Neil M Craigie Pty Ltd
ACN 074 582 282 ABN 29 074 582 282

Waterway Management Consultants

BROMPTON LODGE

980-1050 WESTERNPORT HIGHWAY, CRANBOURNE SOUTH

SURFACE WATER MANAGEMENT STRATEGY

(Version 4)

For: Urban Development Investments Australia Pty Ltd

13 June 2013

Director ***Neil McKinnon Craigie*** *BE(Civil), MEngSci, MIEAust, CPEng*
Email: nmcraigie@bigpond.com
40 Jamieson Court, Cape Schanck, Vic. 3939, Australia
Mob: 0427 510 053

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1. INTRODUCTION

A surface water management strategy (SWMS) has been prepared for development of Brompton Lodge at 980-1050 Western Port Highway in Cranbourne South. Figure 1 is an aerial photo showing the location of the property and its surrounds.

Submissions were made to the Amendment C102 Panel in 2009 for the land to be included in the Cranbourne West Precinct Structure Plan (CW PSP) area, including a strategy for dealing with surface water management. However the Panel rejected inclusion of the land in the CW PSP.

The 105 ha land parcel (plus a neighbouring parcel in the east) has now been brought into the UGB and the main drainage strategy originally put forward as part of the 2009 application has been further developed and refined to address all known site constraints.

The land is proposed to be developed for residential purposes with a neighbourhood activity centre on the Cranbourne-Frankston Road frontage and two open waterways traversing the site linking inlet culverts under Cranbourne-Frankston Road through to a common existing discharge point to the NRCL property (the Anco Turf Farm) across Ballarto Road.

The proposed development plan is shown on Figure 2. A gross developable area of about 86 ha is anticipated, with the Permit 1 application area of 35.1 ha in the northwest section of Brompton Lodge.

The Permit 1 area is proposed to include a major wetland/retarding basin and associated sediment basins, to deal with the bulk of the water quality treatment and peak flow mitigation issues. It also includes a proposed dwarf galaxia habitat pond to replace the lesser quality habitat that has been established in some old sand pits on the site.

The SWMS set out in this report:

(a) provides a concept design layout for the waterways through Brompton Lodge that accords with Melbourne Water's draft Waterway Corridor Guidelines, addresses the known site groundwater and dwarf galaxia habitat constraints, and achieves best practice stormwater quality treatment, flood conveyance and flood mitigation requirements, and

(b) clearly separates MW and Council operational responsibilities.

The strategy assumes no allowance for the use of rainwater tanks nor raingardens within allotment boundaries, nor raingardens or similar assets within the streetscapes of the subdivisions. If any of these were to be included by future landowners or Council then additional benefits would accrue.

All surface drainage assets proposed in this SWMS are integrated within the proposed reserves and underground assets (such as Gross Pollutant Traps-GPT's) will either be in roads or drainage reserves.

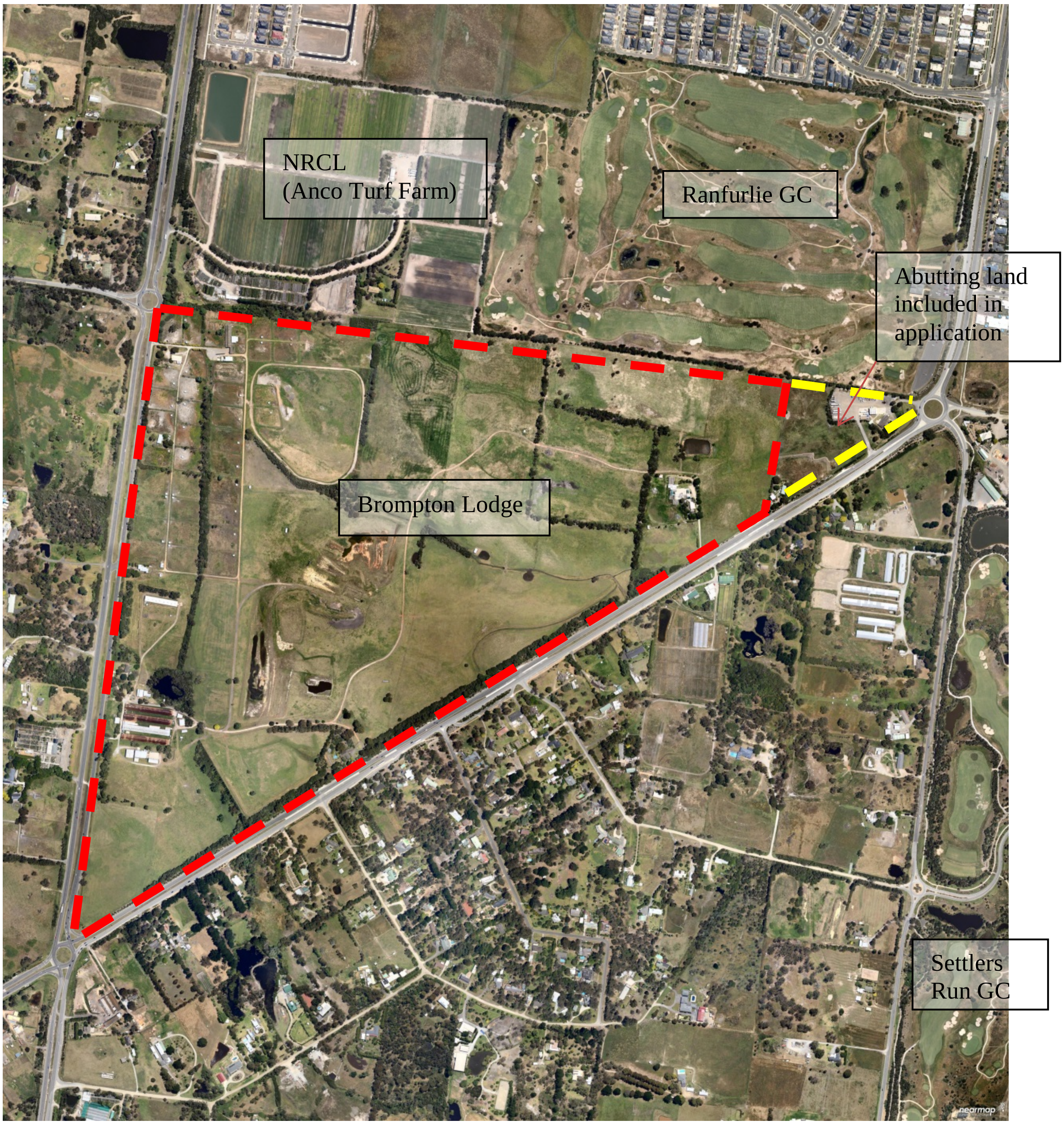


Figure 1 Aerial photo showing Brompton Lodge, abutting land also included in the application, and surrounding land uses.

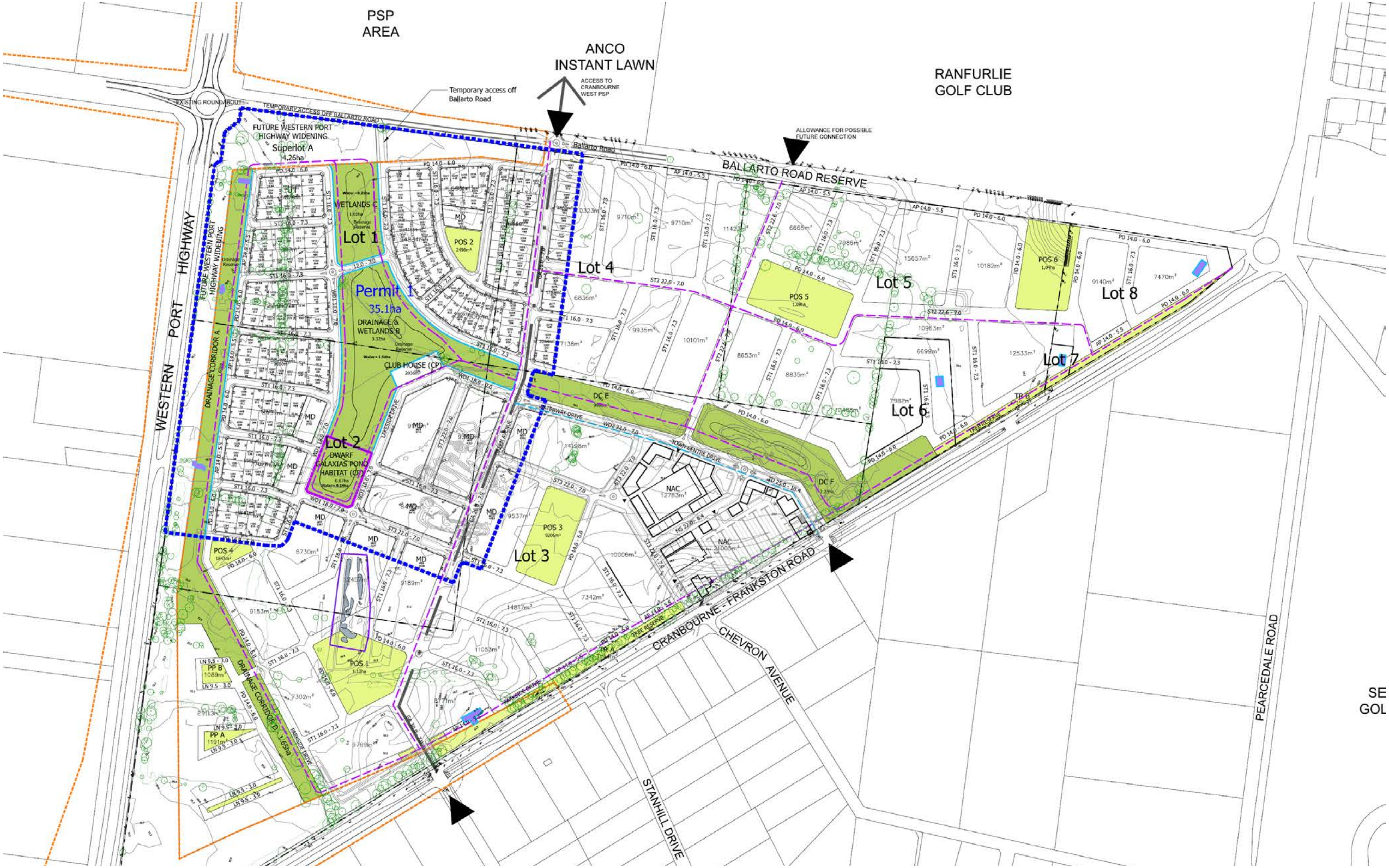


Figure 2 **Concept Development Plan for Brompton Lodge and abutting land (lot 8 and pt Lot 7), and the 35.1 ha area covered by the permit 1 application**

2. DEVELOPING A SURFACE WATER MANAGEMENT STRATEGY

2.1 General Principles

Sound planning and good design can create systems where stormwater is an obvious and vital element of an urban area, and an attractive feature of the urban landscape.

From a holistic viewpoint the surface water management strategy for the subject property development is to be developed to address contemporary Best Management Practices, through application of the principles of Water Sensitive Urban Design (WSUD).

As set out in Section 1.3 of Australian Runoff Quality –A Guide to Water Sensitive Urban Design (IEAust 2006), the guiding principles of WSUD are centred on achieving integrated water cycle management solutions linked to an ecologically sustainable development focus aimed at:

- Treating urban stormwater to meet water quality objectives for reuse and/or discharge to surface waters;

- Using stormwater in the urban landscape to maximise the visual and recreational amenity of developments;

- Preserving the natural hydrological regime of catchments;

- Reducing potable water demand through water efficient appliances, rainwater and greywater reuse;

- Minimising wastewater generation and treatment of wastewater to a standard suitable for effluent reuse opportunities and/or release to receiving waters;

In regard to stormwater (surface water) management ARQ 2006 lists best practice objectives as including:

- providing flood protection and drainage;
- protecting downstream aquatic ecosystems (including groundwater systems);
- removing contaminants;
- promoting stormwater elements as part of the urban form.

The residential subdivision provisions in Clause 56 of planning schemes set out requirements for the design and assessment of residential subdivisions in urban areas throughout Victoria. The Clause 56 changes are supported by complementary State Planning Policy provisions for subdivision, changes in relevant zones and overlays and planning practice notes.

Under the provisions of Clause 56.07 all new residential subdivisions must comply with best practice management standards for water quality treatment and, unless approval is given to the contrary by the responsible authority and there are no detrimental impacts downstream, also ensure no increase in peak discharges of stormwater from the development.

2.2 MWC Drainage Planning and Requirements

Main drainage, floodplain and waterway management in this area is the responsibility of Melbourne Water Corporation (MWC). Responsibility for drainage works in catchments less than 60 ha in area is normally left with Council.

Brompton Lodge is within the Eastern Contour Drain catchment (MWC reference 0700). MWC have kindly supplied a copy of the overall catchment plan (Figure 3) and RORB hydrologic model for the total catchment.

There is no drainage scheme in place for the Ballarto Road catchment. MWC have verbally advised that:

- all main drainage assets within the estate are to be constructed by the developer;
- peak flows at Ballarto Road are to be maintained at existing rates for events up to and including the 100 year Average Recurrence Interval (ARI) flood;
- best practice water quality treatment objectives are to be achieved at the Ballarto Road outfall for full development of Brompton Lodge;
- open waterways should be designed in accordance with MWC’s draft Waterway Corridor Guidelines;
- no drainage works should be required to be carried out within the NRCL land on the north side of Ballarto Road, in order to service development of Brompton Lodge.

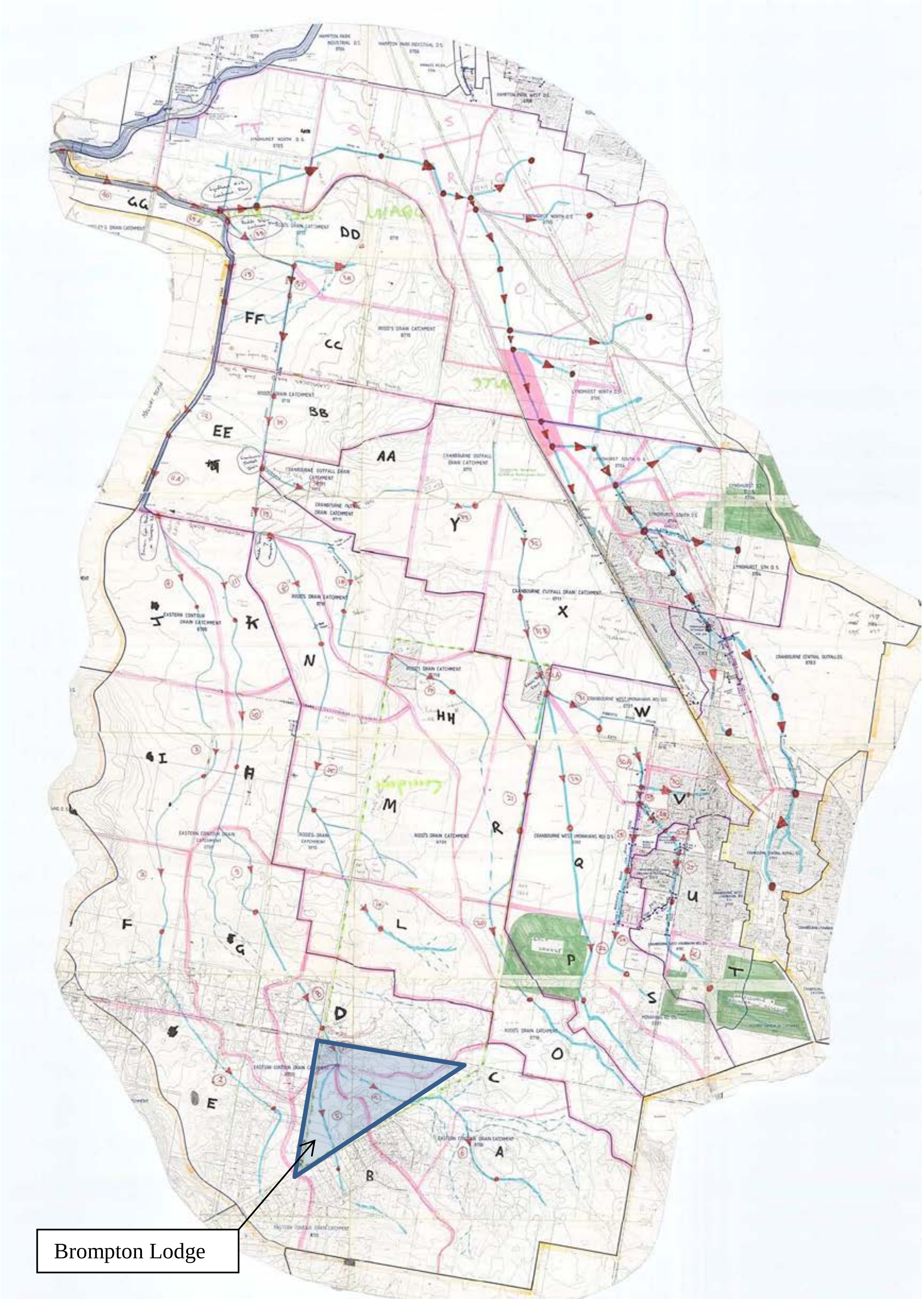


Figure 3
Eastern Contour Drain catchment showing MWC RORB subcatchments and the location of Brompton Lodge

2.3 Water Quality Treatment Requirements and WSUD Opportunities

Best practice storm water quality treatment standards for urban drainage have been set as follows:

- 70% removal of the typical urban load of gross pollutants;
- 80% reduction in suspended solids loads;
- 45% reduction in total phosphorus loads;
- 45% reduction in total nitrogen loads.

These standards are to be met for all discharges at Ballarto Road.

Stormwater treatment on greenfields sites is usually provided as three components:

- Removal of litter from the flow. Usually carried out in prefabricated gross pollutant traps of which there are many commercially available options.
- Trapping of sediment and coarser suspended solids in an appropriately sized sediment trap. This may also be designed to trap litter.
- Removal of nutrients, bacteria, fine suspended solids and other associated pollutants in a wetland treatment facility or in a Bio-Retention Swale (BRS). Treatment is normally provided up to the 1 year ARI flow.

Flows greater than the 1 year ARI flow would normally be bypassed around the treatment system, or ponded in the airspace overhead in a manner which ensured retention of the stored contaminants and protection of aquatic vegetation. In effect this means that more than 95% of the catchment stormwater runoff receives treatment prior to bypass or overflow.

The appropriate arrangement of treatment facilities depends on the pollutants expected from the catchment and other hydrological, economic, subdivisional layout, and amenity constraints. Additionally, any waterbody component is usually constructed as a major landscape feature of the overall development.

Experience and monitoring results indicate that wind-blown litter can be of equal or greater consequence than water-borne litter, especially during the estate construction and building construction phase. For residential developments which do not include major activity sites such as shopping strips or fast food outlets, permanent litter traps are not recommended as litter generation rates are typically low once development is complete. During the subdivisional and building stages in residential areas litter should in the first instance be controlled through permit requirements on builders, and then through temporary traps on pipe outlets. Any litter that does escape will be collected at the inlets to any sediment ponds or wetlands. Drainage systems serving industrial or retail/commercial areas including strip shopping centres and fast food outlets should incorporate litter traps or have drainage systems designed to otherwise exclude entry of litter.

The provision of water treatment infrastructure must be considered in conjunction with satisfaction of WSUD objectives. Constructed wetlands are one WSUD approach where management response is concentrated into one or more defined areas.

Other techniques that are currently being actively promoted by MWC focus on the site or precinct scale and are aimed at reducing runoff peaks, delaying runoff response and minimizing transportation of sediments through the use of "natural" drainage line treatments, swale/trench infiltration systems, grass buffer strips and the like. These techniques also have good potential for reducing the hydraulic and pollutant loads and hence area of treatment wetlands. WSUD techniques that can be applied at the site or precinct scale, offer potential for achieving required water quality treatment with reduced impact on developable land yield.

Apart from treatment measures, stormwater can also be re-used in a variety of ways including household use for garden watering and toilet flushing, for creation of pond features or for irrigation of open space or agricultural production areas. Reuse is a viable alternative or adjunct to treatment as consumption of the excess water is a good means of removing pollutants.

2.4 SWMS Components

Significant earthworks are proposed across the site to confine flooding extents, deepen waterways to service proposed urban development drainage systems, create wetlands and sediment basins, and to raise finished surface levels to provide minimum 600 mm freeboard above 100 year ARI flood levels along the waterways.

The proposed strategy assets and main drainage lines are outlined schematically on Figure 4 and summarised below. The main waterways and water quality treatment assets including proposed invert levels, normal top water levels (NTWL's) and finished surface levels, are shown at larger detail on Figure 5 (Sheets 1 and 2) and Figure 6.

- Two constructed open waterways to convey external catchment inflows from Cranbourne-Frankston Road frontage through to the common existing outfall point in the NRCL land (currently used as the Anco Turf Farm) on the north side of Ballarto Road.

- The west waterway will be generally located within a 30 m reserve along the Western Port Highway frontage. It will convey external catchment flows plus some portion of overland flows from the development for events greater than 5 years ARI. No pipe discharges from the development will enter this waterway.

- The eastern open waterway will be located within a reserve of varying width from 40 m minimum to 70 m. It will be separate from the western waterway until Ballarto Road.

- 5 year Average Recurrence Interval (ARI) pipeline systems to convey urban stormwater from all parts of Brompton Lodge (and the abutting property to the east), into water quality treatment systems and thence to the eastern waterway. Several pit surcharge structures will be installed along the frontage of the open waterway to keep pipe sizes as small as practicable.

- One offline sediment basin of 700 m^2 water surface area at the upstream end of the site discharging to the east waterway opposite the NAC (SB1). This basin will pre-treat urban discharges from 13.6 ha of urban development on the north side catchment of Brompton Lodge including the abutting urban land to the east.

- A constructed online major wetland/retarding basin (WLRB) totalling 1.53 ha water surface area including inlet sediment basins, forming the estate landscape and recreational centrepiece on the east waterway at the Clubhouse. The bulk of the Brompton Lodge development drainage (65.3 ha) is directed into the sediment basin inlets.

- An online sediment basin of 2,000 m^2 water surface area on the eastern waterway at the north boundary of the development (SB2), to deal with the residual 9.6 ha development catchment. Although it is acknowledged that MWC would prefer this asset to be effectively offline, due to inadequate outfall depth and pipe cover requirements it is not possible to replace the single online sediment basin with two offline basins without forcing development fill levels to be raised significantly higher.

- A dwarf galaxia habitat pond located just upstream of the major wetland/retarding basin, to replace existing artificial habitat that has developed in some former sand pits in the development area. This pond is to be separated from the surface water drainage system up to the 100 year ARI event but provided with freshwater supply from the wetland as needed. Design is to accord with the recommendations of Streamline Research (March 2013) which are summarised in Appendix A.

- Best practice management of all construction activities.

The key design parameters for the proposed surface water quality management assets are summarised in Table 1.

TABLE 1 Stormwater Quality Management Assets, Brompton Lodge

Asset	NTWL	Water Surface Area at NTWL (m2)	Volume at NTWL (m3)	Extended detention depth (m)
SB1	50.00	700	700	0.3
Clubhouse WLRB	45.00	15,300	9,000	0.3
SB2	43.00	2,000	2,000	0.3

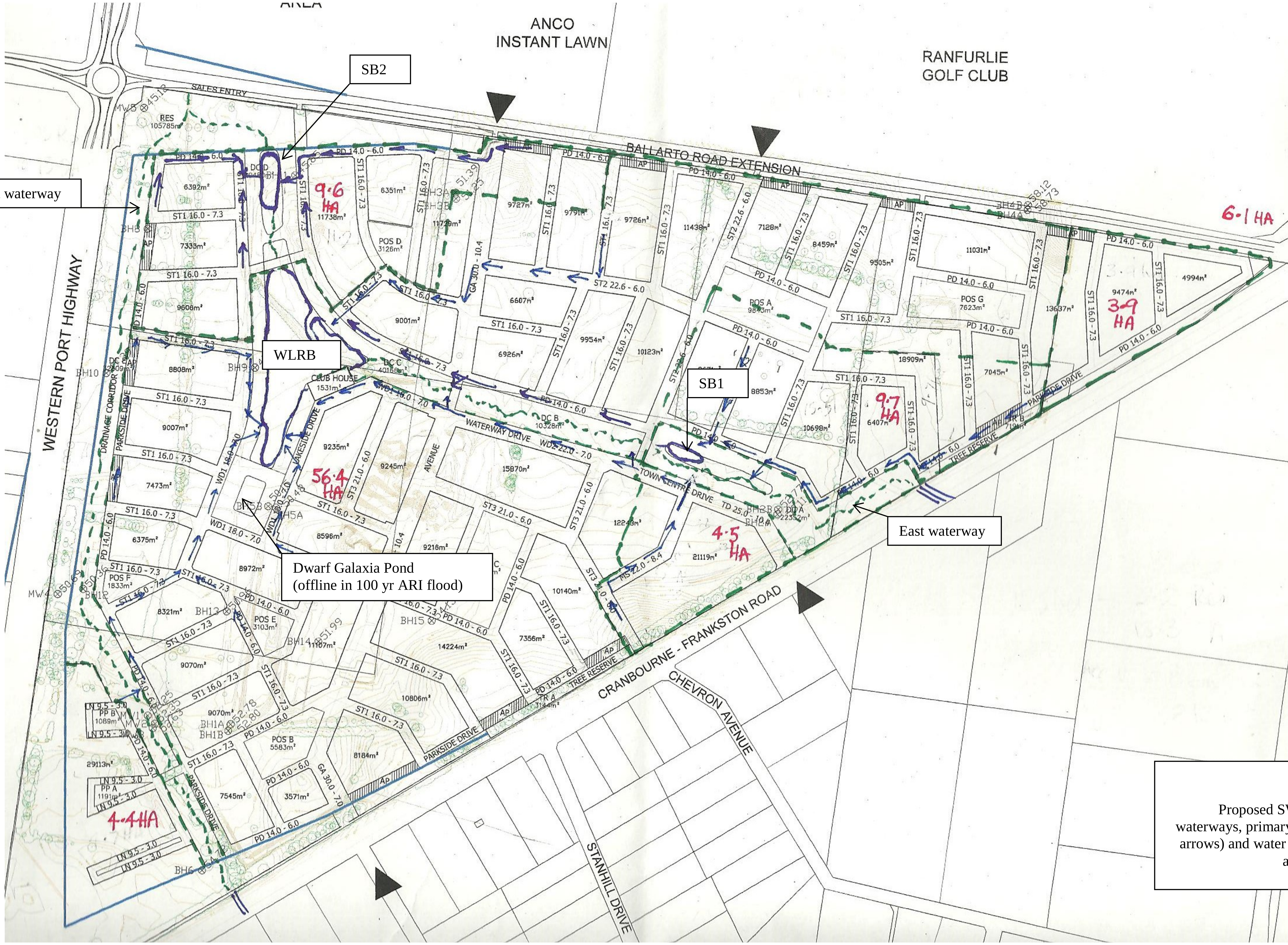


Figure 4

Proposed SWMS Layout with open waterways, primary pipelines (blue dashed arrows) and water quality treatment assets and Dwarf Galaxia pond

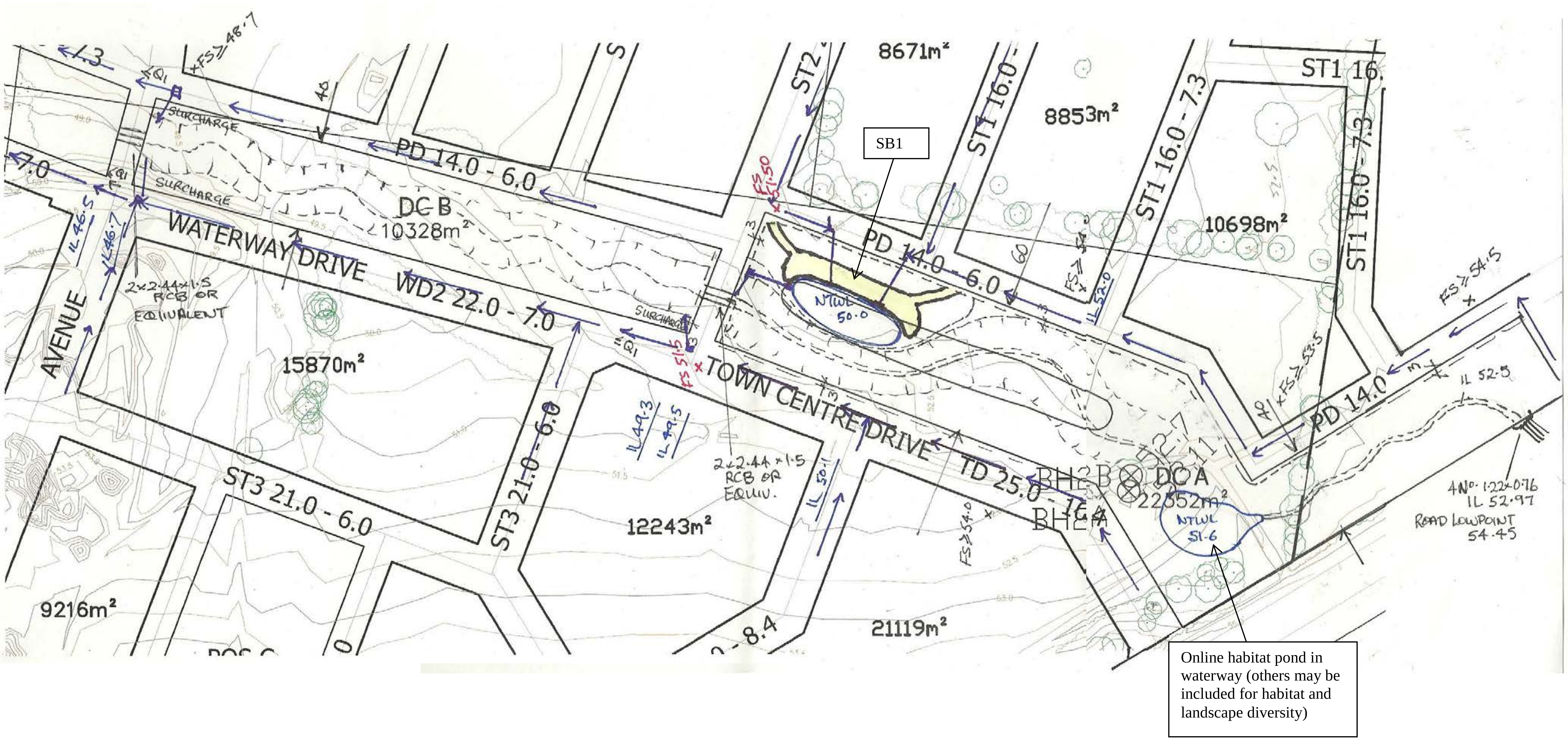


Figure 5 (Sheet 1 of 2)

Enlargements of east waterway, primary pipelines and main water quality treatment assets

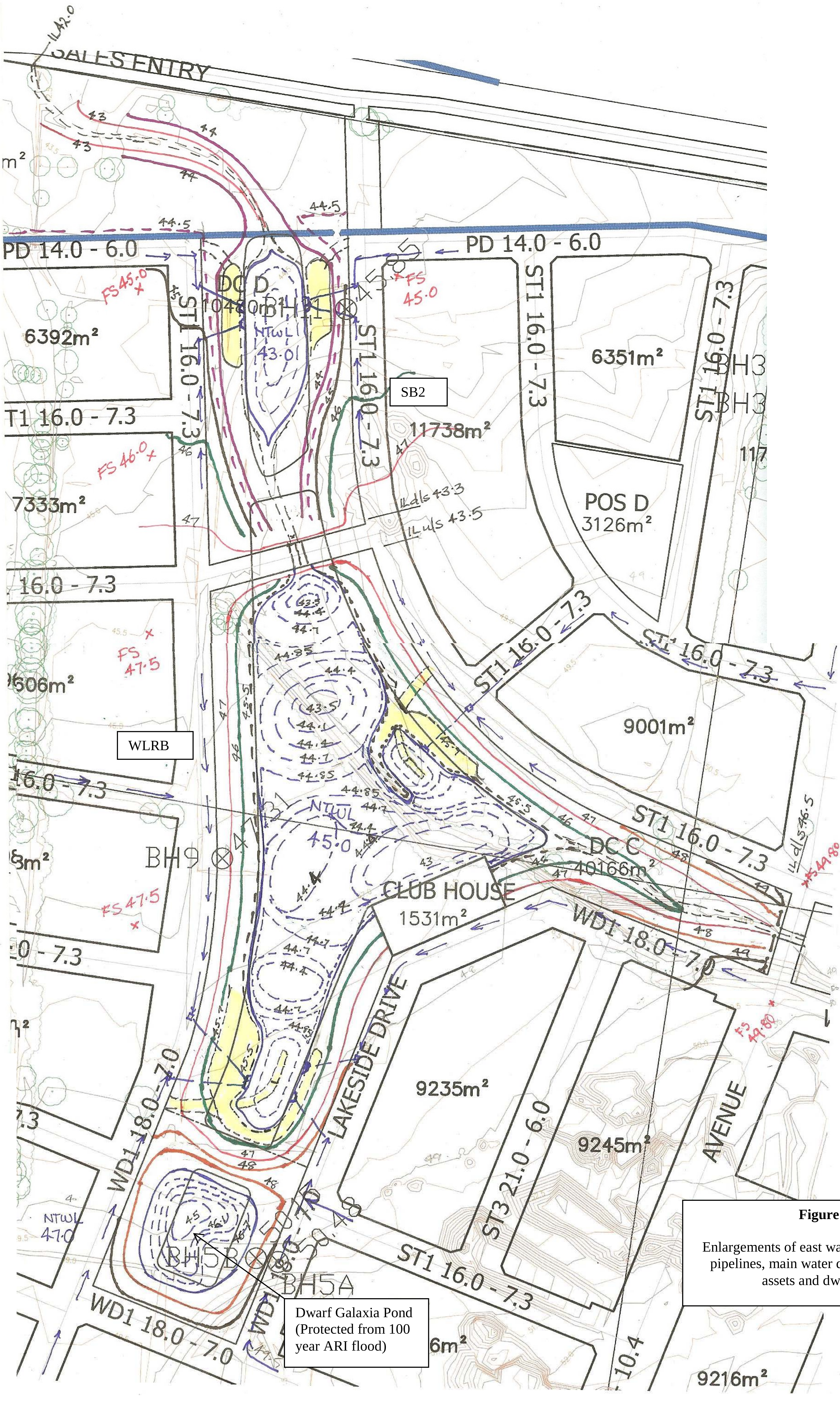


Figure 5 (Sheet 2 of 2)

Enlargements of east waterway, primary pipelines, main water quality treatment assets and dwarf galaxia pond

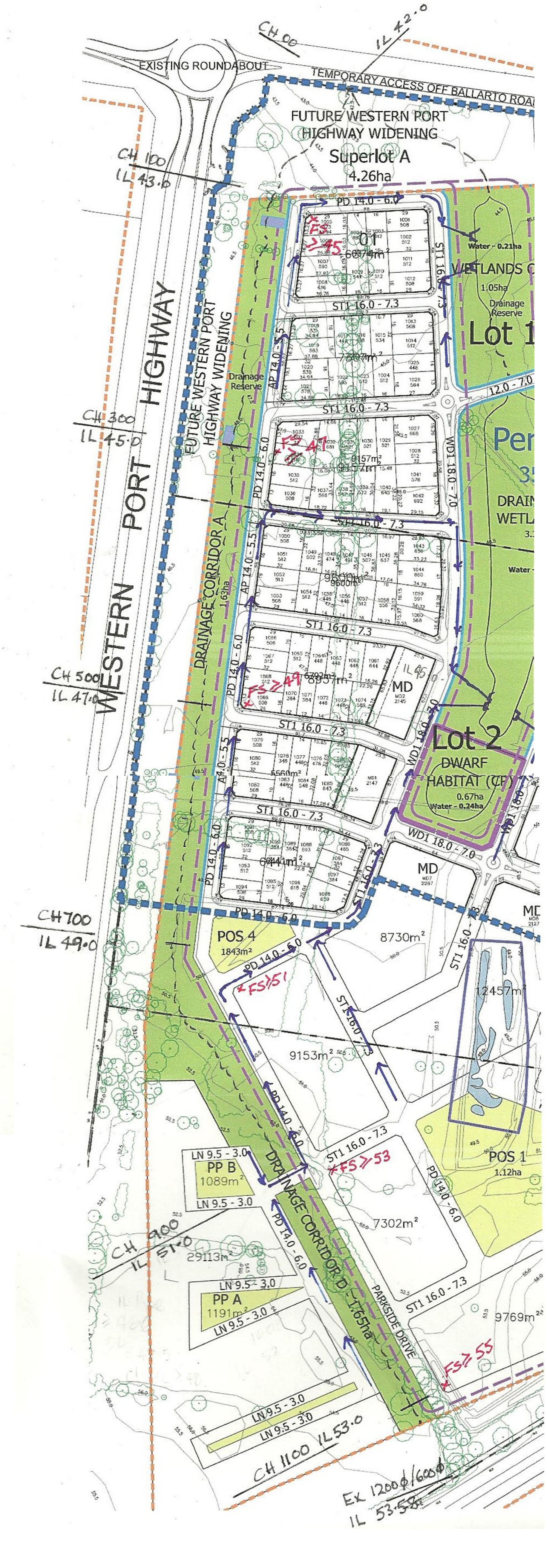


Figure 6

Enlargement of west waterway, showing primary pipelines, channel inverts and minimum finished surface levels

3. HYDROLOGIC MODELLING

Rather than attempting to modify the whole catchment RORB model to suit investigation needs in Brompton Lodge, a separate RORB model structure was prepared for the Eastern Contour Drain catchment to Ballarto Road. This model provided for much finer subdivision of sub-catchments and the addition of as-built diversion catchments in the Botanic Ridge Estate and Settlers Run.

Figure 7 shows the adopted model structure for existing conditions. Filename: **ECD at Ballarto Rd pre-BL.cat**

The total catchment to Ballarto Road is 697.1 ha. Using MWC's standard equation ($K_c = 1.53A^{0.55}$), an initial estimate for K_c = 4.55 is obtained. For the full MWC Eastern Contour Drain (ECD) model, K_c/D_{av} = 1.98. For the Ballarto Road model D_{av} = 1.82, hence K_c= 3.6. This value is adopted with m = 0.8.

Initial Loss = 10 mm, Runoff Coefficient (pervious area) = 0.6 (100 year ARI), 0.55 (50 year ARI), 0.50 (20 year ARI), 0.40 (10 year ARI), 0.30 (5 year ARI), 0.25 (2 year ARI) and 0.20 (1 year ARI).

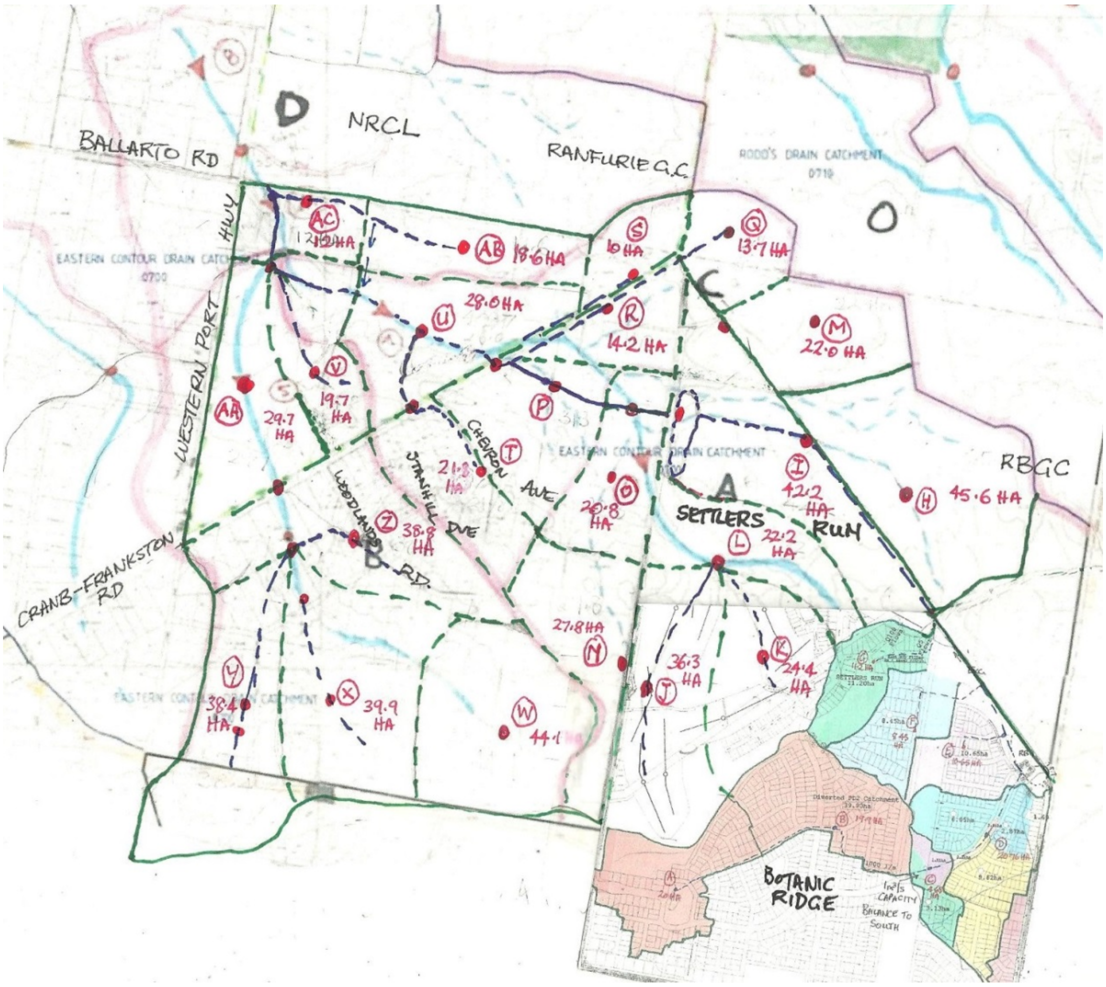


Figure 7 RORB Catchment Model for Existing Conditions at Ballarto Road

The model was run to obtain existing conditions peak design flows through Brompton Lodge with results summarised in Table 2.

TABLE 2 RORB Model Results-EC Drain catchment at Ballarto Road - Existing Conditions							
Location	**Peak Flow (m3/s)**						
	1 year ARI	**2 year ARI**	**5 year ARI**	**10 year ARI**	**20 year ARI**	**50 year ARI**	**100 year ARI**
Cranb-F'ton Rd (east)	0.6 (9)	0.9 (9)	1.3 (9)	2.5 (48)	4.6 (30)	5.9 (30)	7.4 (12)
East (NAC) inlet	0.6 (9)	0.9 (9)	1.5 (9)	2.5 (48)	4.8 (30)	6.1 (30)	7.7 (12)
Cranb-F'ton Rd (west)	0.7 (9)	1.0 (9)	1.6 (9)	2.5 (9)	3.6 (9)	4.7 (9)	5.9 (9)
Main confluence	1.6 (9)	2.5 (9)	3.9 (9)	5.8 (9)	8.4 (9)	10.9 (9)	13.8 (9)
Ballarto Road	1.7 (9)	2.6 (9)	4.1 (9)	6.2 (9)	9.1 (9)	11.8 (9)	14.9 (9)

The RORB model structure was then modified to include the proposed Brompton Lodge development imperviousness and the following changes to drainage alignments via the pipe/channel drainage systems:

- Separation of the west waterway from the development through to the Ballarto Road outfall;
- Capture of the development drainage to the east waterway and the WLRB via pipelines.

The sediment basins SB1 and SB2 were not simulated as storages given their comparatively small size and storage volumes. The main WLRB was included with stage-area-storage relation as set out in Table 3.

The model was initially run in trial and error mode to establish the outlet controls required to meet the peak flow objectives and these are listed in Table 3 as well.

There remains some flexibility for outlet works to be modified if required, as part of detail design.

TABLE 3 Stage-discharge-storage relation for Clubhouse WLRB				
Stage (m)	**Area (m2)**	**Active Storage (m3)**	**Comments**	**Hydraulic controls**
45.00	15,300	0	NTWL of wetland and inlet sediment basins	0.15 m wide weir crest
45.30	15,600	4,635	Top of extended detention depth	1.00 m wide weir crest
45.50	16,000	7,825	Lower edge of drying zones	
45.70	20,000	11,425	Upper edge of drying zones	
46.00	21,800	17,695		4 m wide weir crest
47.00	26,200	41,695		

The changes to the model structure resulted in D_{av} increasing to 1.96 which in turn increased Kc to 3.88. All other parameter values remained the same. Filename: **ECD at Ballarto Rd BL+WLRB.cat**

The results in Table 4 confirm the proposed WLRB achieves the peak flow mitigation objectives for the development as a whole, and that proposed finished surface levels around the WLRB frontages (refer Figure 5 (Sheet 2 of 2)) provide minimum 600 mm freeboard above the 100 year ARI flood level of 46.90 m.

TABLE 4 RORB Model Results-EC Drain catchment at Ballarto Road-Developed Conditions

Location	**Peak Flow (m3/s)**						
	1 year ARI	**2 year ARI**	**5 year ARI**	**10 year ARI**	**20 year ARI**	**50 year ARI**	**100 year ARI**
East w'way @ NAC	0.7 (9)	1.0 (9)	1.6 (9)	2.4 (48)	4.8 (30)	6.4 (48)	7.8 (12)
East w'way at WLRB							8.9 (12)
Clubhouse WLRB							
Peak Outflow (m3/s)	1.1 (36)	1.4 (12)	2.5 (9)	3.8 (9)	5.8 (30)	8.4 (30)	10.0 (9)
Peak Level (m)	45.92	46.03	46.21	46.36	46.56	46.78	46.90
Peak Storage (m3)	16,100	18,400	22,700	26,300	31,100	36,500	39,300
West w'way	0.7 (9)	1.0 (9)	1.6 (9)	2.4 (9)	3.6 (9)	4.7 (9)	5.9 (9)
Ballarto Road Outfall	1.7 (48)	2.3 (9)	4.2 (9)	6.2 (9)	8.9 (9)	12.0 (9)	15.0 (9)

4. WATER QUALITY MODELLING

The catchment runoff and treatment system for Brompton Lodge was modelled using MUSIC Version 3 with the 6 minute rainfall data sequence for Koo Wee Rup for 2004 (as is now required by MW), and assuming full development of Brompton Lodge and the land abutting in the east.

SB1 and SB2 were set at 700 m^2 and 2,000 m^2 water surface areas respectively, with 300 mm extended detention depths. The sizing of SB1 matches normal MWC guidelines for 95% removal of particles less than or equal to 125 micron in size. The sizing of SB2 significantly exceeds the minimum area and is more closely based on the requirement to maintain 100 year ARI flow velocities at or below 0.5 m/s through the online pondage, so as to prevent re-suspension and scour of deposited sediments.

Pollutant treatment performance is summarized in Table 5. The MUSIC model is named **Brompton Lodge 6 May 13 KWR 2004 6 min** and is attached to this report. The model structure is shown in Figure 8.

The results confirm that the proposed sediment basins and wetland suffice to remove loads in excess of that required to achieve best practice outcomes.

TABLE 5 MUSIC Model Results

Asset/Parameter	Inflow loads	Residual loads	Loads removed	Load Removal (%)
SB1				
Flow (ML/yr)	90	89	1	1
TSS (kg/yr)	16,700	6,080	10,620	64
TP (kg/yr)	36	19	17	46
TN (kg/yr)	252	197	55	22
GP (kg/yr)	2,840	0	2,840	100
WLRB				
Flow (ML/yr)	1,700	1,680	20	1
TSS (kg/yr)	198,000	136,000	62,000	31
TP (kg/yr)	474	369	105	22
TN (kg/yr)	4,190	3,680	510	12
GP (kg/yr)	17,100	0	17,100	100
SB2				
Flow (ML/yr)	1,730	1,730	0	0
TSS (kg/yr)	145,000	109,000	36,000	25
TP (kg/yr)	389	352	37	10
TN (kg/yr)	3,830	3,730	100	3
GP (kg/yr)	1,710	0	1,710	100
Brompton Lodge development	**Source Loads**		**Total Loads Removed**	**Development Source Load Removal (%)**
Flow (ML/yr)	469		21	4
TSS (kg/yr)	89,000		108,620	122
TP (kg/yr)	186		159	85
TN (kg/yr)	1,340		665	50
GP (kg/yr)	15,900		21,650	136

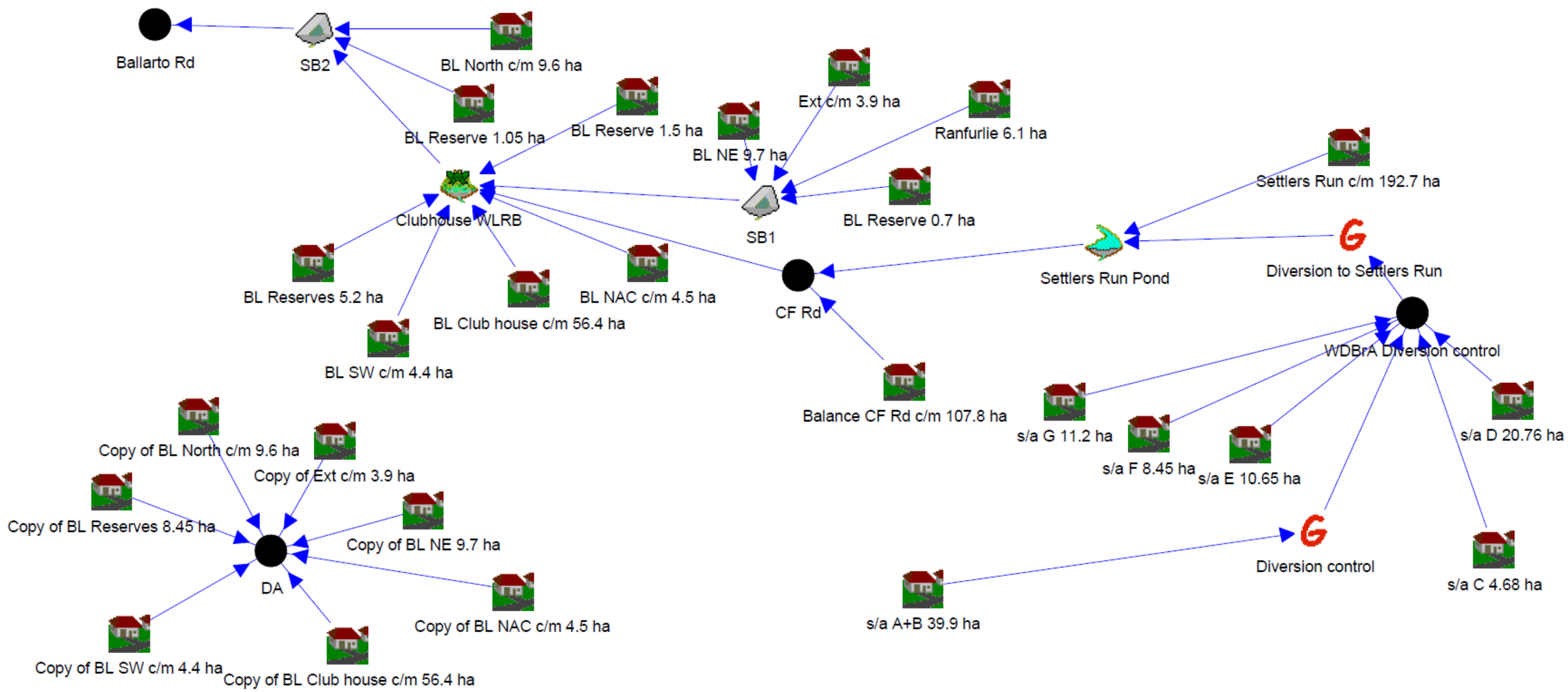


Figure 8
Eastern Contour Drain (east waterway) catchment to Ballarto Road
MUSIC model structure

5. OPEN WATERWAY DESIGN

5.1 General Design Approach

All existing drainage lines in Brompton Lodge are artificial in origin. There are no significant environmental values associated with any of them and existing capacity, depth and alignments are not suited to their retention as part of the urban development layout.

Instead constructed open waterways will replace the two main drainage lines on amended alignments in dedicated reserves with conventional pipelines serving lots and roads.

The results in Table 4 infer that peak 100 year ARI flows for the west and east waterways can be set at 6 m^3/s and 10 m^3/s respectively.

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 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),

The primary aim is for flood flow velocities and depths to be kept low so as to maximise public safety, water quality performance and protection of habitat, whilst slowing down and attenuating peak flow rates downstream.

For the longitudinal slopes averaging between 0.5-1% in Brompton Lodge it is desirable 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, with 6:1 batters on average back to finished surface. Depths to invert will be generally 2 m or more below finished surface so as to provide for effective pipe connections. Total width of the vegetated base zone beyond the low flow course will vary from zero to 12 m, depending on landscape design and spatial restrictions imposed by offline water quality treatment systems.

Whenever significant storm flows occur the capacity of the low flow course is quickly exceeded, flow spreads over the wider floodway base and water borne pollutants, particularly organic materials and silts, are filtered and removed.

Indigenous vegetation species are selected for ability to resist the impacts of flowing water, to maintain filter performance during flow events, to cope with highly variable water supply including drought, and to enhance landscape appeal and habitat diversity. It is intended that dense communities of flexible shrubs and sedge ground covers (carex/melaleuca) will be established within the waterway proper.

To cope with erosion threats, especially during the vegetation establishment period, selective use of the stepped rock/planted edge treatment is used along the main channel batter toe zones. Similar treatments may apply around the internal batters of any offline water quality treatment assets to increase landscape diversity and to save space.

With the recommended indigenous vegetation communities established, the waterway will not require mowing or irrigation, other than where landscape design dictates more formal grassed areas.

With low velocities and gentle cross-section slopes, significant opportunity is retained for trail provision (including boardwalk crossings) and for landscape design to enhance aesthetic and recreational values. Boardwalk crossings must provide 300 mm clearance between the underside of any supporting beams to the 100 year ARI flood level. Supporting piers are to be minimised in number and width across the channel flow area.

5.2 Channel Hydraulics

PC-Convey has been used to determine some options for functional cross-section design.

<u>*Option 1 Minimum Channel Width*</u>

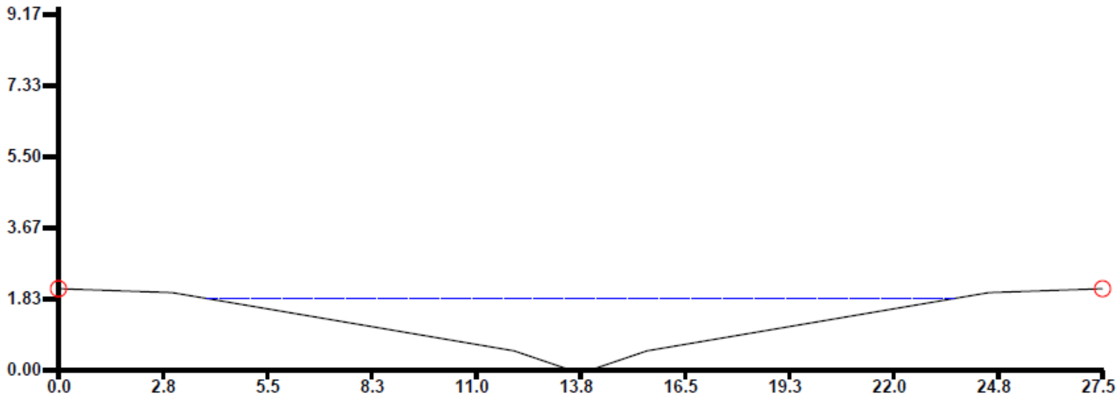
The standard low flow course is 4 m wide and dish-shaped with depth up to 0.5 m. It is mostly rock-lined but interstices are topsoiled and planted. Batter slopes are 6:1 on both banks. Minimum 3 m wide trail zones are provided on both verges at 2.0 m above channel invert. Cross-section width at the outer edge of the trail zones is 27.5 m.

The PC-Convey output on the following pages shows the following results:

Peak Flow (m3/s)	6.0	10.0
Depth (m)	1.12	1.34
Channel velocity (m/s)	1.09	1.21
Flow Width (m)	10.94	13.58

PC-Convey Output
Option 1-Minimum Channel Width (1:1 Plot)

1. CROSS-SECTION:



2. DISCHARGE INFORMATION:

Non-standard storm event

Total discharge = 25.0 cumecs

There is no pipe discharge
Overland/channel/watercourse discharge = 25.0 cumecs

3. RESULTS:

Note: Q = discharge, Ave. Vel. = average flow velocity for cross-section at this water surface elevation.
Fr. No. = Froude Number at this water surface elevation; if Fr < 1 then flow is subcritical.
WP = wetted perimeter, Hydr. Rads. = hydraulic radius = Area/WP at this water surface elevation.
SF indicates whether or not Split Flow occurs at this water surface elevation.
Comp n = composite Manning's n value for cross-section at this water surface elevation.

Grade = 1 in 100

Water Surface Elevation (m)	Q (m^3/s)	Ave. Vel. (m/s)	D(Max) (m)	D(Max) x V(Ave) (m^3/s-m)	Fr. No.	Area (m^2)	WP (m)	Flow Width (m)	Hydr. Rads. (m)	Comp. n	SF?
1.00	4.3	1.02	1.00	1.02	0.49	4.25	9.75	9.50	0.44	0.056	No
1.01	4.5	1.02	1.01	1.03	0.49	4.35	9.87	9.62	0.44	0.056	No
1.02	4.6	1.03	1.02	1.05	0.49	4.44	9.99	9.74	0.44	0.057	No
1.03	4.7	1.04	1.03	1.07	0.49	4.54	10.11	9.86	0.45	0.057	No
1.04	4.8	1.04	1.04	1.08	0.49	4.64	10.23	9.98	0.45	0.057	No
1.05	5.0	1.05	1.05	1.10	0.49	4.74	10.35	10.10	0.46	0.057	No
1.06	5.1	1.05	1.06	1.12	0.49	4.84	10.47	10.22	0.46	0.057	No
1.07	5.2	1.06	1.07	1.13	0.49	4.94	10.60	10.34	0.47	0.057	No
1.08	5.4	1.07	1.08	1.15	0.49	5.05	10.72	10.46	0.47	0.057	No
1.09	5.5	1.07	1.09	1.17	0.49	5.15	10.84	10.58	0.48	0.057	No
1.10	5.7	1.08	1.10	1.19	0.49	5.26	10.96	10.70	0.48	0.057	No
1.11	5.8	1.08	1.11	1.20	0.49	5.37	11.08	10.82	0.48	0.057	No
1.12	6.0	1.09	1.12	1.22	0.49	5.48	11.20	10.94	0.49	0.057	No
1.13	6.1	1.10	1.13	1.24	0.49	5.59	11.33	11.06	0.49	0.057	No
1.14	6.3	1.10	1.14	1.26	0.49	5.70	11.45	11.18	0.50	0.057	No
1.15	6.4	1.11	1.15	1.27	0.49	5.81	11.57	11.30	0.50	0.057	No
1.16	6.6	1.11	1.16	1.29	0.49	5.92	11.69	11.42	0.51	0.057	No
1.17	6.8	1.12	1.17	1.31	0.49	6.04	11.81	11.54	0.51	0.057	No
1.18	6.9	1.13	1.18	1.33	0.49	6.15	11.93	11.66	0.52	0.057	No
1.19	7.1	1.13	1.19	1.35	0.50	6.27	12.06	11.78	0.52	0.057	No
1.20	7.3	1.14	1.20	1.37	0.50	6.39	12.18	11.90	0.52	0.057	No
1.21	7.4	1.14	1.21	1.38	0.50	6.51	12.30	12.02	0.53	0.057	No

3. RESULTS: (continued)

Note: Q = discharge, Ave. Vel. = average flow velocity for cross-section at this water surface elevation.
Fr. No. = Froude Number at this water surface elevation; if Fr < 1 then flow is subcritical.
WP = wetted perimeter, Hydr. Rads. = hydraulic radius = Area/WP at this water surface elevation.
SF indicates whether or not Split Flow occurs at this water surface elevation.
Comp n = composite Manning's n value for cross-section at this water surface elevation.

Grade = 1 in 100

Water Surface Elevation (m)	Q (m^3/s)	Ave. Vel. (m/s)	D(Max) (m)	D(Max) x V(Ave) (m^3/s-m)	Fr. No.	Area (m^2)	WP (m)	Flow Width (m)	Hydr. Rads. (m)	Comp. n	SF?
1.22	7.6	1.15	1.22	1.40	0.50	6.63	12.42	12.14	0.53	0.057	No
1.23	7.8	1.16	1.23	1.42	0.50	6.75	12.54	12.26	0.54	0.057	No
1.24	8.0	1.16	1.24	1.44	0.50	6.88	12.66	12.38	0.54	0.057	No
1.25	8.2	1.17	1.25	1.46	0.50	7.00	12.79	12.50	0.55	0.057	No
1.26	8.4	1.17	1.26	1.48	0.50	7.13	12.91	12.62	0.55	0.057	No
1.27	8.6	1.18	1.27	1.50	0.50	7.25	13.03	12.74	0.56	0.057	No
1.28	8.7	1.19	1.28	1.52	0.50	7.38	13.15	12.86	0.56	0.057	No
1.29	8.9	1.19	1.29	1.54	0.50	7.51	13.27	12.98	0.57	0.057	No
1.30	9.1	1.20	1.30	1.56	0.50	7.64	13.39	13.10	0.57	0.057	No
1.31	9.4	1.20	1.31	1.58	0.50	7.77	13.52	13.22	0.57	0.057	No
1.32	9.6	1.21	1.32	1.60	0.50	7.90	13.64	13.34	0.58	0.057	No
1.33	9.8	1.22	1.33	1.62	0.50	8.04	13.76	13.46	0.58	0.058	No
1.34	10.0	1.22	1.34	1.64	0.50	8.17	13.88	13.58	0.59	0.058	No
1.35	10.2	1.23	1.35	1.66	0.50	8.31	14.00	13.70	0.59	0.058	No
1.36	10.4	1.23	1.36	1.68	0.50	8.45	14.12	13.82	0.60	0.058	No
1.37	10.6	1.24	1.37	1.70	0.50	8.59	14.25	13.94	0.60	0.058	No
1.38	10.9	1.24	1.38	1.72	0.50	8.73	14.37	14.06	0.61	0.058	No
1.39	11.1	1.25	1.39	1.74	0.50	8.87	14.49	14.18	0.61	0.058	No
1.40	11.3	1.26	1.40	1.76	0.51	9.01	14.61	14.30	0.62	0.058	No

4. CROSS-SECTION DATA:

SEGMENT NO.	LEFT HAND POINT CHAINAGE (m)	LEFT HAND POINT R.L. (m)	RIGHT HAND POINT CHAINAGE (m)	RIGHT HAND POINT R.L. (m)	MANNING'S N
1	0.000	2.100	3.000	2.000	0.020
2	3.000	2.000	12.000	0.500	0.060
3	12.000	0.500	13.500	0.000	0.050
4	13.500	0.000	14.000	0.000	0.050
5	14.000	0.000	15.500	0.500	0.050
6	15.500	0.500	24.500	2.000	0.060
7	24.500	2.000	27.500	2.100	0.020

Option 2 Composite Channel

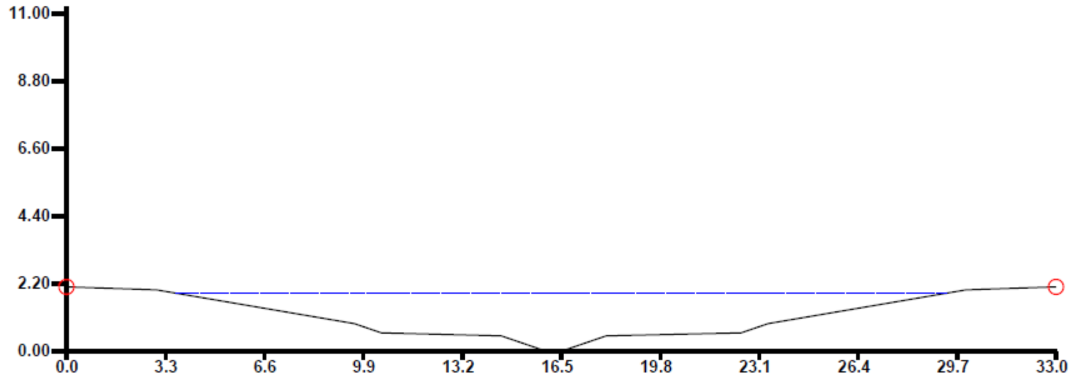
The standard low flow course is 3.5 m wide and dish-shaped with depth up to 0.5 m. It is mostly rock-lined but interstices are topsoiled and planted. The low flow course sits within a densely vegetated flat base zone extending a total of 8 m beyond the low flow course. The low flow course can meander back and forth across the flat base. Batter slopes are 6:1 on both banks, except for minor additional rock edging at the toe to resist erosion during vegetation establishment. Minimum 3 m wide trail zones are provided on both verges at 2.0 m above channel invert. Cross-section width at the outer edge of the trail zones is 33 m.

The PC-Convey output on the following pages shows the following results:

Peak Flow (m3/s)	6.0	10.0
Depth (m)	1.17	1.39
Channel velocity (m/s)	0.61	0.73
Flow Width (m)	17.04	19.68

PC-Convey Output
Option 2-Composite Channel (1:1 Plot)

1. CROSS-SECTION:



2. DISCHARGE INFORMATION:

Non-standard storm event

Total discharge = 25.0 cumecs

There is no pipe discharge
Overland/channel/watercourse discharge = 25.0 cumecs

3. RESULTS:

Note: Q = discharge, Ave. Vel. = average flow velocity for cross-section at this water surface elevation.
Fr. No. = Froude Number at this water surface elevation; if Fr < 1 then flow is subcritical.
WP = wetted perimeter, Hydr. Rads. = hydraulic radius = Area/WP at this water surface elevation.
SF indicates whether or not Split Flow occurs at this water surface elevation.
Comp n = composite Manning's n value for cross-section at this water surface elevation.

Grade = 1 in 100

Water Surface Elevation (m)	Q (m^3/s)	Ave. Vel. (m/s)	D(Max) (m)	D(Max) x V(Ave) (m^3/s-m)	Fr. No.	Area (m^2)	WP (m)	Flow Width (m)	Hydr. Rads. (m)	Comp. n	SF?
1.00	3.6	0.51	1.00	0.51	0.24	7.09	15.28	15.00	0.46	0.118	No
1.01	3.7	0.51	1.01	0.52	0.24	7.24	15.40	15.12	0.47	0.117	No
1.02	3.8	0.52	1.02	0.53	0.24	7.39	15.52	15.24	0.48	0.117	No
1.03	4.0	0.53	1.03	0.54	0.24	7.54	15.64	15.36	0.48	0.117	No
1.04	4.1	0.53	1.04	0.55	0.24	7.69	15.77	15.48	0.49	0.116	No
1.05	4.2	0.54	1.05	0.57	0.24	7.85	15.89	15.60	0.49	0.116	No
1.06	4.4	0.54	1.06	0.58	0.24	8.01	16.01	15.72	0.50	0.116	No
1.07	4.5	0.55	1.07	0.59	0.24	8.16	16.13	15.84	0.51	0.115	No
1.08	4.6	0.56	1.08	0.60	0.25	8.32	16.25	15.96	0.51	0.115	No
1.09	4.8	0.56	1.09	0.61	0.25	8.48	16.37	16.08	0.52	0.115	No
1.10	4.9	0.57	1.10	0.62	0.25	8.65	16.50	16.20	0.52	0.114	No
1.11	5.1	0.57	1.11	0.64	0.25	8.81	16.62	16.32	0.53	0.114	No
1.12	5.2	0.58	1.12	0.65	0.25	8.97	16.74	16.44	0.54	0.114	No
1.13	5.3	0.59	1.13	0.66	0.25	9.14	16.86	16.56	0.54	0.114	No
1.14	5.5	0.59	1.14	0.67	0.25	9.30	16.98	16.68	0.55	0.113	No
1.15	5.7	0.60	1.15	0.69	0.25	9.47	17.10	16.80	0.55	0.113	No
1.16	5.8	0.60	1.16	0.70	0.25	9.64	17.23	16.92	0.56	0.113	No
1.17	6.0	0.61	1.17	0.71	0.26	9.81	17.35	17.04	0.57	0.112	No
1.18	6.1	0.61	1.18	0.72	0.26	9.98	17.47	17.16	0.57	0.112	No
1.19	6.3	0.62	1.19	0.74	0.26	10.15	17.59	17.28	0.58	0.112	No
1.20	6.5	0.63	1.20	0.75	0.26	10.33	17.71	17.40	0.58	0.112	No
1.21	6.6	0.63	1.21	0.76	0.26	10.50	17.83	17.52	0.59	0.111	No

3. RESULTS: (continued)

Note: Q = discharge, Ave. Vel. = average flow velocity for cross-section at this water surface elevation.
Fr. No. = Froude Number at this water surface elevation; if Fr < 1 then flow is subcritical.
WP = wetted perimeter, Hydr. Rads. = hydraulic radius = Area/WP at this water surface elevation.
SF indicates whether or not Split Flow occurs at this water surface elevation.
Comp n = composite Manning's n value for cross-section at this water surface elevation.

Grade = 1 in 100

Water Surface Elevation (m)	Q (m^3/s)	Ave. Vel. (m/s)	D(Max) (m)	D(Max) x V(Ave) (m^3/s-m)	Fr. No.	Area (m^2)	WP (m)	Flow Width (m)	Hydr. Rads. (m)	Comp. n	SF?
1.22	6.8	0.64	1.22	0.78	0.26	10.68	17.95	17.64	0.59	0.111	No
1.23	7.0	0.64	1.23	0.79	0.26	10.85	18.08	17.76	0.60	0.111	No
1.24	7.2	0.65	1.24	0.80	0.26	11.03	18.20	17.88	0.61	0.110	No
1.25	7.3	0.65	1.25	0.82	0.26	11.21	18.32	18.00	0.61	0.110	No
1.26	7.5	0.66	1.26	0.83	0.27	11.39	18.44	18.12	0.62	0.110	No
1.27	7.7	0.67	1.27	0.84	0.27	11.57	18.56	18.24	0.62	0.110	No
1.28	7.9	0.67	1.28	0.86	0.27	11.76	18.68	18.36	0.63	0.109	No
1.29	8.1	0.68	1.29	0.87	0.27	11.94	18.81	18.48	0.63	0.109	No
1.30	8.3	0.68	1.30	0.89	0.27	12.13	18.93	18.60	0.64	0.109	No
1.31	8.5	0.69	1.31	0.90	0.27	12.31	19.05	18.72	0.65	0.109	No
1.32	8.7	0.69	1.32	0.91	0.27	12.50	19.17	18.84	0.65	0.108	No
1.33	8.9	0.70	1.33	0.93	0.27	12.69	19.29	18.96	0.66	0.108	No
1.34	9.1	0.70	1.34	0.94	0.27	12.88	19.41	19.08	0.66	0.108	No
1.35	9.3	0.71	1.35	0.96	0.27	13.07	19.54	19.20	0.67	0.108	No
1.36	9.5	0.72	1.36	0.97	0.28	13.26	19.66	19.32	0.67	0.108	No
1.37	9.7	0.72	1.37	0.99	0.28	13.46	19.78	19.44	0.68	0.107	No
1.38	9.9	0.73	1.38	1.00	0.28	13.65	19.90	19.56	0.69	0.107	No
1.39	10.1	0.73	1.39	1.02	0.28	13.85	20.02	19.68	0.69	0.107	No
1.40	10.4	0.74	1.40	1.03	0.28	14.05	20.14	19.80	0.70	0.107	No

4. CROSS-SECTION DATA:

	LEFT HAND POINT		RIGHT HAND POINT		
SEGMENT NO.	CHAINAGE (m)	R.L. (m)	CHAINAGE (m)	R.L. (m)	MANNING'S N
1	0.000	2.100	3.000	2.000	0.020
2	3.000	2.000	9.600	0.900	0.060
3	9.600	0.900	10.500	0.600	0.060
4	10.500	0.600	14.500	0.500	0.150
5	14.500	0.500	16.000	0.000	0.050
6	16.000	0.000	16.500	0.000	0.050
7	16.500	0.000	18.000	0.500	0.050
8	18.000	0.500	22.500	0.600	0.150
9	22.500	0.600	23.400	0.900	0.060
10	23.400	0.900	30.000	2.000	0.060
11	30.000	2.000	33.000	2.100	0.060

5.3 The East Waterway

Figure 5 (Sheets 1 and 2) show proposed inverts and finished surface levels along the course of the waterway to the Clubhouse WLRB inlet and downstream of the WLRB to the Ballarto Road outfall.

Gradient out of the Cranbourne-Frankston Road culverts is 1.67% for the first 30 m (rocklined for erosion protection) then averages 1% downstream between pondages and road crossings.

The PC-Convey figures in Section 5.2 show that either cross-sectional form option can be applied within the minimum reserve width of 40 m whilst retaining minimum

600 mm freeboard to proposed finished surface levels above the 100 year ARI flood levels.

In fact there are significant opportunities to further manipulate and vary the cross-sectional form and to meander the waterway in most parts of the reserves.

Option 1 form will be required around the proposed SB1 asset with the crest of the confining embankment set 1.4 m or higher than channel invert. This will ensure the asset is fully protected in the 100 year ARI event.

Further landscape and subdivisional drainage design is required before a final waterway design can be completed. At that time HEC-RAS modelling will be carried out to confirm all water levels and final finished surface levels.

5.4 The West Waterway

Figure 6 shows proposed inverts and finished surface levels along the course of the west waterway between Cranbourne-Frankston Road and the Ballarto Road outfall.

Gradient out of the Cranbourne-Frankston Road culverts is 1.67% for the first 30 m (rocklined for erosion protection) then averages 1% downstream.

The PC-Convey figures in Section 5.2 show that cross-sectional form option 1 can be applied within the minimum reserve width of 30 m whilst retaining minimum 600 mm freeboard to the 100 year ARI flood levels.

With the hydraulic width providing combined setback of just over 19 m and with road edging to both verges, the 30 m reserve width is considered to satisfactorily comply with the draft MWC Waterway Corridor Guidelines.

If Option 2 form was contemplated it would be necessary to either delete one trail (on the Highway frontage), or reduce the flat base width.

There are opportunities to further manipulate and vary the cross-sectional form within the 30 m reserve.

Further landscape and subdivisional design is required before a final waterway design can be completed. At that time HEC-RAS modelling will be carried out to confirm all water levels and final finished surface levels.

The Pipeline Underpass

The southwest corner of Brompton Lodge is effectively an island development confined by the Western Port Highway and Cranbourne-Frankston Road and the west waterway. All pipe drainage from this area is to pass under the west waterway and be conveyed to the Clubhouse WLRB, a distance of at least 500 m.

With outlet invert set to match the NTWL of 45.00 m in the Clubhouse WLRB, the minimum likely pipeline invert at the waterway crossing is estimated to be 46.7 m using a grade of 1 in 300 (0.33%). This is 4.3 m below the estimated west waterway invert so there is ample clearance available and significant opportunity to locally vary the waterway and/or pipe detail design to best suit overall landscape and subdivisional design requirements.

5.5 Ballarto Road Outfall Crossing

The figures in Table 4 indicate 100 year ARI peak flow is 15 m^3/s at the confluence of the west and east waterways. The channel invert is 42.0 m to maintain existing conditions at the entry to the NRCL property downstream.

The concept development plan shows a temporary road connection from the existing Ballarto Road roundabout. This temporary road formation should have a minimum finished surface overtopping level of 44.0 m to provide for culverts up to 900 mm height being installed.

The road formation can be raised to 44.5 m if desired but final design levels will be dictated by existing roundabout levels and decisions in regard to required flow capacity under the temporary road access.

Given the number of alternative access options from Cranbourne-Frankston Road frontage including westwards back along the Ballarto Road frontage from the east end, it is considered that the Permit 1 temporary access road does not require more than 10 year ARI flood protection. However this is a matter for the responsible authorities to decide and confirm during detail design.

Assuming 10 year ARI protection will suffice Table 4 indicates a peak flow of 6.2 m^3/s. For 900 mm high RCB units and average velocities of 1.5 m/s, a total flow width of 4.6 m is needed. Three 1.5*0.9 m RCB units should suffice.

6. GROUNDWATER CONSIDERATIONS

Groundwater quality and levels have been extensively investigated and monitored in Brompton Lodge. Permanent and temporary monitoring bores are in place across the site, including immediately adjacent to the proposed dwarf galaxia habitat pond.

The following plans and assessment of implications for surface water asset design have been gleaned from the report by John Leonard Consulting Services (JLCS); "Hydrogeological Assessment, Brompton Lodge Estate, 980-1050 Western Port Highway, Cranbourne South", May 2013.

Groundwater contours prepared using the May 2013 records are shown on the following plan, labelled Figure 9. The May 2013 records are the lowest since records commenced in 2008. Longitudinal section A-B follows on Figure 10 also by JLCS.

Based on the work by JLCS the following conclusions have been reached in regard to impact on surface water management design:

- Groundwater contours show depths below existing surface are typically around 1 to 1.5 m and closely matched to the topography. The hydraulic gradient is therefore relatively steep across the western part of the site and much flatter to the east.

- The depth to groundwater in the current low-lying areas to the west and northwest of the proposed dwarf galaxias pond, wetland/retarding basin and sediment basin SB2 will be increased by the addition of 1-2 m of fill material to raise the design ground surface level to a minimum of 600 mm above the design 100 year ARI flood levels. (D Muscillo, Watsons, pers. comm., May 2013; in JLCS, 2013).

- This infers that inverts of constructed waterways across the site would be expected to reasonably match or sit below the groundwater contours. Normal Top Water Levels (NTWL's) in constructed waterbodies in the east end of the site would be expected to sit up to 1 m below the groundwater contours.

- Larger waterbodies are proposed in the west part of the site in the Permit 1 application area. As shown by the longitudinal section on Figure 10 the base of the waterbodies will be well below the water table. Upslope frontages to the waterbodies will be well below groundwater inflows, allowing free inflow which will distort the local water table configuration and cause a steepening of the hydraulic gradient~~s~~ close to the water bodies. Downslope frontages will sit at or above groundwater levels.

- The quality results show that groundwater is reasonably fresh with just one bore showing brackish quality.

- This infers there is no significant threat of salt bleaching around the high side of ponds where groundwater levels are above NTWL's.

- Groundwater yields in all bores are low. The generally slow water level recovery in the bores after sampling indicates that the sands are very fine and/or silty-clayey with relatively low permeability. Drawdown cones in low permeability soils are deeper and more localised than those in more permeable soils. Consequently, formation of ponds and wetlands will only influence local groundwater levels and not the whole site.

- The shallow depth to groundwater, generally low salinity and low yields all infer that lining of the water bodies will either be minimal in extent or not required in order to stop seepage outflow losses to groundwater.

- Groundwater inflow rates into the water bodies will be small which means that in the absence of external water inputs evaporation will result in gradual drawdown of water levels in offline ponds between inflow periods.

- The low yield is therefore only a potential concern in the proposed dwarf galaxia habitat pond which is to be protected from all surface runoff. Wetlands and ponds which are directly online with urban development drainage systems will receive sufficient water supply to offset evaporation effects at most times.

- The dwarf galaxia habitat pond water supply issue is best addressed by using top up supply from nearby stormwater treatment systems, subject to water quality and predator access prevention measures being incorporated into those works. Specific recommendations are contained in the report by Streamline Research, a summary of which is in Appendix A.

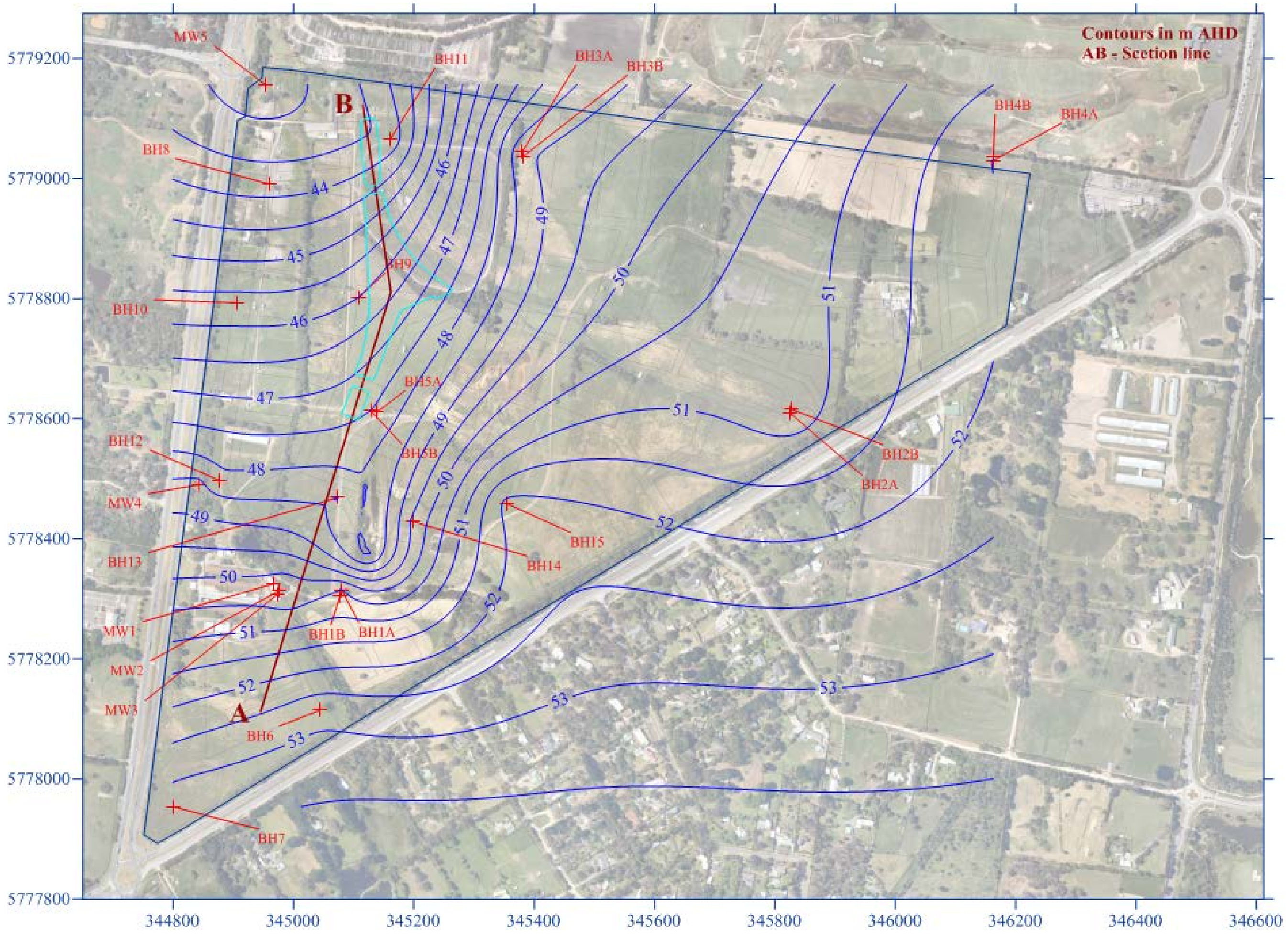


Figure 9 **May 2013 groundwater contours as determined by JLCS**

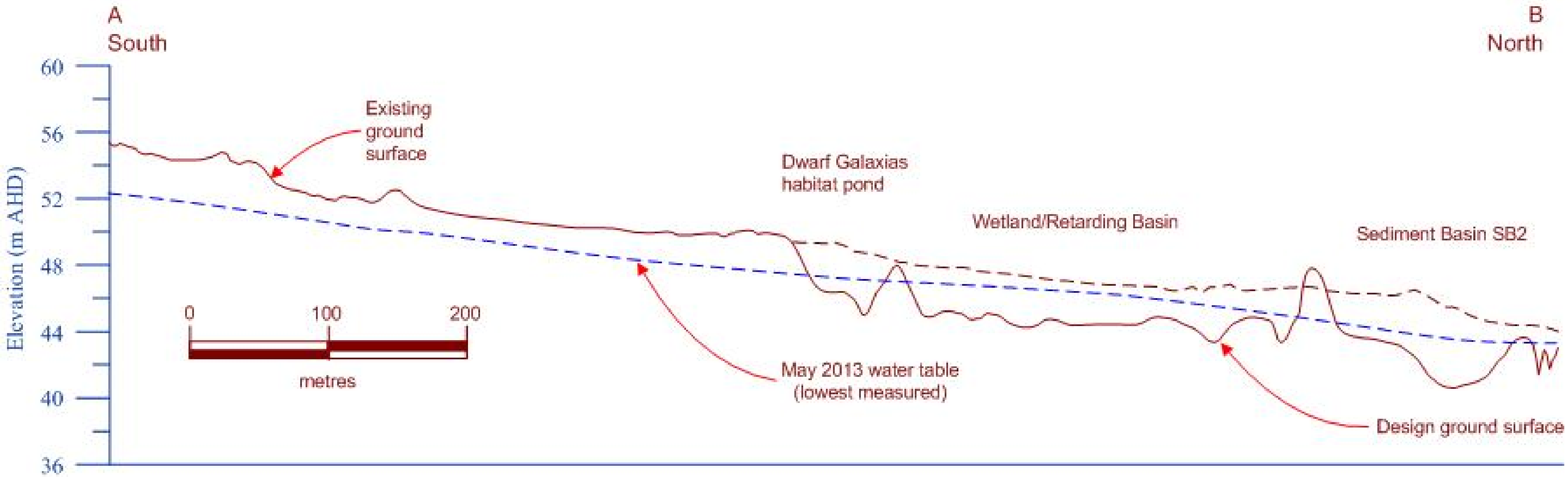


Figure 10 **Longitudinal plot along Section A-B on Figure 9, as provided by JLCS.**

7. GEOTECHNICAL INVESTIGATIONS

Other than surficial soils investigations for site contamination assessments by Coffeys (2013), and the extensive bore logs obtained as part of groundwater monitoring investigations, no geotechnical studies have yet been carried out in Brompton Lodge to confirm soil quality and suitability for construction uses.

With significant cut/fill operations required to achieve the development layout and drainage system levels it will be necessary to conduct suitable geotechnical studies prior to completion of detail design.

Key issues for geotechnical investigations in regard to surface water management design are as follows:

- soil permeability around downslope frontages of proposed water bodies to assess need for lining, if any;

- topsoil and subsoil dispersion characteristics, to assess the need for treatment of same or importation needs to guard against water quality problems in pondages arising from dispersive soils.

Detail design will require geotechnical conditions to be confirmed at depths of up to 4 m below natural surface along the waterway reserves.

8. SUMMARY AND CONCLUSIONS

This report has outlined a surface water management strategy (SWMS) for development of Brompton Lodge and abutting land in the east corner.

The SWMS complies with and addresses:

- all known environmental constraints and objectives, especially dwarf galaxia protection requirements;
- groundwater constraints and opportunities;
- the MWC requirement for no works to be needed in the NRCL land on the north side to accommodate the Brompton Lodge development;
- best practice storm water quality management, floodplain management and waterway management objectives.

Operation and Maintenance

Referring to Figures 4-6 inclusive:

- SB1 and the attendant inlet and outlet pipes and structures will become the responsibility of Council to maintain.
- All subdivisional pipelines and pits connecting to the waterways and treatment assets will become the responsibility of Council to maintain.
- Council will also assume structural responsibility for the road crossing structures, trails and crossings and any other landscape features that may be proposed as part of future detail design.
- MW will retain responsibility for maintenance and operation of the Clubhouse WLRB and SB2, and the two open waterways, including the clearing of culvert openings under the road crossings.

Neil M Craigie

APPENDIX A   DWARF GALAXIA HABITAT CONSIDERATIONS

The following extracts are taken from the March 2013 report by Streamline Research.

A fish survey conducted by Streamline Research in 2008 for VicRoads found a population of dwarf galaxias in sand pit/s several hundred metres from the road, in Brompton Lodge.

A subsequent targeted survey for dwarf galaxias made for Melbourne Water in the Eastern Contour Drain catchment headwater failed to find the dwarf galaxias population responsible for colonising the sand pit/s at Brompton Lodge. Drought and the draining of low lying land with the construction of the Settlers Run golf course was suspected to have resulted in the loss of headwater populations of dwarf galaxias (McGuckin, 2008a).

With consideration that Brompton Lodge be added to the City of Casey Urban Growth Zone, a thorough fish investigation was made in 2011 to confirm the presence of dwarf galaxias in the sand pit/s and whether any other locations on the property supported dwarf galaxias. A lower abundance of dwarf galaxias found in the sand pit/s was suspected to be due to dwarf galaxias movement out and recent eastern gambusia movement into the sand pits during the 2010-2011 flood periods.

Key issues related to the dwarf galaxias population in the sand pit/s at Brompton Lodge are:

- the sand pit/s are man-made and have, quite accidentally through inflow from floodwaters allowed for the establishment of a self-sustaining population of the nationally threatened dwarf galaxias (McGuckin, 2008).

- if not for interception with the underlying groundwater the sand pit/s would have probably dried out during the drought period between 1996 and 2012, resulting in the loss of the dwarf galaxias population (McGuckin, 2008a).

- flooding between 2008 and 2011 has allowed a pest species, the eastern gambusia to become established in the sand pit/s. Eradication and future exclusion is necessary for protection of the dwarf galaxias population (McGuckin, 2011).

- change in land use from open agriculture to a built-up residential area has the potential to change the on-site water balance with loss of the dwarf galaxias population (John Leonard, 2011).

- neither the City of Casey or Melbourne Water are prepared to undertake management of the dwarf galaxias population in the sand pit/s of Brompton Lodge (Ross Morcombe, Watsons, pers. com., 2013).

- the 2013 fish survey of the sand pit/s shows that few dwarf galaxias are present (28 fish captured with a population estimated to be only several hundred). The habitat in the sand pit/s is considered in poor ecological condition and is less than favourable for the long term support of dwarf galaxias.

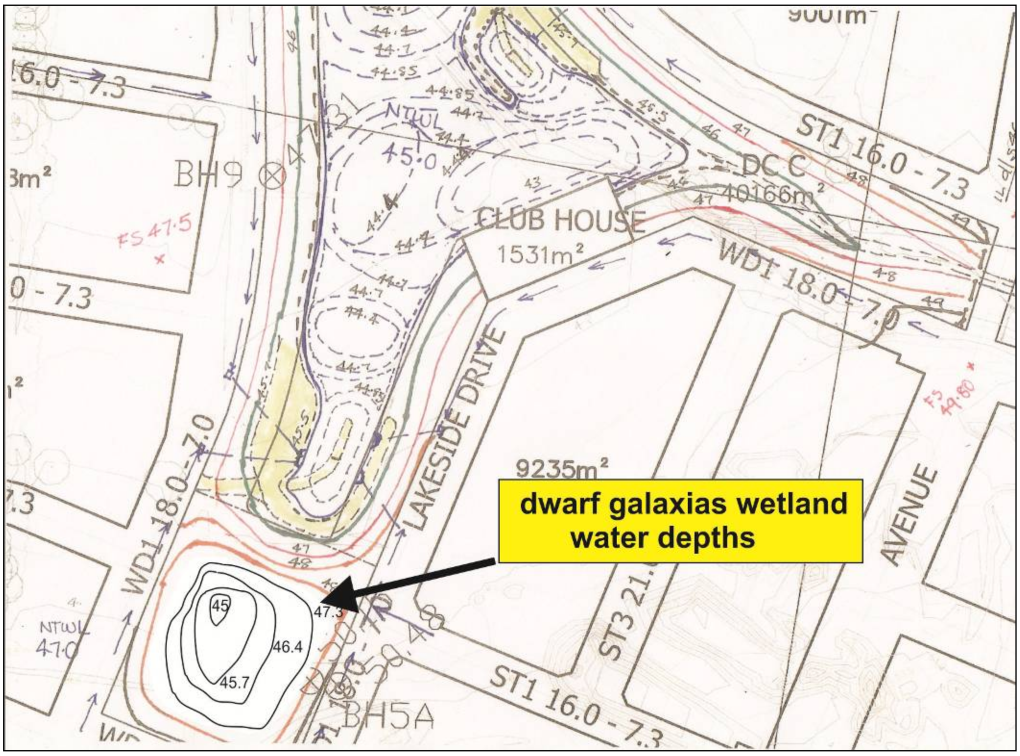
Retention of the sand pit/s is not considered a preferred option as the habitat is so degraded that the dwarf galaxias population is most likely to perish in the near future if remedial improve of habitat conditions are not adopted, most of which would be easier to address with the creation of a new purpose built habitat.

A more acceptable man-made habitat could be made for the dwarf galaxias, one that has appropriate plantings, a guaranteed water supply and favourable water quality. To achieve this the Brompton Lodge development could develop the land occupied by the sand pit/s, particularly if an appropriate off-set results. It is proposed that a purpose built dwarf galaxias wetland will be constructed as compensation. Sufficient funding is to be set aside to ensure that dwarf galaxias translocations can be made from the sand pit/s, eastern gambusia can be excluded from the new wetland, permanent water supply can be assured and a 10 year monitoring program is conducted.

Construction of a purpose built dwarf galaxias habitat with fringing native vegetation is to be made just to the north of the existing sand pit/s as shown below. The design and location of the new wetland will be approved though consultation with DSE and Melbourne Water. The wetted area of habitat will be approximately 1500 m^2, which is much larger than the existing areas of the sand pit/s that can be used by the dwarf galaxias.

Shallow margins will be constructed on the wetlands, as these habitats are favoured by the dwarf galaxias. Dense submergent aquatic and riparian plantings (swamp shrub EVC) on the north and western sides of the waterbody will help reduce summer water temperatures and maintain some shaded areas that will favour the dwarf galaxias.

The water depths will be up to 3.0 m. The deeper water will provides refuge when other parts of the wetland may dry up, providing permanent water throughout summer and refuge habitat during drought periods. There is no plan for large open reaches of water, as they favour pest fish species like eastern gambusia.



Interception with the underlying groundwater will ensure that the wetland always retains surface water. By having trigger water levels in the wetland any unforeseen hydrological change in the underlying groundwater can be addressed. A permanent bore is to be located on the edge of the wetland so that groundwater levels can also be monitored. If critical water levels occur, contingency will be made to ensure water is put into the wetland.

Bunding above the 1:100 year flood level will prevent accidental water inflow from nearby waterways, preventing species like the eastern gambusia from using floodwaters to enter the dwarf galaxias wetland.

A channel along the base of the wetland will allow for occasional draining of the new wetland should it be necessary (if someone deliberately introduces eastern gambusia or some other pest species). Dwarf galaxias could be collected and housed in aquaria until being put back into the wetland habitat after the pest species have been eliminated.

The new habitat combined with a management plan will provide support for the long term survival of the dwarf galaxias over the next ten years.

A number of mitigation measures are expected to be beneficial to the protection of the existing population of dwarf galaxias in the sand pit/s of Brompton Lodge and to the future protection of a purpose built wetland habitat. The measures to avoid impacts for the dwarf galaxias are:

Sand pits

- The existing sand pit/s are to be excluded from the early stages of the development and will not be disturbed until the purpose built wetland has been constructed, aquatic and riparian established and translocation of fish has occurred.

- During works, a clear indication needs to be made to construction personnel of expected mitigation measures and importance to maintaining ecological condition for the dwarf galaxias in the sand pit/s. Direct disturbance due to construction equipment or indirect disturbances due to spills from machinery could have a detrimental effect on the survival of the dwarf galaxias.

- Contractors need to have contingency for reporting accidents (possible polluting to water or any physical disturbance to the sand pit/s). A chain of command between construction personnel, Watsons and Streamline Research is needed to report problems and to provide appropriate on-ground responses. Monitoring following an incident will comprise a survey and appropriate sampling to confirm the extent of the disturbance to the dwarf galaxias. If a spillages occurs, post incident monitoring will be repeated at weekly intervals until the contaminant is no longer considered to be a threat.

New dwarf galaxia wetland

- Fencing the new wetland should allow for establishment of riparian vegetation without disturbance from the residential development. The shallow slopes of the new wetland should have minimal bank erosion, assist with the filtering of runoff water and help prevent deposition of loose material into the new wetland.

- Stormwater is not to be drained into the new dwarf galaxias wetland. Floodwaters are also to be prevented from spilling into the wetland.

- A water quality monitoring program should be incorporated into the fish sampling program. The monitoring program should include measurements of turbidity, pH, dissolved oxygen, electrical conductivity as well as checks on sedimentation and erosion control structures.

- Revegetate riparian zones of the new wetland to increase shade in the riparian zone. This measure by itself is not specifically needed for protecting or enhancing dwarf galaxias habitat, but for improving waterway condition and likelihood that the habitat can be utilised by dwarf galaxias.

- Annual monitoring of the dwarf galaxias population is to be performed by Streamline Research. Reporting will be prepared for the Department of Sustainability and Environment, Melbourne Water and the City of Casey.