road.

- Peak 100 year ARI discharge to Sparrovale Farm will be 22.3 m^3/s for full development compared with 12.2 m^3/s for existing conditions.

Key summary results are also overlaid on Figure 9.

TABLE 5 RORB Model Results for fully developed conditions (Model: HBP Developed Final.cat)

ARI (years)	Location	Peak Inflow (m3/s)	Peak Outflow (m3/s)	Critical duration (hrs)	Water Level (m)	Storage Volume (m3)
1	Horseshoe Bend Rd South SBRB	3.1	1.8	9	17.02	6,060
	Batten Rd		2.6	9		
	Barwon Heads Road South SBRB	3.1	2.4	9	5.01	11,000
	Charlemont Road Outfall		2.6	9		
	Boundary Rd diversion	1.3	1.3 (north) 0 (to MAC)	25 m		
	Barwarre Road at 4D/Rail		1.8	25 m		
	Reserve Road SBRB	2.9	1.3	9	9.69	8,930
	Horseshoe Bend Road North		1.6	9		
	Sparrovale North (Sewer crossing) SBRB	4.5	2.6	9	7.60	10,500
	Sparrovale Road Outfall		2.8	9		
	Combined Outfall to Sparrovale Farm		5.6	9		
2	Horseshoe Bend Rd South SBRB	3.7	2.3	9	17.12	6,870
	Batten Rd		3.5	9		
	Barwon Heads Road South SBRB	4.0	3.3	9	5.15	13,400
	Charlemont Road Outfall		3.4	9		
	Boundary Rd diversion	1.6	1.6 (north) 0 (to MAC)	15 m		
	Barwarre Road at 4D/Rail		2.1	25 m		
	Reserve Road SBRB	3.5	1.7	9	9.88	11,100
	Horseshoe Bend Road North		2.2	9		
	Sparrovale North (Sewer crossing) SBRB	5.5	3.7	9	7.72	12,100
	Sparrovale Road Outfall		4.1	9		
	Combined Outfall to Sparrovale Farm		7.7	9		

TABLE 5 RORB Model Results for fully developed conditions (Model: HBP Developed Final.cat)

ARI (years)	Location	Peak Inflow (m3/s)	Peak Outflow (m3/s)	Critical duration (hrs)	Water Level (m)	Storage Volume (m3)
5	Horseshoe Bend Rd South SBRB	5.3	2.9	9	17.25	8,000
	Batten Rd		4.7	9		
	Barwon Heads Road South SBRB	5.4	4.4	9	5.32	16,400
	Charlemont Road Outfall		4.7	9		
	Boundary Rd diversion	2.2	2.2 (north) 0 (to MAC)	15 m		
	Barwarre Road at 4D/Rail		3.3	2		
	Reserve Road SBRB	5.2	2.4	9	10.15	14,000
	Horseshoe Bend Road North		3.1	9		
	Sparrovale North (Sewer crossing) SBRB	7.8	5.0	9	7.83	14,200
	Sparrovale Road Outfall		5.6	9		
	Combined Outfall to Sparrovale Farm		10.8	9		
10	Horseshoe Bend Rd South SBRB	6.8	3.4	2	17.34	8,790
	Batten Rd		5.5	9		
	Barwon Heads Road South SBRB	6.3	5.2	9	5.42	18,300
	Charlemont Road Outfall		5.6	9		
	Boundary Rd diversion	3.0	3.0 (north) 0 (to MAC)	2		
	Barwarre Road at 4D/Rail		4.2	2		
	Reserve Road SBRB	6.9	2.8	9	10.33	16,000
	Horseshoe Bend Road North		3.7	2		
	Sparrovale North (Sewer crossing) SBRB	10.1	5.9	9	7.91	15,700
	Sparrovale Road Outfall		6.5	9		
	Combined Outfall to Sparrovale Farm		12.8	9		
20	Horseshoe Bend Rd South SBRB	8.7	4.6	2	17.54	10,500
	Batten Rd		6.6	9		
	Barwon Heads Road South SBRB	7.6	6.3	9	5.56	20,800
	Charlemont Road Outfall		6.8	9		
	Boundary Rd diversion	3.8	3.6 (north) 0.2 (to MAC)	2		
	Barwarre Road at 4D/Rail		5.4	2		
	Reserve Road SBRB	9.4	4.7	2	10.29	15,500
	Horseshoe Bend Road North		1.6	9		
	Sparrovale North	13.2	7.2	9	8.01	17,800

TABLE 5 RORB Model Results for fully developed conditions (Model: HBP Developed Final.cat)

ARI (years)	Location	Peak Inflow (m3/s)	Peak Outflow (m3/s)	Critical duration (hrs)	Water Level (m)	Storage Volume (m3)
	(Sewer crossing) SBRB					
	Sparrovale Road Outfall		7.9	9		
	Combined Outfall to Sparrovale Farm		15.5	9		
50	Horseshoe Bend Rd South SBRB	11.4	6.2	2	17.79	12,600
	Batten Rd		8.4	2		
	Barwon Heads Road South SBRB	9.9	7.7	9	5.72	23,700
	Charlemont Road Outfall		8.2	9		
	Boundary Rd diversion	4.7	3.6 (north) 1.1 (to MAC)	2		
	Barwarre Road at 4D/Rail		6.9	2		
	Reserve Road SBRB	12.3	4.6	9	10.76	21,500
	Horseshoe Bend Road North		6.0	1.5		
	Sparrovale North (Sewer crossing) SBRB	17.1	8.8	9	8.12	19,900
	Sparrovale Road Outfall		9.7	9		
	Combined Outfall to Sparrovale Farm		18.9	9		
100	Horseshoe Bend Rd South SBRB	14.0	7.9	1	18.01	14,600
	Batten Rd		10.6	2		
	Barwon Heads Road South SBRB	12.4	9.2	2	5.89	26,600
	Charlemont Road Outfall		9.7	9		
	Boundary Rd diversion	5.6	3.6 (north) 2.0 (to MAC)	2		
	Barwarre Road at 4D/Rail		8.4	2		
	Reserve Road SBRB	15.0	5.5	9	10.97	24,600
	Horseshoe Bend Road North		7.2	9		
	Sparrovale North (Sewer crossing) SBRB	21.0	10.5	9	8.22	21,900
	Sparrovale Road Outfall		11.5	9		
	Combined Outfall to Sparrovale Farm		22.3	9		

5.3 Water Quality Modeling

The proposed stormwater drainage system to the Sparrovale Wetlands was modeled using MUSIC Version 3 with the 6 minute rainfall data sequence for Geelong North, 1980-89 (***Filename: HBP Developed Final GN 1980-89 6 min***), and assuming:

- full development of the subject lands;
- asset sizing and characteristics as set out in Table 6;

The model structure is shown diagrammatically on Figure 11.

In addition to the four major treatment SB's upstream of the main sewer alignment, the MUSIC model includes two extra sediment storages at Sparrovale Road and at the combined outfall downstream of the precinct boundary, to protect the receiving wetlands.

A hypothetical wetland area is added at the downstream end of the MUSIC model treatment train to quantify what additional treatment area would be required to ensure compliance with best management practice (BMP) stormwater quality treatment standards for the full precinct, should the proposal to utilise the whole Sparrovale Farm wetlands area not materialize for some reason.

TABLE 6 Components of Stormwater Quality Treatment System, HBP

Asset	NTWL (m)	Water Surface Area at NTWL (m^2)	Volume at NTWL (m^3)	Extended detention depth (m)
Horseshoe Bend Rd South SB	16.00	5,000	4,000	0.5
Barwon Heads Road South SBR	4.00	8,500	7,000	0.5
Reserve Road SB	8.50	5,500	4,500	0.5
Sparrovale North (Sewer Crossing) SB	6.75	10,250	9,500	0.5
Sparrovale Road SB	1.00	1,200	1,000	0.5
Sparrovale Wetland Inlet SB	1.00	2,500	2,000	0.5
Sparrovale Farm Wetland (hypothetical minimum extra wetland area needed to comply with BMP	1.00	75,000	45,000	0.3

The results in Table 7 confirm that:

- the key sediment management criteria for protection of open waterways in the HBP will be achieved;

- in conjunction with the sediment basins, a hypothetical wetland of 7.5 ha at the outlet from the HBP to Sparrovale Farm would suffice to ensure compliance with BMP standards for the full Precinct.

It follows from these results that with a water surface area of some 220 ha at 0.95 m:

- the proposed major freshwater wetland system in Sparrovale Farm is far larger than required to deal with stormwater management issues arising from the HBP;

- other than minor earthworks to protect identified vegetation areas in the southeast corner of the farm from prolonged inundation, and weed management, no special measures are required to manage stormwater across the farm if and when it is converted to public ownership.

TABLE 7 MUSIC Model Results-Sparrovale Wetlands Catchment (Geelong North 1980-89 6 minute data sequence)

Asset/Parameter	Input Loads	Residual Loads	% load removal
Horseshoe Bend Road SB			
Flow (ML/yr)	377	373	1
Suspended Solids (Kg/yr)	62,100	18,000	71
Total Phosphorus (Kg/yr)	139	69	50
Total Nitrogen (Kg/yr)	974	761	22
Gross Pollutants (kg/yr)	13,700	0	100
Barwon Heads Road South SB			
Flow (ML/yr)	760	753	1
Suspended Solids (Kg/yr)	92,600	32,500	65
Total Phosphorus (Kg/yr)	224	131	42
Total Nitrogen (Kg/yr)	1,860	1,530	18
Gross Pollutants (kg/yr)	16,200	0	100
Reserve Road SB			
Flow (ML/yr)	407	403	1
Suspended Solids (Kg/yr)	79,100	20,700	74
Total Phosphorus (Kg/yr)	164	76	54
Total Nitrogen (Kg/yr)	1,160	874	24
Gross Pollutants (kg/yr)	17,100	0	100
Sparrovale North (Sewer Crossing) SB			
Flow (ML/yr)	855	847	1
Suspended Solids (Kg/yr)	107,000	35,400	67
Total Phosphorus (Kg/yr)	254	145	43
Total Nitrogen (Kg/yr)	2,170	1,740	20
Gross Pollutants (kg/yr)	18,900	0	100
Sparrovale Rd SB			
Flow (ML/yr)	930	929	0
Suspended Solids (Kg/yr)	51,500	40,400	22
Total Phosphorus (Kg/yr)	178	161	9
Total Nitrogen (Kg/yr)	1,970	1,920	3
Gross Pollutants (kg/yr)	3,470	0	100
Reserve Road SB			
Flow (ML/yr)	407	403	1-
Suspended Solids (Kg/yr)	79,100	20,700	74
Total Phosphorus (Kg/yr)	164	76	54
Total Nitrogen (Kg/yr)	1,160	874	24

TABLE 7 MUSIC Model Results-Sparrovale Wetlands Catchment (Geelong North 1980-89 6 minute data sequence)			
Asset/Parameter	**Input Loads**	**Residual Loads**	**% load removal**
Gross Pollutants (kg/yr)	17,100	0	100
Sparrovale Wetlands SB			
Flow (ML/yr)	1,870	1,870	0
Suspended Solids (Kg/yr)	105,000	82,400	21
Total Phosphorus (Kg/yr)	361	326	10
Total Nitrogen (Kg/yr)	3,960	3,840	3
Gross Pollutants (kg/yr)	5,990	0	100
Total Assets including Sparrovale Wetlands SB	**Total Source Load**	**Loads removed in HBP Assets**	**% removal of HBP source loads**
Flow (ML/yr)	1,890	1,870	1
Suspended Solids (Kg/yr)	361,000	82,400	77
Total Phosphorus (Kg/yr)	752	326	57
Total Nitrogen (Kg/yr)	5,360	3,840	29
Gross Pollutants (kg/yr)	77,400	0	100
Total Assets including 7.5 ha Sparrovale Wetlands	**Total Source Load**	**Loads removed in HBP Assets**	**% removal of HBP source loads**
Flow (ML/yr)	1,890	1,770	7
Suspended Solids (Kg/yr)	361,000	47,500	87
Total Phosphorus (Kg/yr)	752	210	72
Total Nitrogen (Kg/yr)	5,360	2,950	45
Gross Pollutants (kg/yr)	77,400	0	100

6. DRAINAGE DESIGN AND IMPLEMENTATION CONSIDERATIONS

6.1 Diversion Conduits

The diversion conduit southeast from the Reserve Road SBRB to Horseshoe Bend Road and the outfall from the Sparrovale North (Sewer Crossing) SBRB to Sparrovale Road will be pipelines.

To confirm pipe sizing and levels hydraulic gradeline analysis was undertaken using a spreadsheet program developed by the author. Invert levels and lengths used for the analyses are preliminary estimates only and will be subject to variation to comply with servicing and development layout constraints.

The results summarised in Figure 10 confirm the following:

- The Reserve Road SBRB diversion pipeline will need to be 1800 mm diameter to the junction pit at Horseshoe Bend Road, increasing to 1950 mm diameter downstream to the next SBRB.

  (Notes: These pipes will convey 100 year ARI discharges so as to eliminate the need for an additional excavated surface floodway across the subcatchment divide. However a 20 m green link doubling as a surface floodway should be retained east of Horseshoe Bend Road. Flows exceeding 100 years ARI at the Reserve Road SBRB will rise and overflow the 4D alignment (at natural surface level) and continue northwards through to the Marshall Precinct.)

- The Sparrovale North Outfall pipeline from the Sewer Crossing SBRB across Barwon Heads Road to Sparrovale Road will generally be a 1500 mm diameter to convey 10 year ARI flows. The actual sewer crossing is envisaged to be a 600 mm diameter pipe at invert of 6.3 m for low flows with an offset grassed floodway at invert of 7.25 m which terminates at a special intake structure to the 1500 mm pipe. A similar grassed floodway will continue to Barwon Heads Road at invert of 7.85 m to carry flows greater than 10 years ARI. Cover restrictions will likely require twin 1350 mm pipes to be provided across Sparrovale Road to the linear wetland downstream.

  (Note: Surcharge flows greater than 10 year ARI pipe capacity will be conveyed overland in grassed floodways not less than 30 m in width (including pedestrian trail)s. The Barwon Heads Road crossing will be duplicated or otherwise augmented with appropriate inlet/outlet structures to convey up to 100 year ARI flows below the road, as required by VicRoads).

The Boundary Road/Rail diversion pipe will need to be not less than 1200 mm in diameter to convey the minimum 10 year ARI flow of 3 m^3/s.

6.2 Open Waterway Reserves

The open waterways proposed to be constructed within the HBP are shown as straight lines on Figure 9. The design intent for future subdivisional design however is for every opportunity to be taken to meander the section through urban areas.

From a cross-sectional perspective the intent is to establish a "naturalised" waterway environment which is capable of evolving with time as vegetation communities become established under the changing hydrologic regime associated with catchment urbanisation. The same approach has underpinned the design of the Armstrong Creek waterway in ACEP and it is anticipated that a common visual and environmental outcome will be created in the HBP, albeit at reduced scale commensurate with the lower flows.

The key design objectives are as follows in no specific order of priority:

- Channel stability and sustainable capacity to carry flows,
- maintainability (gentle batters and access trails where mowing is needed),
- accessibility and safety (again resolved to gentle batter slopes especially where free public access is available, plus low velocities),
- landscape appeal (diversity of batter slopes and plantings and pools/runs/riffles plus some open views),
- environmental values (sediment control, plantings and habitat diversity- pools/runs/riffles),

Waterway width is basically governed by the need to have adequate depth to "daylight" tributary drainage pipes and to insert sediment basins, wetlands, bioretention systems etc. With pipe sizes of about 1 m and similar cover requirements to provide for services, it is most unusual to have a total depth of less than 2.0 m, with extra freeboard of 600 mm above the 100 yr flood level to adjacent floor levels.

On the (steep) slope of 1% along the Sparrovale South waterway it is necessary to design a "rough" channel to limit how fast the water will flow. The shape typically has a meandering shallow rocky low flow channel (0.3-0.5 m deep and ~3 m wide) which is recessed into, and meandered back and forth across, a wide densely vegetated base zone (up to 6 m wide each side of the low flow channel rising about 0.2 m) with 6:1 batters on average back to finished surface. That equates to a total width of just over 30 m. Allowing for access and setback the minimum reserve width is therefore 35 m.

Dense indigenous vegetation plantings are proposed across the base zone to assist in maintaining benign hydraulic conditions in floods. The vegetation species used will be of local provenance with an emphasis on dense plantings of flexible shrubs with sedge understorey (eg., melaleuca/carex or leptospermum/carex community structures) to create the robust hydraulic control required.

There are several precedents for this environmentally based waterway design approach now operating successfully across the greater Melbourne area and the same design approach is currently being established as part of the Armstrong Creek restoration works in the ACEP.

6.3 Other Subdivisional Floodways

All roads and reserves used to convey overland flows through the subdivisions to and from the various storages in the main waterways should also provide at least 300 mm freeboard above 100 year ARI flood levels to adjacent finished surface levels or floor levels.

Final levels are also subject to 600 mm freeboard being applied above the main waterway flood levels and the Barwon River floodplain level of 3.00 m. Hence the minimum floor level of any dwelling in the HBP is 3.60 m.

6.4 4D Road Corridor Catchment Definition and Trifilos Drain

Figure 2 (sheet 2 of 2) shows that under existing conditions some of the overbank flows in Trifilos Drain spread northeasterly along the 4D corridor and across part of the HBP development lands near Reserve Road.

In the future the works associated with the 4D corridor will formalise that land as the catchment barrier between the Southeast Grovedale catchments and the HBP.

However until such time as the 4D works are completed the HBP lands remain subject to overland flow inundation from Trifilos Drain. Hence if development of the HBP lands was to proceed earlier, interim flood protection works in the form of general filling of the development verge, or construction of a fill mound, would be required to confine extent of overland flows to the southerly boundary of the 4D reserve. Whatever option is selected the height of the flood barrier need only be 0.5-0.6 m.

Those works would be the responsibility of the developers concerned and would not form part of the Development Contributions Plan.

The flood barrier works would have no impact on stability or flood levels in Trifilos Drain and would not divert flood flows away from the current alignment at Reserve Road.

No modifications would be required to the drain or its structures to Reserve Road.

Trifilos Drain would remain in its current form and continue to be managed by CoGG.

6.5 Sparrovale Wetlands - Assets and Works

6.5.1 Inlet Drainage

At Charlemont Road/ Sparrowvale Road the natural surface levels prevent free-draining open waterways from being constructed downstream on both branches. With negligible grades it is necessary to adopt a linear wetland system for the drainage lines with NTWL set at approximately 1.00 m AHD as in the East precinct. In turn this requires reserve widths to increase to not less than 50 m.

On the north branch it is necessary to provide an online sediment basin at the start of the linear wetland (adjacent to Sparrowvale Road) to intercept coarser sediments from the local catchments entering between the sewer crossing and Sparrowvale Road. The basin is easily created as an over-excavation zone within the 50 m reserve. Using the same 70% TSS removal criteria as before, the required water surface area is determined as 1,200 m^2. NTWL matches the linear wetland at 1.00 m AHD.

On the south branch the proximity of the Barwon Heads Road SBRB means minimal additional catchment enters so it is not necessary to provide an additional sediment basin in the Charlemont Road linear wetland.

A final online sediment basin will be created in the main Sparrovale Wetlands inlet drain downstream of the confluence of the north and south branch linear wetlands. This location controls all future urban drainage systems in the HBP. The basin is again simply created as an over-excavated and widened zone on the existing drain alignment. Using the same 70% TSS removal criteria as before, the required water surface area is determined as 2,500 m^2. NTWL matches the linear wetland system at 1.00 m AHD.

6.5.2 Vegetation Protection Works

The modified coastal marsh vegetation identified within the easterly end of the Sparrovale Farm is depicted on Figure 5 (Sheet 2 of 2). Survey data confirms the vegetation is established on land generally between 0.5-1.0 m AHD.

The wetlands proposal would result in virtually complete and permanent inundation of the vegetation by freshwater, unless protected by an embankment of sufficient height to separate it from the main wetlands.

The bank shown on Figure 5 (Sheet 2 of 2) has a minimum crest width of 4 m at 1.25 m AHD, to provide separation from the proposed freshwater wetland operating levels and an additional maintenance access route. Existing drains which cut through the vegetation zone will continue to service most of the lowpoints trapped by the existing Barwon River levee and the new embankment via the existing regulator outlet. In major floods the salt marsh zone will remain subject to inundation when wetland levels rise above the crest, and/or the Barwon River levee is overtopped.

To provide for maintenance drawdown in the main wetlands by gravity means the new embankment should incorporate a 600 mm diameter pipe culvert and gate valve or similar control on the alignment of the existing drain connecting to the regulator outlet under the Barwon River levee.

6.6 Waterbody Edge Design Considerations

It is intended that, with the possible exception of some hydraulic structures, all waterbodies to be constructed in the HBP will be freely accessible to the public. This requires the water edge zones to comply with standard safe edge design all around.

Standard safe edge design is recommended to be 3:1 (horizontal:vertical) through the edge zone (+/-150 mm at NTWL) and 8:1 out to 600 mm below NTWL. This gives a 4.05 m aquatic planting strip all around. Upper slopes can vary for landscape effect around an average of 6:1.

For sediment basins a suitably sized drying zone needs to be located next to the water line with hardstand access tracks extending back up to perimeter finished surface at 10:1 average slopes.

6.7 Hydraulic Control Structures for Primary SBRB Assets

The outlet pit controls for the four main assets in the HBP need to perform three functions:

- low flow control for water quality treatment within the Extended Detention Depth (EDD);

- gravity drainage or pumpout capacity to facilitate drainage of the waterbody for maintenance, and

- high flow controlled discharge capacity for floods to the 100 year ARI water levels.

Conceptual arrangements for twin-function structures which meet the first two objectives have been recently prepared by Melbourne Water for application on all new systems. These are shown on Figure 11.

The twin-function pit concepts can be adapted to provide the third (flood control) function through variation in sizing and levelling.

6.8 Staging/Implementation Considerations

6.8.1 General Principles

The number and location of the stormwater management assets shown on Figure 9 has been arranged to minimise overall capital and ongoing costs and to utilise as much land which is already encumbered by flooding as is practicable (rather than otherwise developable land), having regard to other constraints such as flora/fauna values, the 4D and Rail corridors, and the main outfall sewer.

It is possible to split SBRB's or WLRB's into segments to better suit staged or "out-of-sequence" development, or to resolve property ownership demarcations. However there is an "efficiency" penalty in doing this. As storage depths are basically fixed by flood levels and creek levels, and batter lengths are increased, splitting storages directly increases land area requirements. Other studies indicate storage capacity requirements rise by about 20% on average when a WLRB is split into two segments.

Similarly there is a penalty for ongoing operation and maintenance costs with increased numbers and total areas of assets.

Subject to suitable arrangements being put in place to cover any capital cost or ongoing cost penalties and the same performance standards being met, there is no technical reason why a storage cannot be split to better suit development layouts or land ownership differences.

It is standard practice in urban development contributory drainage schemes across the greater Melbourne area, for any temporary management facilities that may be required to service "out-of-sequence" development (as may be required to protect downstream undeveloped land and/or the environment) to be funded by the proponents of that development without reimbursement from the scheme, or in this case the DCP.

Timing of construction of SBRB's and WLRB's (and connecting pipelines or waterways) is entirely governed by the progress, rate and staging of development. The need for, and extent/size of any temporary management facilities that may be required to service "out-of-sequence" development is similarly affected.

Subject to Council agreement (as the ongoing responsible body for operation and maintenance) flexibility should always be retained to allow different landowners to negotiate changes to drainage layout and design of assets-with any extra capital costs outside the DCP also being negotiated between them.

6.8.2 Some Specific Recommendations for the HBP

(a) Sparrowvale North Catchment

Development in this catchment area downstream of Horseshoe Bend Road will require early construction of the linear SBRB upstream of the main sewer and connection to the existing culvert under Barwon Heads Road, in order to provide an adequate depth for future urban tributary drainage systems.

Development west of Horseshoe Bend Road could proceed in advance of works downstream, subject to adequate temporary site management facilities being constructed as discussed in Section 6.8.1.

Subject to prior completion of the linear SBRB, upgrading of the culvert outfall under Barwon Heads Road can be deferred until development in the upstream catchment exceeds about 25% of the developable area. This represents about the practical limit of control that the linear SBRB can exert over peak runoff rates.

Upgrade of the Barwon Heads Road culvert will trigger the need for the works downstream to the proposed Sparrovale Wetland system to be completed in order to gain the necessary lowered invert level (pipelines, the Sparrowvale Rd SB and linear wetland).

(b) Sparrowvale South Catchment

Development west of Horseshoe Bend Road could proceed in advance of works downstream, subject to adequate temporary site management facilities being constructed as discussed in Section 6.8.1.

Development of land around the Barwon Heads Road/Batten Road area will require upgrade of the culverts under Barwon Heads Road, completion of the upstream part of the linear SBRB, and cleanout works downstream to the sewer crossing.

Upgrade of the culverts under Barwon Heads Road will trigger the need for the works downstream to the proposed Sparrovale Wetland system to be completed in order to gain the necessary lowered invert level.

(c) Reserve Road Catchment

If initial stages of land development are sufficiently remote from the Reserve Rd SBRB site then temporary site management facilities may be constructed as discussed in Section 6.8.1.

Any development west of Barwarre Road abutting the rail corridor must make provision for and include the diversion pipe capacity from Boundary Road.

Development east of Barwarre Road near the 4D corridor will likely trigger the need for the Reserve Road SBRB to be constructed.

Timing of the main outfall diversion pipeline works from the Reserve Road SBRB back into the Sparrovale North drainage system will be dependent on rate and location of development.

If development in the Sparrovale North catchment had not proceeded to the point where the Sparrovale North SBRB had been built, then it may be feasible to provide a temporary low flow outlet to the existing drain at Reserve Road/Drews Road intersection.

Along the 4D alignment frontage it may be necessary to fill to create a barrier against inflow of overland flows from the Trifilos Drain catchment into the HBP development land. Such filling can be created by forming a temporary levee on the boundary (wrapping around the upstream end to create the flood barrier) or it can be formed as general raising of the verge roads/allotments. Such works do not form part of the DCP and are considered as temporary works to facilitate development within the HBP, in advance of the 4D road works.

(d) The Sparrovale Wetland System

This asset is virtually in place already as a hydrological control. To suit development management needs, modifications may be staged as follows:

The wetland will be effectively online when the outlet control structure to the Barwon River barrage pool is modified to retain all water to 0.95 m and include a one-way tideflex valve system to prevent river backflow.

At the same time the embankment to 1.25 m AHD must also be completed at the east end of the wetlands area to protect the salt marsh vegetation area.

Refurbishment works should also be completed as required to ensure integrity of the dropboard outlet regulator system to Hospital Swamps.

When development commences east of Barwon Heads Road, the relevant open waterway and linear wetland segments will need to be constructed (north or south drainage lines), at least to a stage sufficient to complete the hydraulic linkage downstream into the Sparrovale Wetland. The inlet sedimentation pondage for the Sparrovale Wetland will be required to be completed in conjunction with initial drainage construction east of Barwon Heads Road.

Away from the constructed works areas (eg., the inlet SB which must be planted at the time of construction), aquatic vegetation is expected to naturally colonise the wetland area with time, once extended inundation conditions are established.

However, regular maintenance efforts will be required to control weed or pest plant growth issues as they emerge. Spot spraying or other approved control techniques can be used as per expert advice.

Interim Uses of Verge Land Area

Depending on agreements and financial arrangements and timing in regard to transfer of the Sparrovale Farm into public ownership, there may well be a need (or opportunity) for interim management of part of the margins of the proposed wetlands area to suit short term ongoing agricultural use of the land (cropping, grazing, hay cutting etc.), or possibly some low intensity community uses. This would likely apply only to higher land areas as gravity outfall to the Barwon River can only occur when water levels rise above 0.85 m AHD.

From the SWMS viewpoint there is no issue in lease arrangements or the like on verge lands, running in parallel with use of the lower lands for stormwater management.

6.8.3 Development Application Requirements and Compliance

Applications for development approval for lands within the HBP may include construction of permanent works included in the DCP, or temporary works to adequately service "out-of-sequence" developments or to defer major works expenditure.

The following principles will be applied by CoGG in responding to all applications:

- Temporary works do not form part of the DCP and hence are to be fully funded by the development proponent, unless they are part of ultimate drainage design works (eg., partial excavation of a larger SBRB or waterway or wetland that are to be funded as part of the DCP).

- Development proponents are required to show in any application how the development proposal affects, or is affected by the requirements of this HBP SWMS.

- Development proponents must provide Stormwater Environmental Management Plans which identify potential waterway stability/environmental/drainage/flooding problems and constraints arising from their development proposals (including upstream or downstream impacts on existing receiving environments, waterways, land uses and assets/works), and quantify and recommend what is required to ensure compliance with best practice water management objectives.

- Every Stormwater Environmental Management Plan must deal explicitly with control over stormwater sediment loads and monitoring of same during estate construction works, and demonstrate how the works comply with best practice whilst addressing high construction-era sediment loads, potential acid sulphate soils and dispersive soils management issues.

- Potential acid sulphate soils and dispersive soils management issues are to be identified and appraised by suitably qualified geotechnical personnel.

- Where the proposed development drainage management measures do not form part of the DCP schedule, the development proponents are required to investigate, design, construct and fund all costs of establishment of the temporary works, including monitoring and reporting of water quality testing as may be required by CoGG, DSE or the CCMA, and ongoing maintenance requirements and costs.

- Statements of compliance will be conditional, in part, on cleanout and resetting of sediment management assets before handover to Council for ongoing responsibility, and on satisfactory financial arrangements being reached with Council for ongoing maintenance and eventual reclamation of temporary works.

Methodology

Best practice water quality performance is to be demonstrated using the MUSIC model.

For hydrologic assessments (flow and storage computations), the RORB model or equivalent is to be used.

For hydraulic modelling of one-dimensional flow systems the HEC-RAS model will suffice for water level, velocity and channel shear stress computations. For more complex hydraulic situations (generally wider floodplains), two-dimensional hydrodynamic models are to be used such as TuFlow or Mike 21 or their equivalents.

Where no gauged streamflow data exists to allow peak flows for existing rural conditions to be derived, the Rational Method may be applied for this purpose using Adams equation for estimation of time of concentration with matched runoff coefficients, all in accord with the recommendations set out in Australian Rainfall and Runoff (ARR). The 10 year ARI runoff coefficients provided in Volume 2 of ARR should be used and not those listed in other references such as VicRoads Design Manuals.

Unless specifically directed otherwise by CoGG:

- temporary drainage management works are to be sized to maintain existing conditions peak flows for all events up to and including 10 years ARI.

- best practice water quality objectives must be achieved prior to water exiting from the boundaries of the relevant development. This allows for options such as overland flow dispersal across vegetated areas within a larger development to be implemented.

Bioretention or infiltration systems will not be accepted as temporary sediment management works for any development application.

7. OTHER OPPORTUNITIES

With the Sparrovale Wetland incorporated into overall surface water management planning for the HBP, the available capacity for management of development runoff quality and quantity far exceeds that required for the HBP catchments alone.

This presents additional opportunities for stormwater management across the future urban areas.

7.1 Linkage to Armstrong Creek in the ACEP

By far the largest inflow of freshwater to Hospital Swamps arrives via Armstrong Creek in the ACEP. At present there is no effective means of offsetting the impact of major increases in freshwater runoff for all development with ACEP/ACWP and the future Western Industrial Precinct.

It is a simple matter to link the terminal wetlands exiting from the Armstrong Creek East Precinct across into the proposed Sparrovale wetlands as indicated on Figure 5 (Sheet 2 of 2). This link could take the form of a submerged pipeline or open drain over-excavated to have a permanent water base or some combination of pipe and channel approaches.

Construction of this link would then complete the hydrologic and water quality protection for the entire catchment to Hospital Swamps.

Funding for such a link cannot be attributed in any way to the HBP and consequently the link does not form part of this SWMS.

It would also follow that if and when such linkage is completed, that other sources of funding should contribute to the final cost of the Sparrovale wetlands project.

7.2 Linkage to South East Grovedale/Marshall Precinct Catchment

Trifilos Drain receives all runoff from the South East Grovedale catchments and part of the ACWP area, south of Reserve Road.

The opportunity is available to cross-connect this drainage line from a terminal SBRB or WLRB located at Reserve Road, by pipeline back across the 4D reservation and into the Reserve Road SBRB in the HBP.

The sizing of the asset will need to be sufficient to reduce the catchment flow back to at least rural conditions (including the existing developed South East Grovedale catchments), and control sediment as well, in order to avoid any significant impact on the current sizing of assets within the HBP.

There are two options for location of such an asset:

- reconstruction of the existing large dam located on the residual land area between the railway, the 4D reservation and Reserve Road;

- on the north side of Reserve Road near Drews Road.

Preliminary investigations in the Reserve Road/Drews Road area have identified some high value vegetation remnants which will compromise location and design of a suitable asset in this location.

Given that the existing large dam will require modification to suit 4D construction and can be confined to a portion of land which is on the south side of Reserve Road, this location is clearly favoured. This potential asset is referred to as the Reserve Road/Drews Road SBRB.

Modelling completed as part of the Marshall Precinct drainage investigations has confirmed it is feasible to divert the first 0.5 m^3/s discharged from the Reserve Road/Drews Road SBRB across the 4D corridor and into the Reserve Road SBRB and thence to the Sparrovale wetlands, without requiring upsize of any pipes or basins in the HBP drainage system. Reserve Road SBRB water levels and outflows are increased for all events less than about 50 years ARI but in the critical 100 year ARI event no significant changes occur.

This outcome will produce further significant reductions in inflows to the Marshall Precinct and complementary reductions in drainage quality and quantity management requirements.

Hence justification for completion of this link to the HBP drainage systems and thence to the Sparrovale Wetlands, will need to be established as part of the Marshall Precinct planning process. The link across the 4D corridor does not form part of the HBP SWMS.

8. DEVELOPMENT CONTRIBUTIONS PLAN ITEMS

Based on the results of this investigation the items listed in Table 8 should form part of the Development Contributions Plan for the Horseshoe Bend Precinct.

TABLE 8 Recommended HBP DCP Items (refer to Figures 5 (Sheet 2 of 2), 8 and 9)

Item	Item Description
1	Boundary Road/Rail Corridor diversion pipe (Boundary Road to 4D to Reserve Rd SBRB)
2	Reserve Road SBRB
3	Link pipeline to Sparrovale North SBRB-as per Figure 10 quantities
4	Sparrovale North (sewer crossing) SBRB
5	Sparrovale North SBRB-Sparrowvale Road (including sewer and road crossings) -as per Figure 10 quantities
6	Sparrowvale Rd SB
7	Sparrovale North Linear Wetland-Sparrowvale Rd to Sparrovale Wetlands Inlet SB -50 m reserve
8	Horseshoe Bend Road SBRB
9	Horseshoe Bend Rd to Barwon Heads Rd SBRB-35 m reserve
10	Barwon Heads Rd SBRB incl culverts and sewer works
11	Barwon Heads Rd SBRB-Charlemont Road-35 m reserve
12	Sparrovale South Linear Wetland-Charlemont Rd to Sparrovale Wetlands Inlet SB-50 m reserve
13	Sparrovale Wetlands Inlet SB
14	Barwon River levee outlet works refurbishment
15	Salt Marsh Vegetation protection embankment and culvert/valve structures
16	WLRB South A
17	WLRB South B
18	WLRB South C

Neil M Craigie

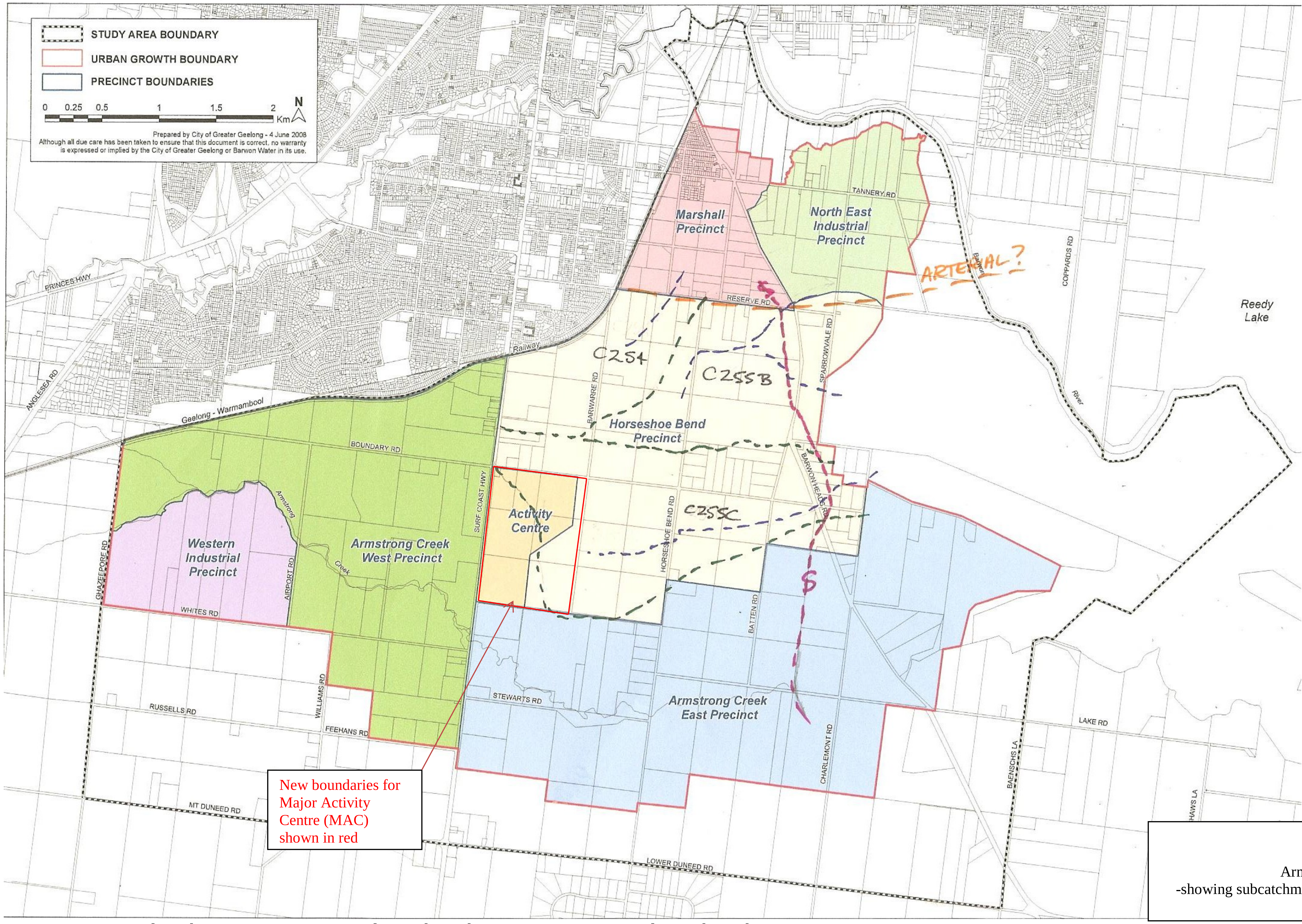


Figure 1

Armstrong Creek Horseshoe Bend Precinct (HBP) -showing subcatchment boundaries and main drainage lines and the existing main sewer

C254=Reserve Road catchment, C255B=Sparrovale North catchment, C255C=Sparrovale South catchment, S=existing main sewer

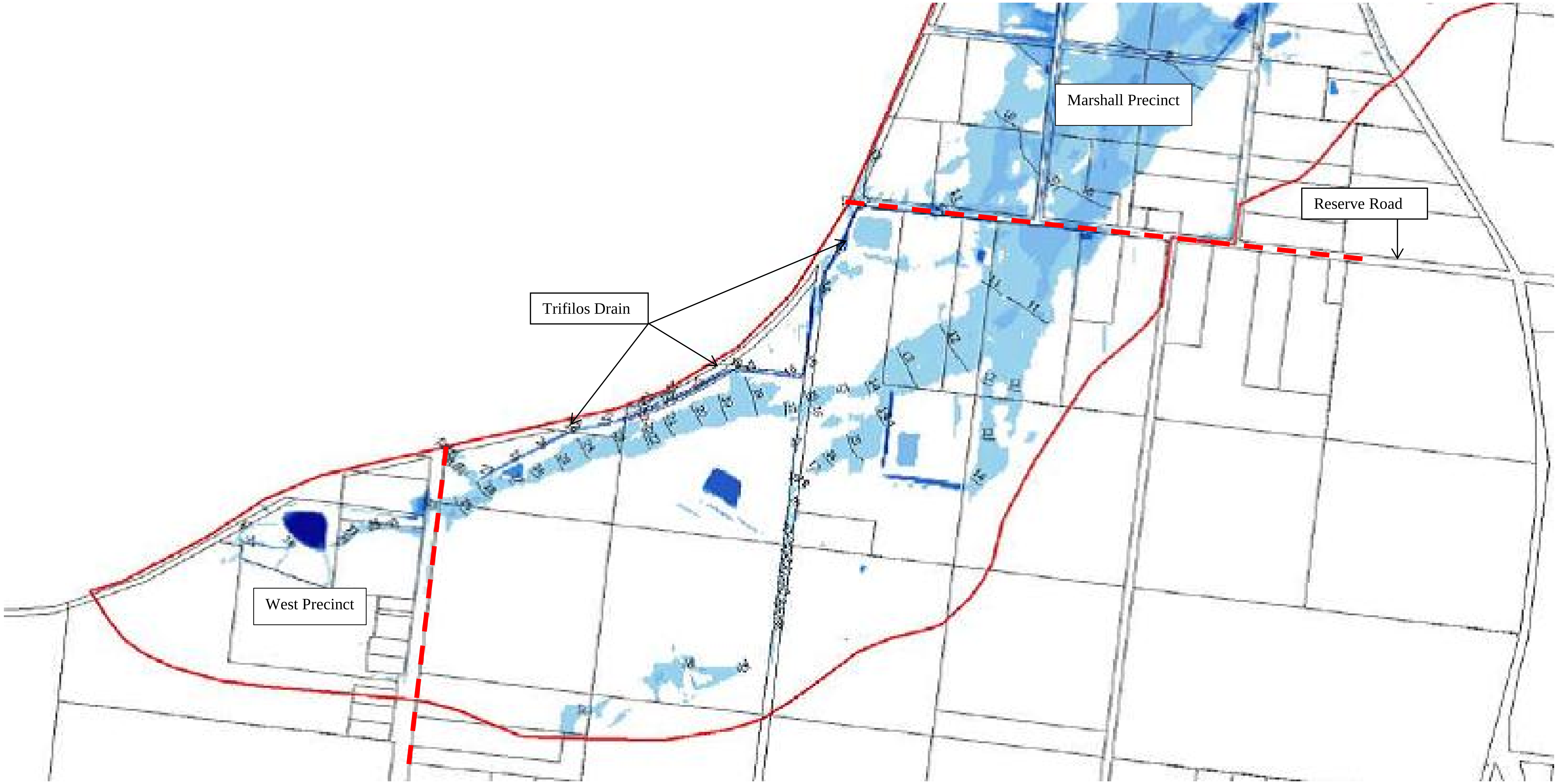


Figure 2 (Sheet 1 of 2)

Armstrong Creek Horseshoe Bend Precinct (HBP)
Extent and levels of inundation for 100 year ARI
(existing conditions-Water Technology 2006)
Reserve Road (Southeast Grovedale) Catchment

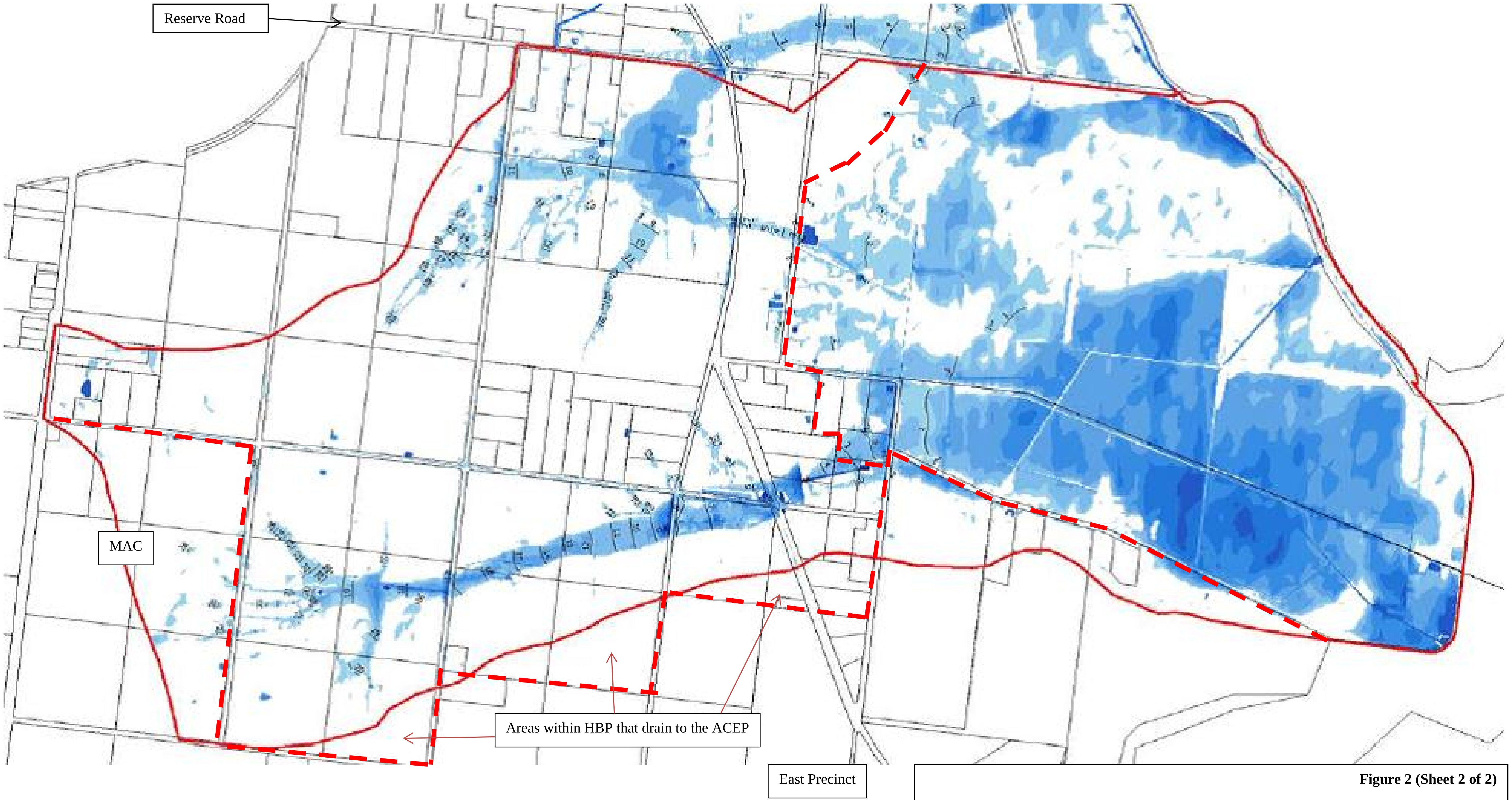


Figure 2 (Sheet 2 of 2)

Armstrong Creek Horseshoe Bend Precinct (HBP)
Extent and levels of inundation for 100 year ARI (existing conditions-Water Technology 2006)-Sparrovale Catchment (north and south).

Note: inundation shown is for local catchment runoff only. Higher flood levels apply for Barwon River flooding across Sparrovale Farm (2.00 m/3.00 m AHD for 10/100 years ARI respectively)

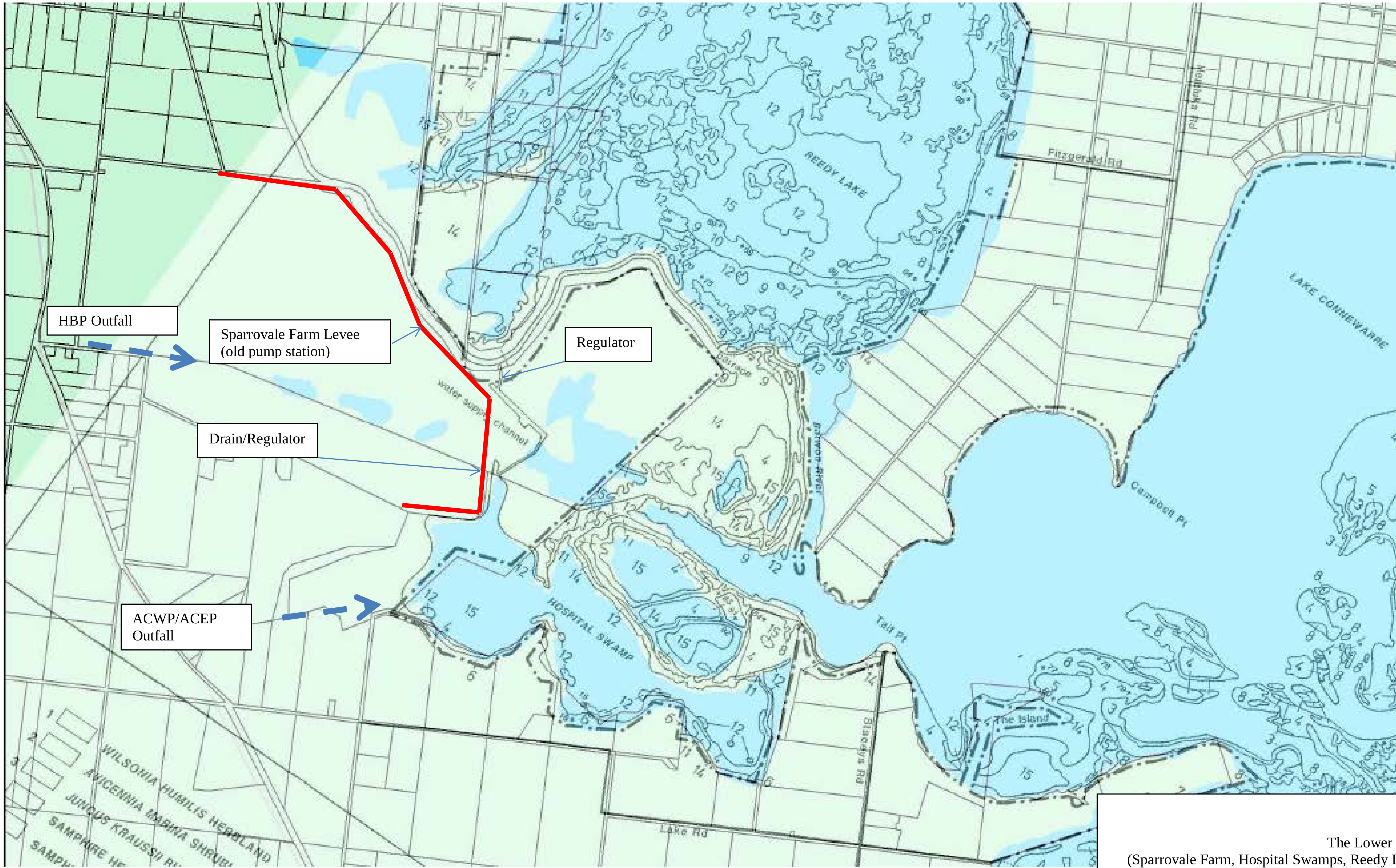


Figure 3

The Lower Barwon River Wetlands
(Sparrovale Farm, Hospital Swamps, Reedy Lake, Lake Connewarre)

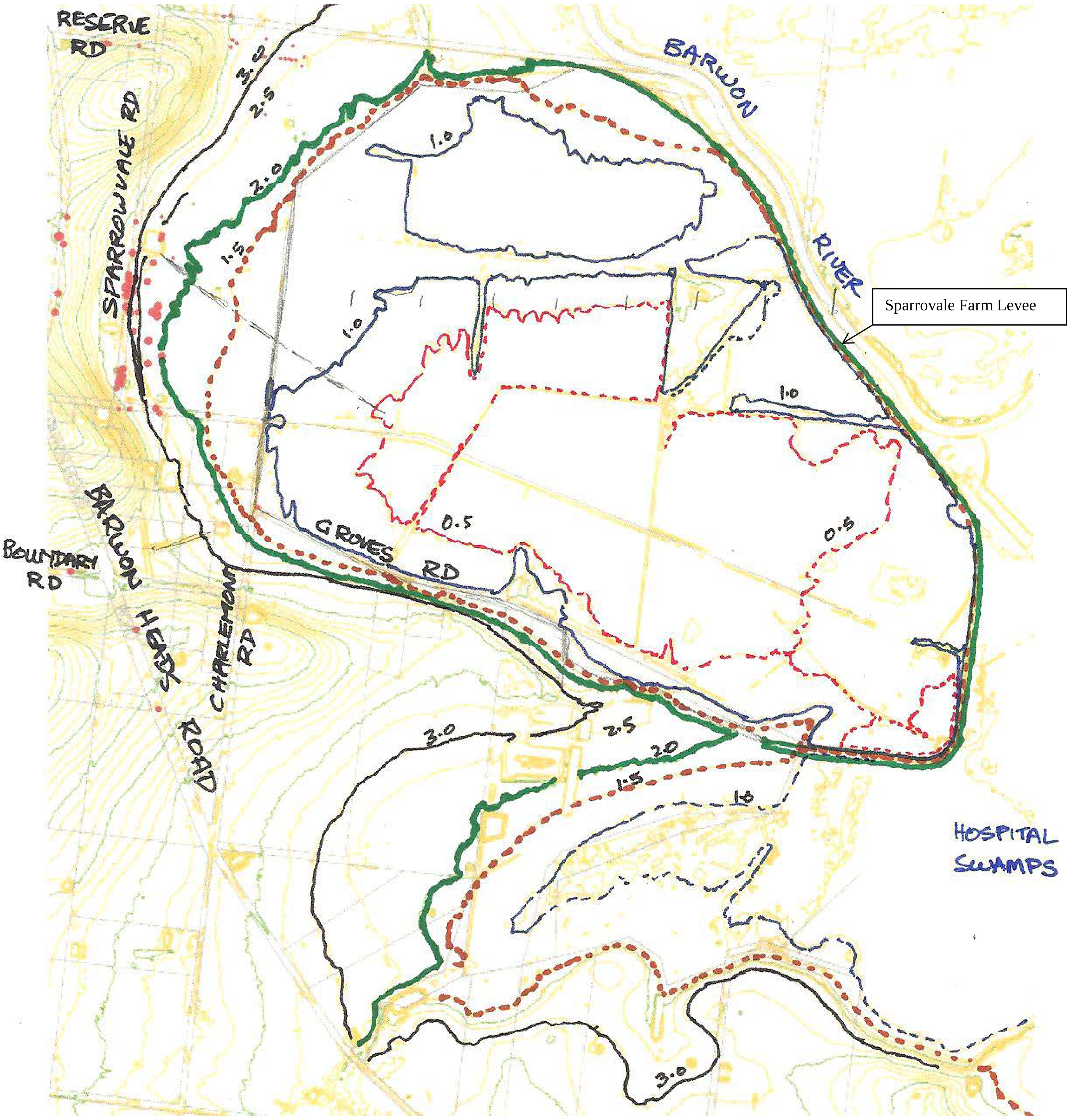
Figure 4 (Sheet 1 of 2)

The Lower Barwon River Wetlands in August 2009
Source: nearmap.com

October 2011

Figure 4 (Sheet 2 of 2)

The Lower Barwon River Wetlands in October 2011
Sparrovale Farm flooded above 0.50 m AHD
Source: nearmap.com



Sparrovale Farm
10 year ARI flood level is a minimum of 2.00 m AHD.

100 year ARI flood level is a minimum of 3.00 m AHD

Figure 5 (Sheet 1 of 2)

LiDAR 0.5 m contour data for Sparrovale Farm and Surrounds

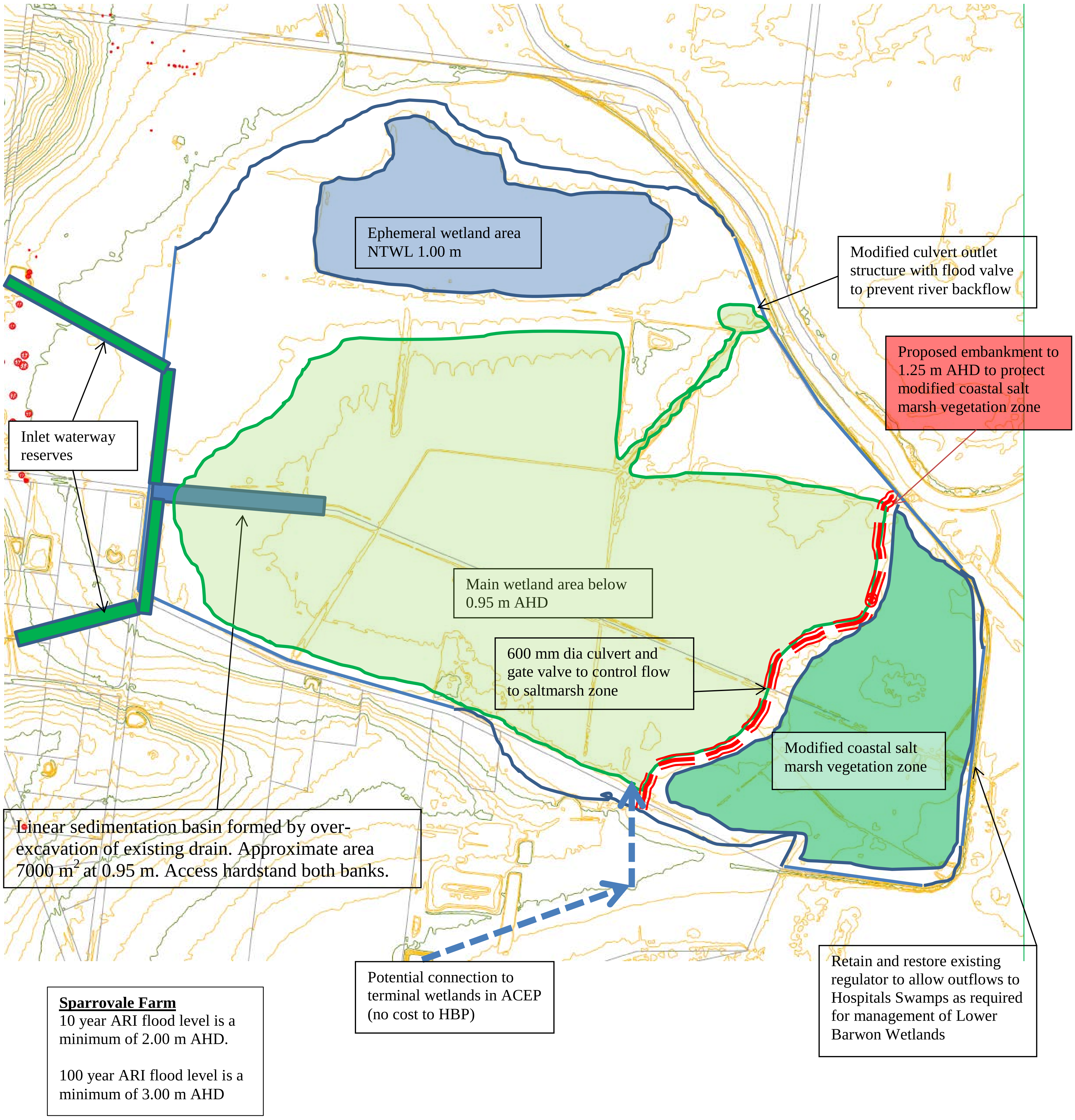
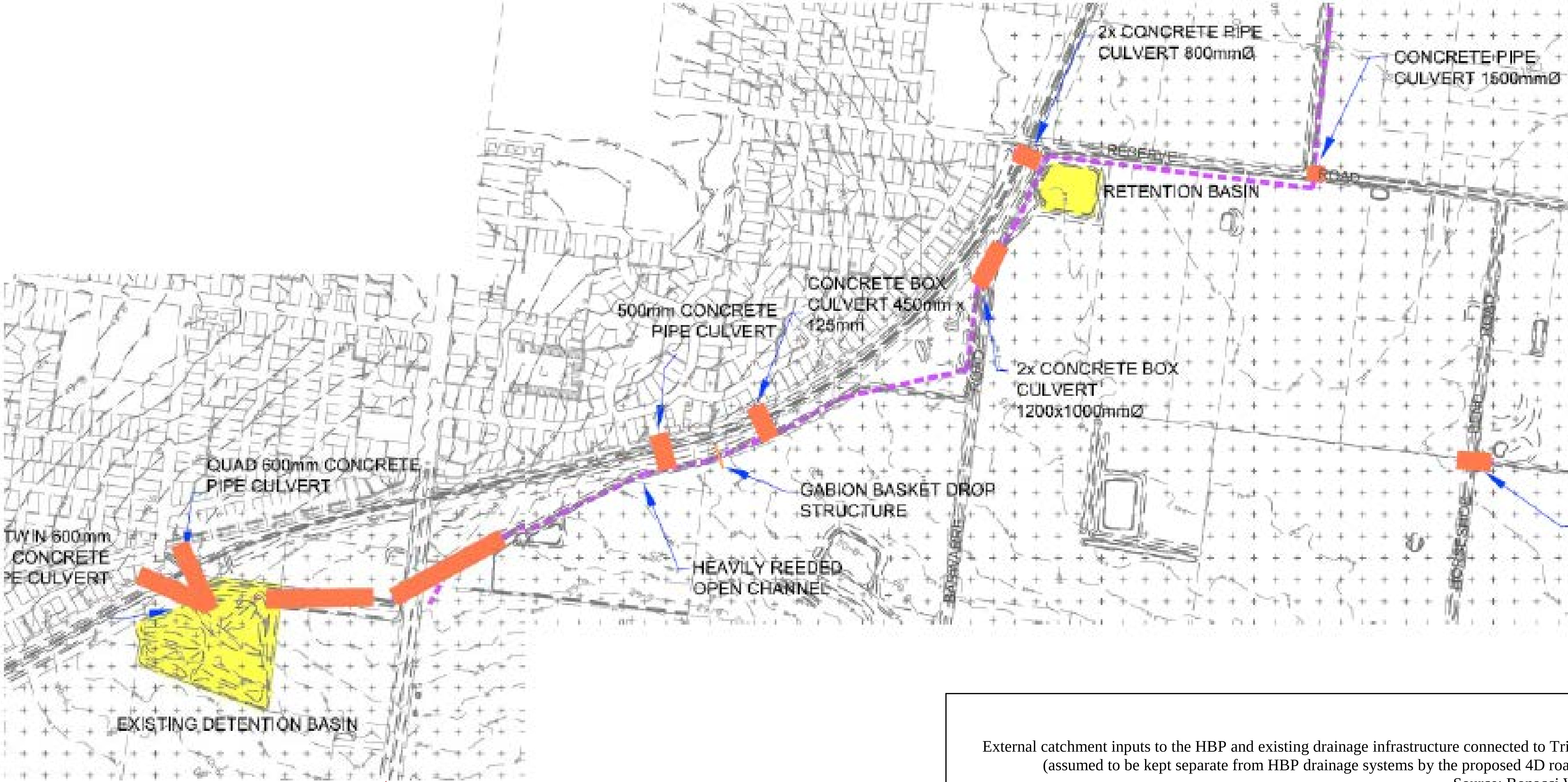


Figure 5 (Sheet 2 of 2)

Recommended Boundaries of Area below 1.20 m AHD to be set aside for Armstrong Creek Growth Area Surface Water Management purposes.

Also showing recommended Development Contributions Plans works including inlet waterways, sedimentation basin, outlet structures and embankment to protect modified coastal salt marsh vegetation



Surf Coast Highway

Figure 6

External catchment inputs to the HBP and existing drainage infrastructure connected to Trifilos Drain (assumed to be kept separate from HBP drainage systems by the proposed 4D road corridor)
Source: Bonacci Water 2008

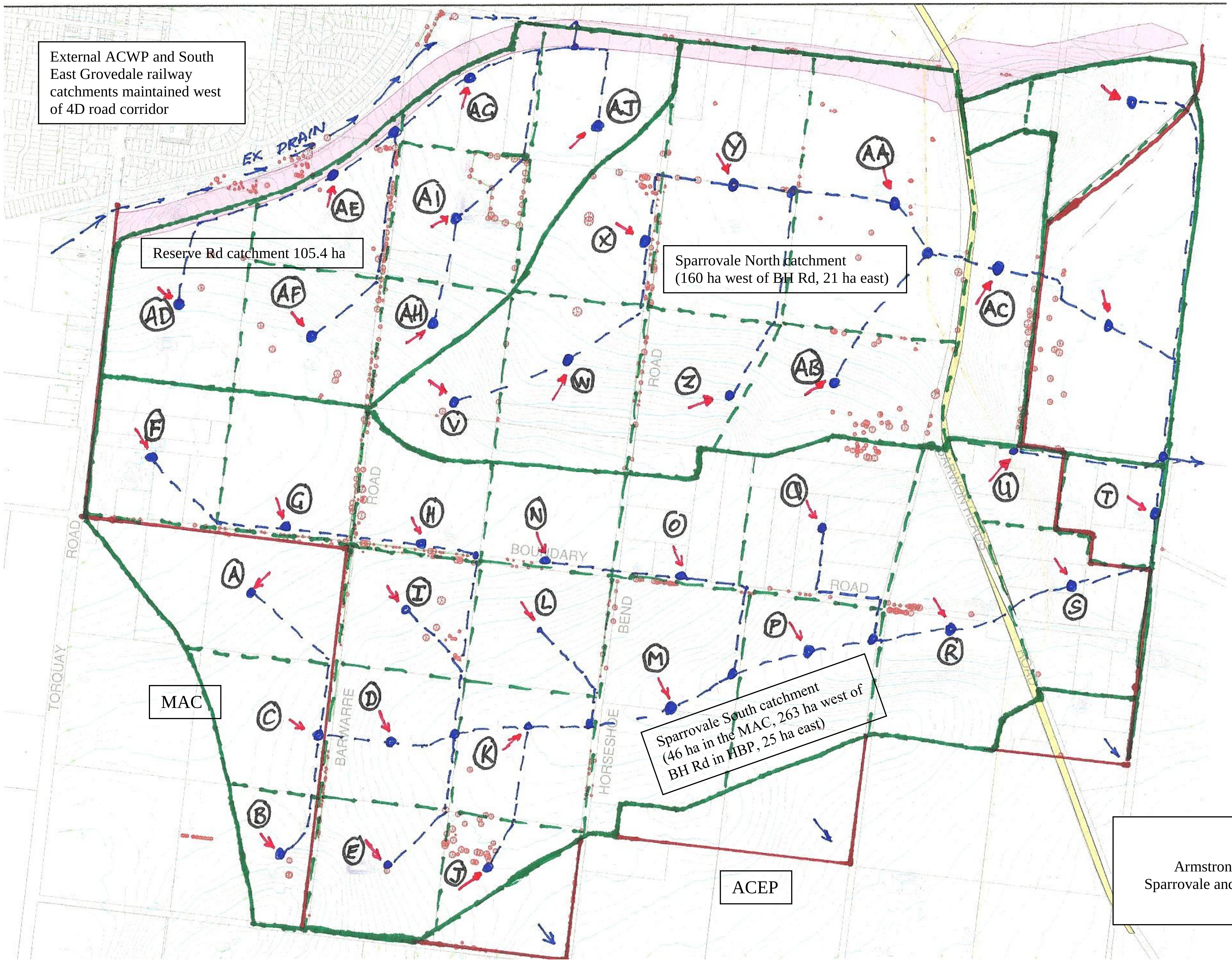


Figure 7

Armstrong Creek Horseshoe Bend Precinct (HBP) showing existing Sparrovale and Reserve Road drainage subcatchments and drainage lines (as used in the RORB Hydrologic Model)

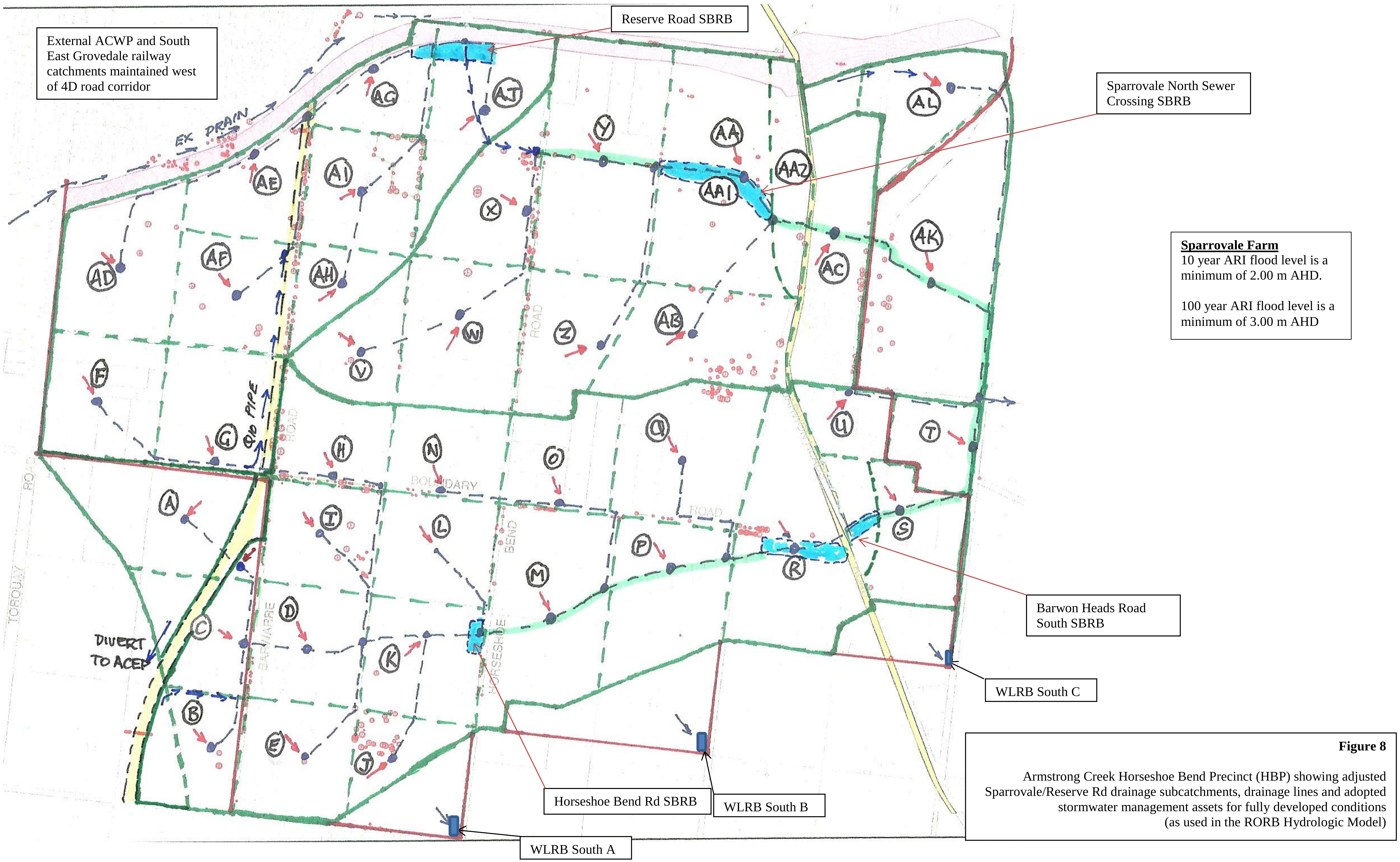


Figure 8

Armstrong Creek Horseshoe Bend Precinct (HBP) showing adjusted Sparrovale/Reserve Rd drainage subcatchments, drainage lines and adopted stormwater management assets for fully developed conditions (as used in the RORB Hydrologic Model)

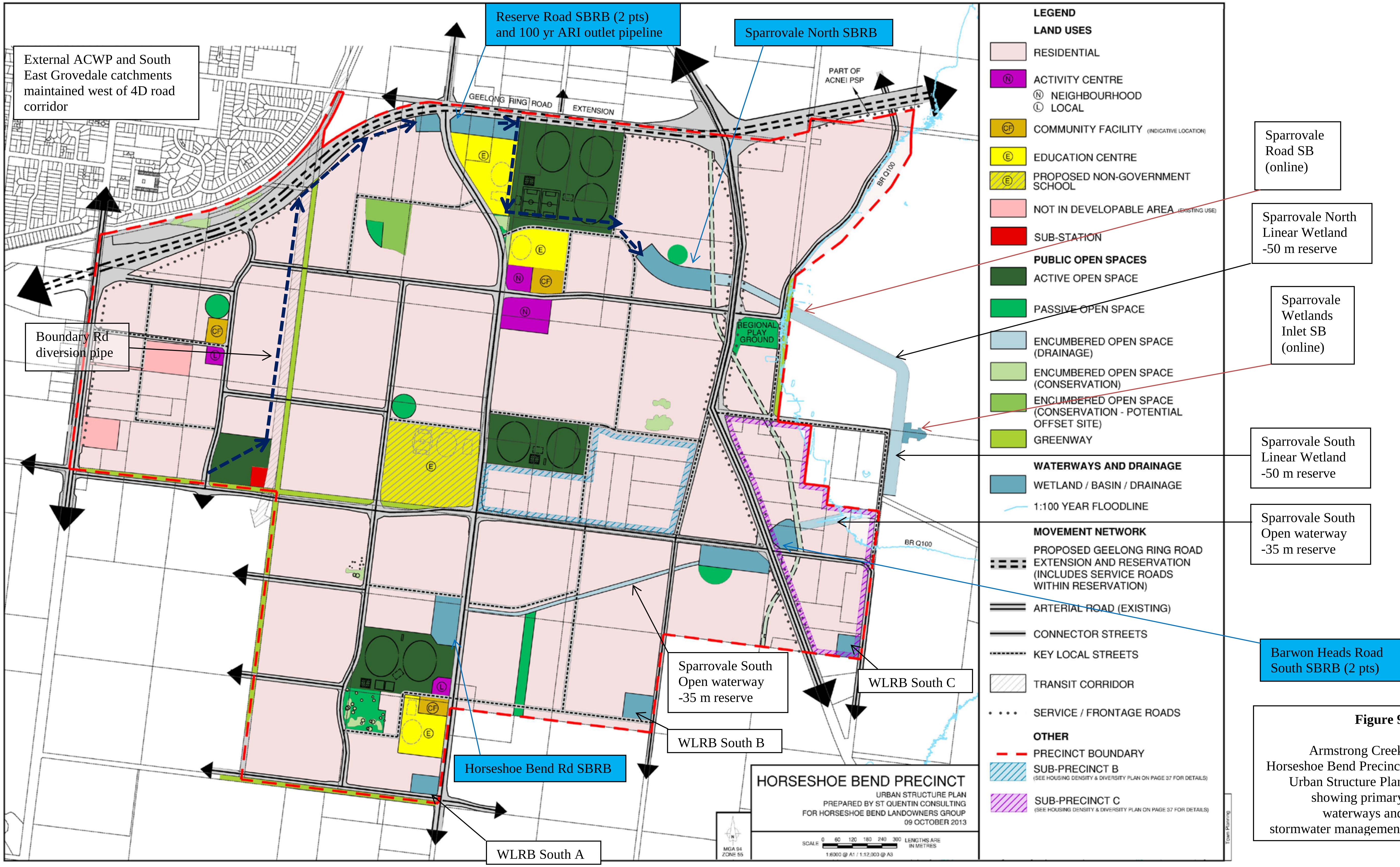


Figure 9

Armstrong Creek Horseshoe Bend Precinct Urban Structure Plan showing primary waterways and stormwater management

HYDRAULIC CHECKING SHEET

CLIENT: HBP Landowners Group PROJECT: Horseshoe Bend Rd Nth Outfall DATE: 09-Apr-12

ASSUMPTIONS Pipe friction calculated using Manning's Formula with "n" = 0.013
Pit form losses from Missouri Charts and Hare(1983)

Pipeline Reference No's 100 yr Starting Water Level 8.00

Downstream Pit Details			Upstream Pit Details			Pipeline Details					Downstream End				Upstream End		Pit Losses							
Pit No.	Invert Level (m)	Chainage (m)	Pit No.	Invert Level (m)	Chainage (m)	Dia D (m)	Design Flow (l/s)	Length L (m)	Full Veloc (m/s)	V*V --- 2g (m)	HGL Level (m)	Obvert Level (m)	Pipe Frict Slope	Pipe Frict Loss (m)	HGL Level (m)	Obvert Level (m)	D u/s ----- D d/s	Q u/s ----- Q d/s	Loss Coeff Ku	ku.V^2 ------ 2g (m)	U/S HGL + Pit Loss (m)	Adopted U/S Pit HGL (m)	U/S Surface Level (m)	F'board at Pit (m)
1	6.25	0.00	2	7.25	410.00	1.95	7250	410.00	2.43	0.30	8.20	8.20	385	1.06	9.26	9.20	0.94	0.77	1.30	0.39	9.65	9.65	11.00	1.35
2	7.40	410.00	3	8.00	710.00	1.82	5600	300.00	2.14	0.23	9.65	9.22	452	0.66	10.32	9.82	0.00	0.00	0.70	0.16	10.48	10.48	11.00	0.52

Pit 1=inlet to Sewer Crossing SBRB, Pit 2 = junction at Horseshoe Bend Road, Pit 3 = outlet from Reserve Road SBRB

HYDRAULIC CHECKING SHEET

CLIENT: HBP Landowners Group PROJECT: Barwon Heads Rd Nth Outfall DATE: 09-Apr-12

ASSUMPTIONS Pipe friction calculated using Manning's Formula with "n" = 0.013
Pit form losses from Missouri Charts and Hare(1983)

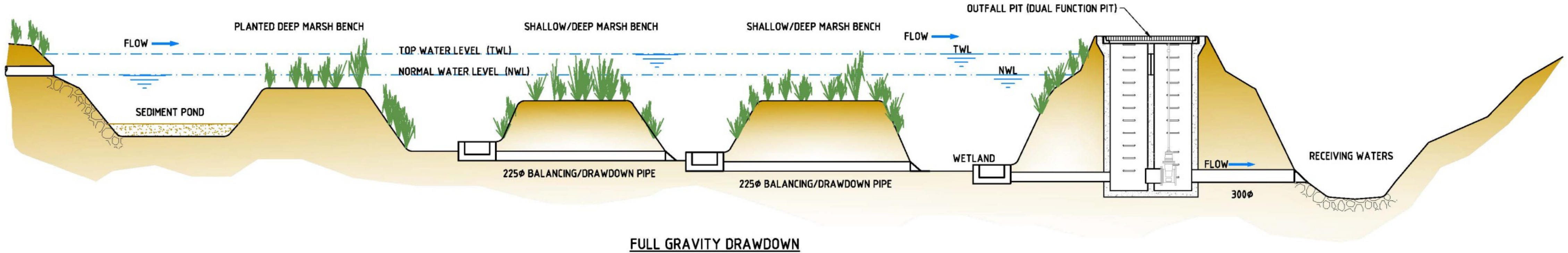
Pipeline Reference No's Sewer Xing SBRB to Sparrowvale Rd SB-10 yr Starting Water Level 2.35

Downstream Pit Details			Upstream Pit Details			Pipeline Details					Downstream End				Upstream End		Pit Losses							
Pit No.	Invert Level (m)	Chainage (m)	Pit No.	Invert Level (m)	Chainage (m)	Dia D (m)	Design Flow (l/s)	Length L (m)	Full Veloc (m/s)	V*V --- 2g (m)	HGL Level (m)	Obvert Level (m)	Pipe Frict Slope	Pipe Frict Loss (m)	HGL Level (m)	Obvert Level (m)	D u/s ----- D d/s	Q u/s ----- Q d/s	Loss Coeff Ku	ku.V^2 ------ 2g (m)	U/S HGL + Pit Loss (m)	Adopted U/S Pit HGL (m)	U/S Surface Level (m)	F'board at Pit (m)
1	0.10	0.00	2	0.70	20.00	1.35	3050	20.00	2.13	0.23	2.35	1.45	306	0.07	2.42	2.05	1.13	2.00	1.30	0.30	2.72	2.72	3.00	0.28
2	1.00	20.00	3	3.00	240.00	1.52	6100	220.00	3.34	0.57	2.72	2.52	146	1.50	4.22	4.52	0.94	0.97	1.30	0.74	4.96	5.27	8.00	2.73
3	3.10	240.00	4	3.50	280.00	1.43	5900	40.00	3.70	0.70	5.27	4.53	109	0.37	5.63	4.93	1.00	1.00	1.30	0.91	6.54	6.54	8.00	1.46
4	3.60	280.00	5	5.00	370.00	1.43	5900	90.00	3.70	0.70	6.54	5.03	109	0.82	7.36	6.43	0.00	0.00	0.70	0.49	7.85	7.85	8.00	0.15

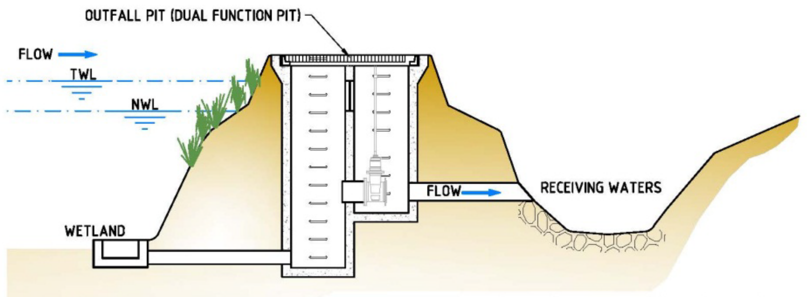
Pit 1-2=twin 1350 mm under Sparrovale Road, Pit 2-3=10 yr pipe to Barwon Heads Rd, Pit 3-4-Barwon Heads Rd crossing (to be duplicated/augmented for 100 year flows), Pit 4-5=Barwon Heads Road to Sewer Crossing SBRB outlet.

Figure 10

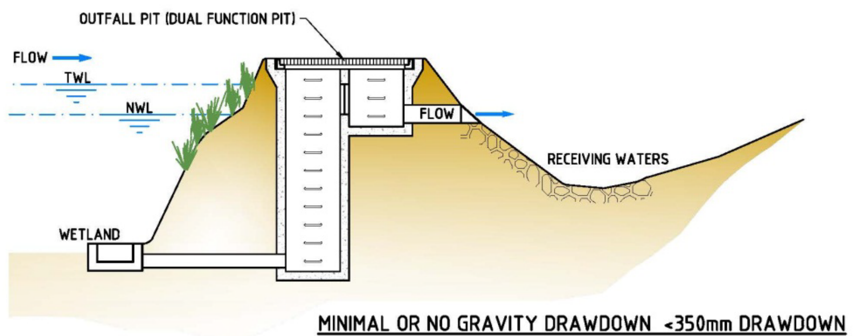
Hydraulic Gradeline Results



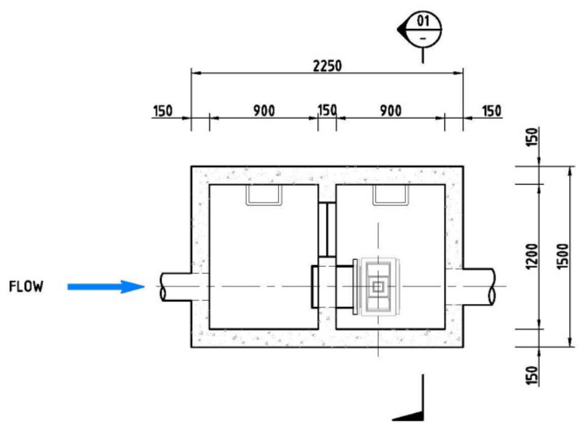
FULL GRAVITY DRAWDOWN
NOT TO SCALE



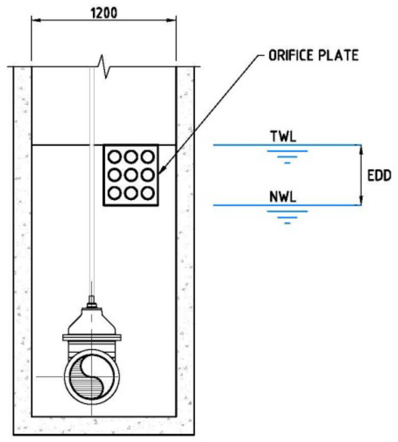
PARTIAL GRAVITY DRAWDOWN >400mm DRAWDOWN
NOT TO SCALE



MINIMAL OR NO GRAVITY DRAWDOWN <350mm DRAWDOWN
NOT TO SCALE



PLAN
DUAL FUNCTION PIT
NOT TO SCALE



SECTION 01
SEPARATOR WALL DETAIL
NOT TO SCALE

LEGEND

TWL	TOP WATER LEVEL
NWL	NORMAL WATER LEVEL
EDD	EXTENDED DETENTION DEPTH

Melbourne Water

Figure 11

Typical Wetland System outlet drainage control arrangements (Melbourne Water)

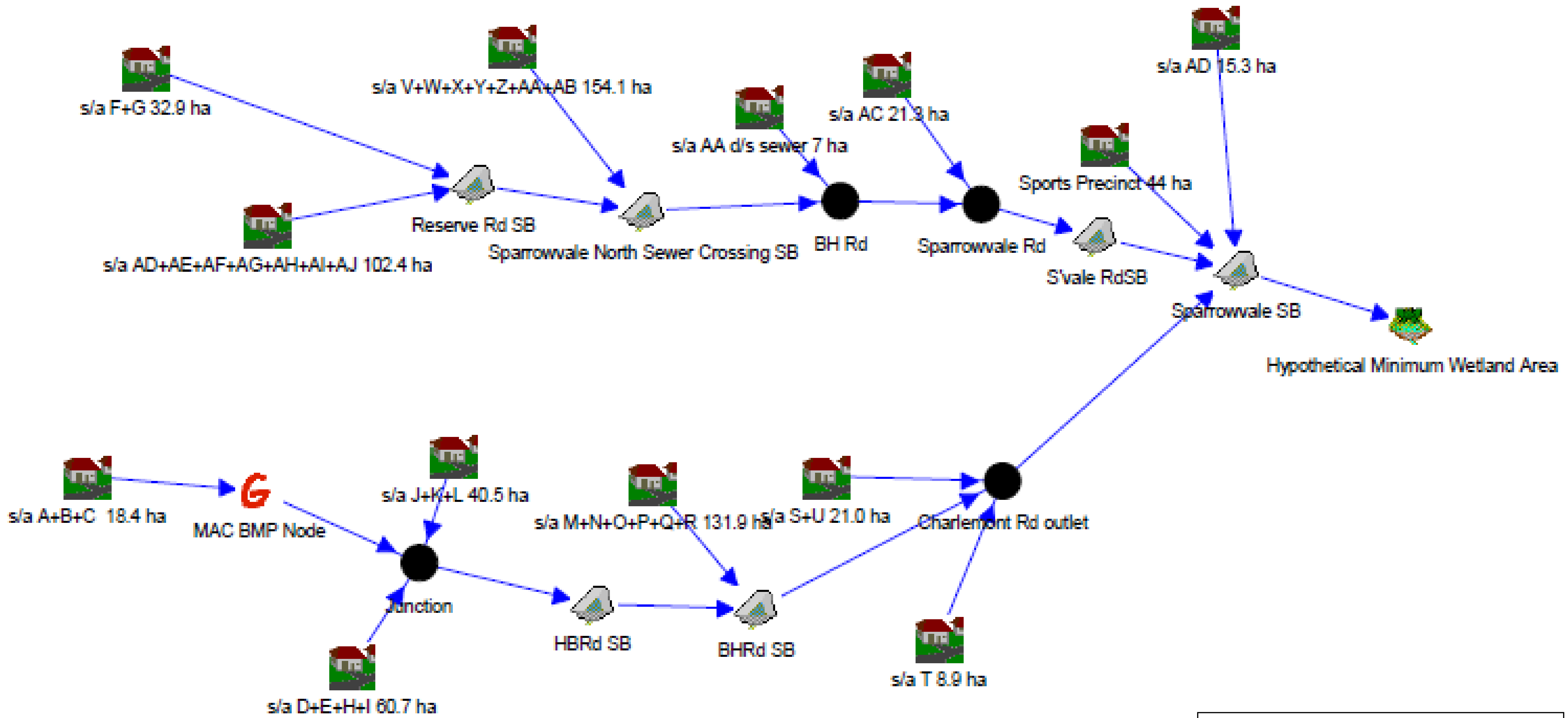


Figure 12

MUSIC model structure for Sparrovale Catchment System in Horseshoe Bend Precinct