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Surf Coast Shire

Report for Stormwater Master Plan - Torquay North

Technical Report

December 2010

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

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1. Introduction

1.1 General

Surf Coast Shire Council engaged GHD to undertake the Torquay North Stormwater Master Plan in September 2010. The Torquay North precinct is located adjacent to the Surf Coast Highway, approximately 20 km south of Geelong as is shown by the location plan in Figure 1-1. This report provides the background technical information for this Stormwater Master Plan.

It includes:

- Catchment and precinct description;
- Stakeholder consultation;
- The modelling undertaken for the conveyance of stormwater flows and associated flood mitigation;
- Consideration of stormwater and roofwater harvesting;
- The modelling undertaken for the water quality assessment and associated treatment; and
- The overall approach for the stormwater master plan.

In addition to this report, the following documents have also been prepared:

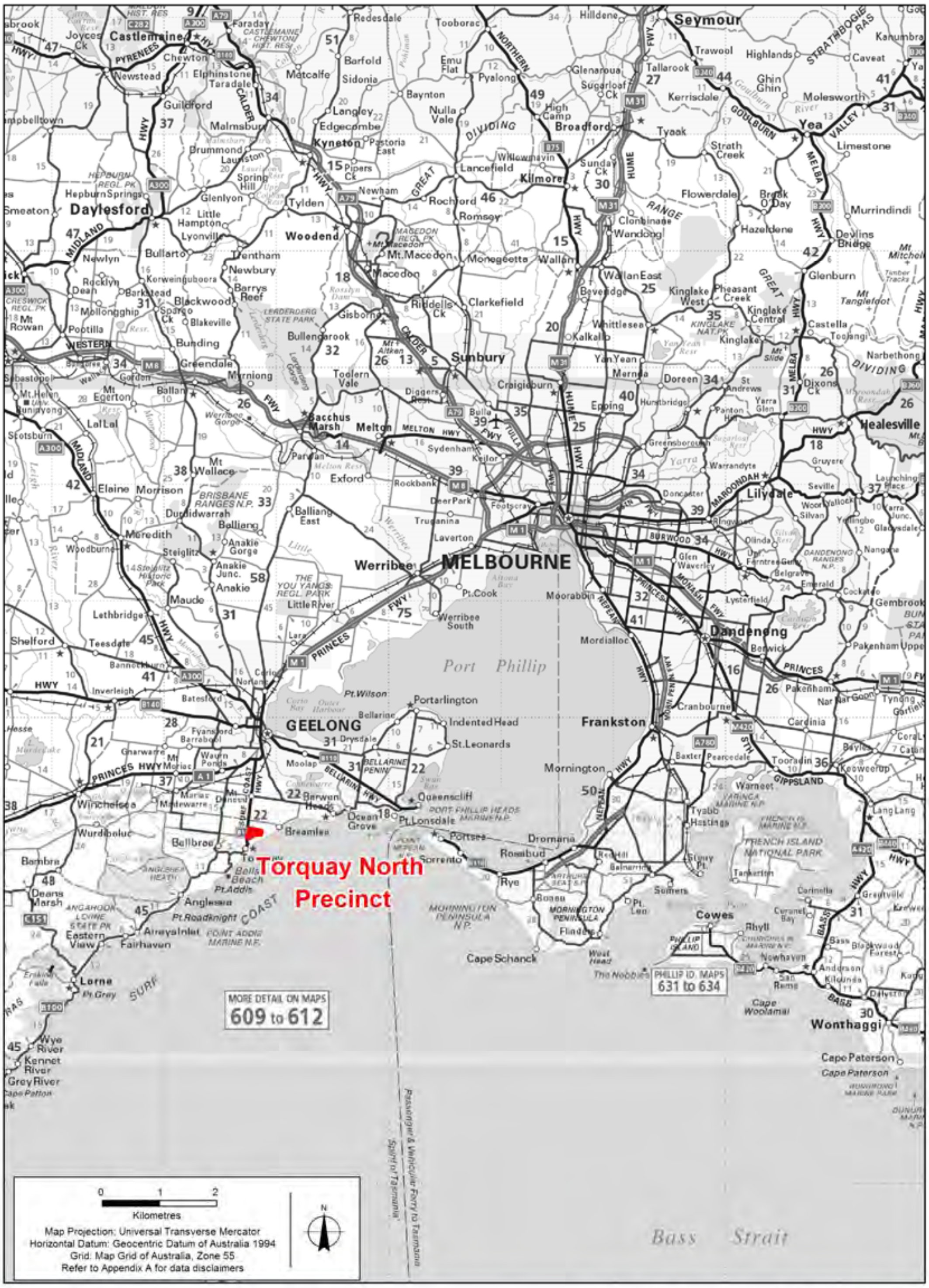
- Stormwater Master Plan (GHD, 2010a); and
- Master Plan Maintenance Guidelines (GHD, 2010b).

1.2 Scope

The scope for this stormwater master plan, as defined in the project brief from Surf Coast Shire Council, was as follows:

- Item 1 – Background review of precinct and desktop analysis of existing catchments;
- Item 2 – Information gathering and stakeholder consultation;
- Item 3 – Site assessment and catchment analysis;
- Item 4 – Analysis and master plan design; and
- Item 5 – Reporting.

Figure 1-1 Torquay North Location Plan



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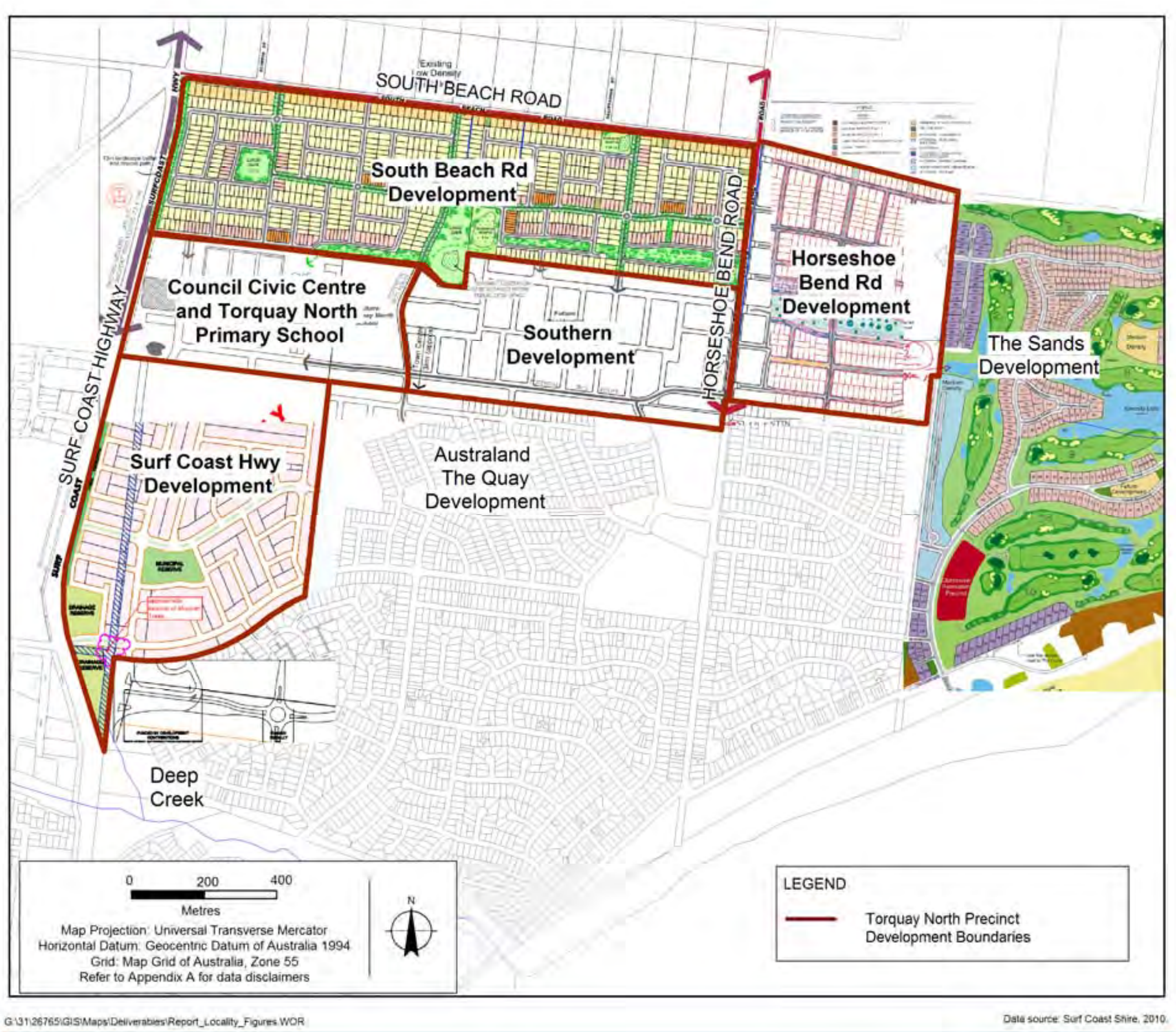
Data source: Melway Map 627, Melways Edition 35 ©, reproduced with permission

2. Catchment Description

2.1 General Layout

The Torquay North precinct covers approximately 300 ha and is bounded by Surf Coast Highway to the west, South Beach Road to the north, the existing Sands development to the east and further existing development to the south (Australand, the Quay Development) as is shown by the site plan in Figure 2-1.

Figure 2-1 Torquay North Precinct Site Plan



The existing land is predominantly cleared, cultivated paddocks, previously used for grazing and cropping. It is proposed to be divided into five individual developments as follows:

1. Horseshoes Bend Road Development;
2. South Beach Road Development;
3. Surf Coast Highway Development;
4. Southern Development; and
5. Community Civic Precinct and Torquay North Primary School (20 ha).

2.2 Drainage

The precinct is mainly covered by two separate catchments as is shown in Figure 2-2. The Northern catchment covers the following developments:

- Horseshoe Bend Road Development;
- South Beach Road Development;
- Southern Development; and
- Civic Centre Precinct and Torquay North Primary School (part).

It falls from the west to the east and discharges into the existing Sands Development. The Deep Creek catchment covers the south west corner of the precinct, which includes:

- Surf Coast Highway Development; and
- Civic Centre Precinct and Torquay North Primary School (part).

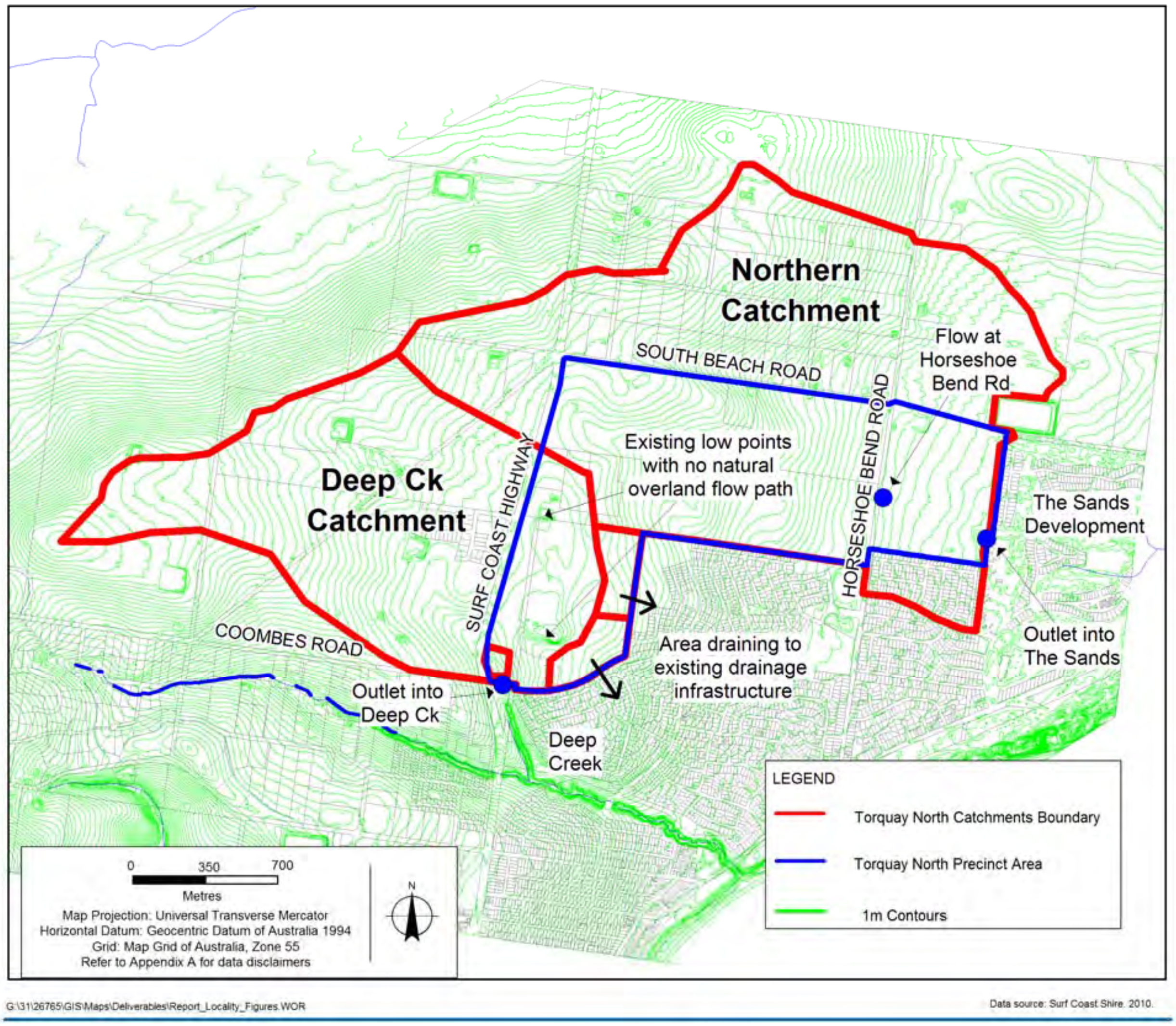
It falls from north to south and discharges into Deep Creek.

The ridge line between the two catchments passes through the proposed Civic Precinct. The small area to the south east of the Civic Precinct does not fall within either of the two main catchments and instead drains towards the east into existing abutting subdivisions. Based on discussions with Council, it is understood that provision has been made in the existing drainage network for stormwater runoff from this part of the precinct.

The northern catchment contains a large existing low density residential area to the north of South Beach Road that generally drains to the east. The drainage path from this part of the catchment appears to initially drain away from the rest of the catchment but feeds back towards the outlet into the Sands around the existing dam to the north of the Sands development.

In the south west catchment, there are two distinct separate low points that do not appear to have a natural overland flow path to drain them. These are located in the south west corner of the Civic Precinct and the middle of the Surf Coast Highway development as is shown in Figure 2-2. The location at the Civic Precinct has been identified by Council as a possible opportunity for a wetland and storage basin for harvesting stormwater to irrigate the sports fields within the precinct. The other location has been identified in the Outline Development Plan (see Section 2.3) as a municipal reserve, but could also provide another potential opportunity for a storage basin to harvest stormwater.

Figure 2-2 Catchment Boundaries



2.3 Outline Development Plan

An Outline Development Plan (ODP) was prepared for Torquay in 2008 and is presented in Appendix B.

In the northern catchment, the ODP shows an open space corridor that runs approximately through the middle of the catchment along the main drainage path, extending from the outlet to the Sands Development upstream to the Civic Precinct. Along this corridor there are three identified areas for local parks, which would also provide drainage opportunities for potential retarding basins, wetlands and possibly storage basins for stormwater harvesting.

A green space corridor is also located along the Surf Coast Highway from South Beach Road in the northern Catchment to Deep Creek in the southern catchment. An area for a local park is indicated where the low point in the southern catchment is located and this is connected with a green space corridor to the corridor along the Surf Coast Highway. This corridor would provide a logical route for the drainage path from that low point.

2.4 Soils

A preliminary geotechnical investigation (Coffey) was prepared for the area proposed for the Civic Precinct. It is understood that the aims of that investigation were as follows:

- To provide a preliminary assessment of subsurface conditions at the site;
- To provide comments on site preparation and presumptive parameters for design of residential pavements;
- To provide a preliminary indicative site classification to AS2870-1996 and advice on suitable footing systems for the proposed buildings;
- To provide an assessment of the suitability of any clay material on site for use in the construction of the proposed residential allotments; and
- To provide recommendations for further investigation to clarify any areas of uncertainty.

It is understood that no permeability testing was undertaken for the soils encountered in that investigation. It has been noted that the Coffey investigation applied to only one part of the site under consideration for the stormwater master plan, located on the western side of the area under consideration. The area investigated by Coffey was inferred to be within the Moorabool Viaduct Formation as determined from the visual logging of test pits. Review of the Geological Survey of Victoria, Anglesea Map Sheet (1:63,360), indicates that the eastern portion of the area under consideration is characterised by Quaternary age post-newer volcanics, which is characterised by sandy clay and clayey quartz sand.

Coffey reported that the subsurface consists of silty sand and sand from the surface to 0.6 m below the surface, overlying low to high plasticity sandy clays and clayey sands generally between 0.6 m and 2.5 m below the ground surface. Some very stiff to hard clays and medium dense to very dense clayey sands were encountered between 0.7 m to 2.5 m below the surface. If it was assumed that this was representative of the whole precinct, it would appear unlikely that stormwater infiltration strategies would be effective for the stormwater management plan. However further geotechnical investigations that covered more of the precinct and tested for permeability would be necessary to confirm this.

3. Stakeholder Consultation

3.1 Approach

In preparing the SMP, meetings and discussions were held with the owners and or the owner's consultant for each of the properties located within the Torquay North precinct and also for the Sands Development. The property and contact details are presented in Appendix C.

The meetings/discussions were organised to enable the requirements for each development to be understood and to then be considered in the development of the SMP.

A summary of the main points from these meetings/discussions is provided in Section 3.2.

3.2 Responses

3.2.1 The Sands Torquay – 2 Sands Boulevard (The Sands Development)

- Testing for Stormwater Quality should be required for Wetlands upstream of The Sands. This would provide a mechanism for determining and isolating possible pollution sources. At present The Sands are required to carry out regular testing for water quality.
- The Sands could use additional water for the irrigation of the gold course if additional storage was made available.

3.2.2 1445 Surf Coast Highway – Torquay (South Beach Road Development)

- Take into consideration existing agreements that are in place.
- Take into consideration current draft development plan.

3.2.3 1095 Horseshoe Bend Road – Torquay (Horseshoe Bend Road Development)

- Take into consideration existing agreements that are in place.
- Take into consideration current draft development plan.

3.2.4 21A Glengarry Drive – Torquay (Surf Coast Hwy Development)

- Take into consideration current draft development plan.
- An area along the eastern boundary abutting the existing development drains to the existing underground drainage system and has been allowed for in the original design.

4. Stormwater Conveyance

4.1 Stormwater Conveyance Objectives

The objectives for the conveyance of stormwater through the precinct was no increase in the peak 100-year ARI flood flows from existing conditions at:

- Horseshoe Bend Road;
- The outlet from the northern catchment to the Sands Development; and
- At the outlet from the south east catchment to Deep Creek.

4.2 Hydrological Modelling

Hydrological modelling was undertaken using RORB to provide estimates of the existing and developed condition flows. This hydrological modelling was then also used to determine appropriate sizes for the proposed retarding basins to achieve the stormwater conveyance objectives. An overview of RORB is provided in Appendix D1.

Two separate hydrological models were setup in RORB to represent the northern and Deep Creek catchments.

The reach and sub-catchment plans, run parameters (including losses) and design rainfall intensities for these RORB models are presented in Appendix D2, D3 and D4 respectively.

For each catchment, calibration was undertaken using a 'natural conditions' RORB model and matching its 100-year ARI flow estimate with that provided by the rural rational method by adjusting k_c. The 'natural conditions' RORB model represented existing conditions within the catchment.

The Rational Method calculations and the RORB model k_c and D_{av} values are presented in Appendix D5.

4.3 Existing and Developed Flood Flows with No Mitigation

A summary of the peak 100-year ARI flood flows for existing and developed conditions is presented in Table 1 at key locations throughout the Northern and Deep Creek catchments. Refer Figure 2-2 for key locations and Appendix D for RORB node locations.

Table 1 Existing and Developed Peak 100-Year ARI Flows with no Mitigation

Location Description[1]	RORB Node[2]	Existing Conditions		Developed Conditions		Change	
		Flow (m3/s)	Critical Duration (hr)	Flow (m3/s)	Critical Duration (hr)	Flow (m3/s)	Flow (%)
Northern Catchment							
Inlet to proposed RB4 (South Beach Road Development West)	N1	2.3	9	4.3	2	2	87%
Inlet to proposed RB3 (South Beach Road Development East)	T2	1.1	9	4	1	2.9	264%
Inlet to proposed RB2 (Southern Development)	U2	1.8	9	7.3	2	5.5	306%
Flow at Horseshoe Bend Rd	Q2	4.6	9	12.7	1	8.1	176%
Inlet to proposed RB1 (Horseshoe Bend Road Development)	AA1	5.6	9	7.4	15 m	1.8	32%
Outlet from southern part of Horseshoe Bend Road Development.	AE1	0.7	2	2.3	2	1.6	229%
Outlet into The Sands	OUTLET	9.6	9	16.2	2	6.6	69%
Deep Creek Catchment							
At Surf Coast Hwy discharging into the Civic Precinct.	A1	2.5	9	3.1	2	0.6	24%
Outlet into Deep Creek	OUTLET	6.6	9	8.6	2	2	30%

Notes:

1. See Figure 2-2 for locations.
2. See Appendix D2 and D3 for RORB node locations.

Based on the results of the hydrological modelling, the effects of future development within the Torquay North Precinct on the peak 100-year ARI flood flows **with no mitigation** can be summarised as follows:

- At the outlet of the Northern Catchment to the Sands Development, the peak 100-year ARI flood flow would increase from 9.6 m^3/s to 16.2 m^3/s (69%);
- At Horseshoe Bend Road, the peak 100-year ARI flood flow would increase from 4.6 m^3/s to 12.7 m^3/s (176%); and
- At the outlet of the Deep Creek catchment, the peak 100-year ARI flood flow would increase from 6.6 m^3/s to 8.6 m^3/s (30%).

4.4 Previous Hydrological Modelling

A hydrological assessment was undertaken as part of the Torquay Sands Development (Neil M Craigie and Pat Condina, 2001). That assessment also used a RORB model to provide estimates of the peak flood flows within the catchments drainage to the Sand Development. A comparison between the flow estimates from that assessment and those estimated as part of this stormwater management plan is provided in Table 2.

Table 2 Existing Conditions 100-yr ARI Peak Flow Comparison with Previous Work

Location	Torquay North SMP Hydrological Investigation (m^3/s)	Sands Development Hydrological Investigation (m^3/s)	Difference (m^3/s)
Horseshoe Bend Road	4.6	5.0	- 0.4
Outlet to the Sands Development	9.6	5.1	+ 4.5
Notes:			

At Horseshoe Bend Road, there was reasonable agreement between the flow estimates. However at the outlet to the Sands development, the peak flow estimate from this SMP was almost double that presented from the previous assessment.

While the report covering the hydrological assessment for the Sands Development was available for this SMP, there was limited information presented to confirm the assumed catchment conditions and therefore further comment between the two estimates was not possible.

4.5 Flood Flow Mitigation

4.5.1 Flood Flow Mitigation Strategy

Based on the objectives presented in Section 4.1 and the results of the hydrological analysis for existing and developed conditions, flood flows will need to be attenuated within the precinct under developed conditions. The approach to provide attenuation for this mitigation strategy is to use a number of separate retarding basins distributed throughout the precinct.

The selected locations for the retarding basin sites has been based on the following:

- The need to provide the required attenuation at the necessary locations identified by the objectives in Section 4.1;
- To achieve a reasonably fair distribution of land take within each separate development for the retarding basin sites; and
- Where possible to locate the sites within existing wetland/retarding basin spaces as identified by the Outline Development Master Plan (see Appendix B).

The locations for the retarding basins is shown on the Stormwater Master Plan (see Appendix E) and are as follows:

- Horseshoe Bend Road Development – immediately upstream (west) from the Sands Development;
- South Beach Road Development East – Immediately upstream (west) from Horseshoe Bend Road;
- South Beach Road Development West – located within the local park defined on the ODP;
- Southern Development - Immediately upstream (west) from Horseshoe Bend Road; and
- Surf Coast Highway Development – Immediately upstream from the outlet to Deep Creek.

While the above retarding basins have been sited at locations where there are proposed open spaces, Council has advised that the retarding basins would themselves not be considered as open space and developers would need to account for this open space separately.

It is understood that lot scale rainwater tanks have been proposed as part of the Southern Development. The use of rainwater tanks in this stormwater master plan is discussed further in Section 5. For the purpose of flood flow mitigation, rainwater tanks within a development cannot be used instead of retarding basins for the following reasons:

- There volumes are generally small compared with the volume of rainwater runoff from a 100-year ARI flood event; and
- The purpose of rainwater tanks is to store rainwater and therefore they cannot be guaranteed to be empty at the start of a flood event to enable them to provide attenuation.

4.5.2 Retarding Basin Details

The key details for each of the retarding basins is presented in Table 3. Features of the retarding basins design include:

- The base of the basins should have a nominal grade of 0.5% to allow the structures to be free draining;
- A three metre wide top of embankment (to allow compaction of the bund) and provide space for a maintenance track; and
- A 1:5 batter slope on all embankments to assist safe maintenance.

Table 3 Retarding Basin Key Details

	Northern Catchment			Deep Ck Catchment
	Southern Development (RB2)	South Beach Road Development East (RB3)	South Beach Road Development West (RB4)	Surf Coast Highway Development (RB5)
100-year ARI Peak Inflow (m^3/s) [1]	7.3	4	4.3	8.5
Peak Outflow - see table notes for ARI (m^3/s)	1.3	1.1	1.1	6.6
Required Volume (m^3)	19,840	12,800	22,240	39,720
Retarding Basin Plan Area (m^2)	11,150	7570	12,280	22,560
Retarding Basin Invert	13.7	14	29.7	38.5
Embankment Crest Level (mAHD)	15.91	16.2	31.9	40.52
Embankment height above basin invert level (m)	2.2	2.2	2.2	2
Peak Water Level (mAHD) - see table notes for ARI	15.61	15.9	31.42	40.22
Inlet Arrangements				
Outlet Arrangement	1 x 675 mm diameter pipe	1 x 600 mm diameter pipe	1 x 600 mm diameter pipe	1,200 mm diameter pipe and 1,350 mm diameter pipe

Notes: All values in this table are approximate and have been determined for the purpose of deriving the stormwater master plan. All values should be confirmed during detailed design.

4.5.3 Offline Retarding Basins

In the Northern catchment, the following three retarding basins have been designed to be offline from the main flow path:

- Horseshoe Bend Road Development;
- South Beach Road Development East; and
- Southern Development.

This has been undertaken so that these retarding basins are only attenuating the additional flood flows joining the main flow path. This means that the retarding basins can work more efficiently towards attenuating flows and their size can therefore be smaller than if they were otherwise online and also receiving flows from the main flow path. The main flow path from the main catchment upstream therefore needs to be directed around these retarding basins as is shown in the Stormwater Management Plan. The outlets from the offline retarding basins would discharge into the main flow path.

4.5.4 Overland Flow Paths

The retarding basins are designed to provide attenuation for the 100-year ARI event. The flood flows draining to the retarding basins will be conveyed along both the local pipe drainage (assumed to be a 5-year ARI design capacity) and also overland along the roads through the precinct (assumed to have a 100-year ARI capacity). The falls along the roads are therefore important in directing overland flood flows towards the retarding basins. Arrows are provided on the Stormwater Master Plan to indicate the direction of falls along the roads to enable flood flows to be conveyed to the retarding basins.

4.5.5 Open Channels

The open channels shown on the SMP have not been sized as part of this assessment. They should be designed to convey the 100-year ARI flows.

4.5.6 Proposed lake within Horseshoe Bend Road Development

The proposed lake shown on the development plans for the Horseshoe Bend Road development has been left on the SMP. However, it should not provide any practical flood attenuation function. The outlet from the lake should therefore be sized to convey the peak 100-year ARI flood flow, under existing conditions, without any significant headloss.

4.5.7 Mitigated Developed Conditions Flood Flows

A summary of the peak 100-year ARI flood flows for mitigated developed conditions is presented in Table 4 at key locations throughout the Northern and Deep Creek catchments. Refer Figure 2-2 for key locations and Appendix D for RORB node locations.

Table 4 Existing and Developed Peak 100-Year ARI Flows with Mitigation

Location Description[1]	RORB Node[2]	Existing Conditions		Mitigated Developed Conditions		Change	
		Flow (m3/s)	Critical Duration (hr)	Flow (m3/s)	Critical Duration (hr)	Flow (m3/s)	Flow (%)
Northern Catchment							
Inlet to proposed RB4 (South Beach Road Development West)	N1	2.3	9	1.1	9	-1.2	-52%
Inlet to proposed RB3 (South Beach Road Development East)	T2	1.1	9	1.1	9	0	0%
Inlet to proposed RB2 (Southern Development)	U2	1.8	9	1.3	9	-0.5	-28%
Flow at Horseshoe Bend Rd	Q2	4.6	9	3.4	9	-1.2	-26%
Outlet from northern part of Horseshoe Bend Road Development.	AA1	5.6	9	7.4	9	1.8	32%
Outlet from southern part of Horseshoe Bend Road Development.	AE1	0.7	2	2.3	2	1.6	229%
Outlet into The Sands	OUTLET	9.6	9	9.6	2	0	0%
Deep Creek Catchment							
At Surf Coast Hwy discharging into the Civic Precinct.	A1	2.5	9	3.1	2	0.6	24%
Outlet into Deep Creek	OUTLET	6.6	9	6.6	9	0	0%

Notes:

1. See Figure 2-2 for locations.
2. See Appendix D2 and D3 for RORB node locations.

Based on the results of the hydrological modelling, the effects of the proposed mitigation on future development within the Torquay North Precinct on the peak 100-year ARI flood flows can be summarised as follows:

- At the outlet of the Northern Catchment to the Sands Development , there would be no predicted change in the peak 100-year ARI flood flow, which would remain at 9.6 m^3/s;
- At Horseshoe Bend Road, there would be no predicted change in the peak 100-year ARI flood flow, which would remain at 4.6 m^3/s; and
- At the outlet of the Deep Creek catchment, there would be no predicted change in the peak 100-year ARI flood flow, which would remain at 6.6 m^3/s.

4.6 Drainage for Existing Low Points

As described in Section 2.2, there are two existing low points within the Deep Creek catchment that are located as follows:

- South west corner of the Civic Precinct; and
- Middle of the Surf Coast Highway development.

At present, neither of these low points have a formal path to the catchment outlet.

As part of the ODP, an open space corridor has been proposed along the east side of the Surf Coast Hwy. This corridor could have potentially provided a route for an open channel drainage path from the low point at the Civic Precinct to the catchment outlet. However, further inspection revealed that some deep cuts (approximately 3 m) would have been necessary in places and there are a number of existing trees that would have required removal.

It is therefore proposed for this SMP that the drainage path from the low point at the Civic Precinct follows the existing ground contours through the middle of the Surf Coast Highway development. This alignment is shown on the SMP in Appendix E. The drainage path would be formed of a culvert beneath the entrance road to the Civic Precinct, which would then discharge into an open channel flowing south towards the second low point in the Surf Coast Highway development.

It is proposed that the low point within the Surf Coast Highway development is drained to the west along an open channel drainage path towards the Surf Coast Highway. At the Surf Coast Highway, the open channel would then turn south and follow the open space corridor (shown on the ODP) to the drainage reserves currently proposed as part of the Surf Coast Highway development. At the drainage reserve, a retarding basin (see Section 4.5) and wetland (see Section 6.4) are proposed as part of this SMP.

The open channel drainage path from the low point at the Civic Precinct would join the open channel drainage path flowing west from the low point in the Surf Coast Highway development.

The drainage paths from the two low points presented on the SMP in Appendix E are indicative. There exact alignment can be adjusted, within reason, to fit within the eventual layout design of the Surf Coast Highway development.

5. Stormwater and Roofwater Harvesting

5.1 Proposed Third Pipe

Opportunities to harvest stormwater and/or roofwater to meet household non-potable water demand are today a common component of stormwater master plans. It is understood that for the Torquay North precinct, the Surf Coast Shire Council have made a commitment to connect the precinct to a third pipe system, which will supply non-potable water from the Armstrong Creek catchment to each lot within the precinct. Based on the assumption that the supply of water from this third pipe system will be enough to meet future non-potable water demand within the precinct, the need for harvesting initiatives is negated. However, developers and/or individual lot owners could still choose to pursue separate harvesting initiatives if they desired.

5.2 Lot Scale Roofwater Harvesting

It is understood that the Southern Development within the precinct has proposed to use lot scale roofwater harvesting to supply water to meet each individual lot's non potable water demand (toilet flushing and irrigation of gardens). This is similar to a scheme that has been adopted for the existing Quay Development, located south of the Torquay North precinct. However with the commitment to the third pipe, there is no need for additional lot scale roofwater harvesting within the Torquay North precinct.

As well as providing a supply of non-potable water, roofwater harvesting would also help improve the water quality of stormwater discharging from the precinct through the removal and diversion of roofwater into the sewerage system via toilet flushing etc. This would then reduce, but not expected to totally remove, the need for water quality treatment measures, such as wetlands, within the precinct. This additional benefit is considered to be minor and would not solely justify a roofwater harvesting scheme in addition to the third pipe.

5.3 Precinct Scale Stormwater/Roofwater Harvesting

Open spaces throughout the precinct have been defined as part of the previously completed Outline Development Plan (see Appendix B). Spaces specifically for storage basins were not included within that plan and therefore opportunities for precinct scale stormwater and roofwater harvesting are limited.

However within the precinct there are two low points that do not appear to have a natural overland flow path to drain them and they appear to be located within areas of defined open space, which could therefore potentially provide opportunities to harvest stormwater. These low points are shown on the Stormwater Master Plan and located as follows:

- South west corner of the Civic Precinct; and
- Municipal reserve within the Surf Coast Highway development.

The location or a storage basin within the civic precinct could be used to help irrigate the sports fields proposed as part of the civic precinct. However this potential storage basin site is located high in the catchment and the area draining to it is relatively limited (approximately 60 ha) and mostly rural. It is therefore not expected to receive a high yield. Further more detailed investigations involving a water balance analysis would be required to confirm this.

The potential storage basin site located within the proposed municipal reserve in the Surf Coast Highway development is further down the catchment. A significant part of the catchment draining to it is also proposed to be developed and therefore the yield at this site would be expected to be significantly more. Again further more detailed investigations involving a water balance analysis would be required to confirm this.

6. Stormwater Quality

6.1 Stormwater Quality Objectives

With regard to the protection of receiving waters, the State Environment Protection Policies (Waters of Victoria) (SEPP) specify objectives for receiving waters in the State of Victoria. The Stormwater Agreement between the EPA, Municipal Association of Victoria (MAV) and Melbourne Water allows for urban areas to be 'deemed to comply' with SEPP if the Best Practice Stormwater Management objectives are applied. These objectives are referred to in the Urban Stormwater Best Practice Environmental Management Guidelines (BPEMG) published by the EPA for the design of stormwater treatment systems. These objectives relate to target reductions in annual pollutant loads compared with typical urban pollutant loads, and are summarised as follows:

Table 5 Stormwater Quality Objectives

Stormwater Pollutant	Stormwater Objective
Total Nitrogen	45% reduction from typical urban loads
Total Phosphorus	45% reduction from typical urban loads
Total Suspended Solids	80% reduction from typical urban loads
Litter (Gross Pollutants)	70% reduction from typical urban loads

The Torquay Stormwater Master Plan has been developed to achieve the BPEMG objectives.

6.2 Stormwater Quality Strategy

Council have expressed a preferred water quality treatment train hierarchy based on their experience from a maintenance point of view. The water quality treatment train hierarchy adopted for this master plan is as follows:

- Wetlands are the first preference;
- Swales and buffer strips are the second preference; and
- Bioretention systems are the third preference.

Wetlands are an effective end-of-line treatment measure and are therefore generally applied at the catchment outlet. However a distributed stormwater quality strategy is preferable where practical. The distributed approach is a 'near to source' stormwater treatment strategy where stormwater from the developed area is treated close to where it is produced. Further, a distributed approach ensures that there is no heavy reliance on one form of treatment and the application of different treatment types targets the full range of anticipated pollutants i.e. gross pollutants through to nutrients.

Throughout the Northern and Deep Creek catchments there are a number of open spaces identified in the Outline Development Plan (see Appendix B). These open spaces have been utilised in the siting of the retarding basins proposed as part of the flood mitigation strategy (see Section 4.5).

The stormwater quality strategy proposed for the Torquay North precinct is therefore to provide a distributed approach at a sub-catchment scale with wetlands generally located within the footprints of each of the proposed retarding basins as shown in the stormwater management plan (see Appendix E). This approach should be adopted in the Northern and Deep Creek catchments with the following exceptions:

- An additional wetland treating runoff from the southern half of the Horseshoe Bend Road development; and
- An additional wetland located within the open space adjacent to South Beach Road within the South Beach Road development.

The proposed treatment train would include (from upstream to downstream) a gross pollutant trap, sediment trap and a vegetated wetland (macrophyte zone) to target gross pollutants, suspended solids and nutrients respectively. Gross pollutant traps (GPT) have not been modelled in MUSIC at this conceptual master plan stage. Due to the variable levels of GPT performance, it is proposed that the benefits associated with a preferred GPT are assessed at the functional design stage.

The exception to this is proposed for the precinct draining directly to the existing Quay development. There is lack of space available for the application of wetlands and hence GPTs have been modelled at the outlets to these subcatchments. GPT's are designed to collect gross pollutants and coarse sediment in stormwater runoff and would therefore reduce the overall pollutant loading within the Surf Coast Hwy Development.

Due to the lack of available space to implement WSUD initiatives in the area draining to the existing Quay development, it is proposed that the Deep Creek wetland is oversized to enable best practice to be met for the Surf Coast Hwy development.

6.3 Stormwater Quality Assessment

6.3.1 Approach

To estimate the annual quality of stormwater from the site, MUSIC[1] (Version 4) software was used. MUSIC uses historical climate data to estimate the effectiveness of a stormwater quality treatment network and has options for different land uses as well as treatment devices. A number of in-built modules simulate the generation of pollution from different land uses and the treatment effectiveness of treatment devices.

[1] MUSIC is a computer simulation model developed by the Cooperative Research Centre for Catchment Hydrology (CRC) as a Model for Urban Stormwater Improvement Conceptualisation. MUSIC simulates both quantity and quality of stormwater generated from Australian stormwater catchments including urban, rural and forested land uses based on published research and data collected by the CRC.

6.3.2 Climate Data

Climate data was sourced from Bureau of Meteorology (BoM) for Geelong North (Station ID – 87133). Historical records (1968 – 2010) indicate that the region receives an average of 534 mm of rainfall per annum. A reference year of 1986 was selected for the MUSIC modelling as this represented a typical annual rainfall, similar to the long term average. Monthly evapotranspiration values were adopted based the Geelong North BoM averages.

6.3.3 MUSIC Subcatchments and Impervious Fractions

The MUSIC subcatchments were determined from the RORB subcatchments detailed in Section 4. The MUSIC layout adopted for the Torquay North development site including the subcatchments, and treatment devices is illustrated in Figure 6-1. For each sub catchment area, an impervious fraction was applied to determine the rainfall runoff generated. The sub-catchment areas and impervious fractions are presented in Table 6.

Table 6 MUSIC Subcatchment and Impervious Fractions

Subcatchment	Area (ha)	Impervious Area (ha)	Percentage Impervious (%)
Catch1	24.1	10.8	45
Catch2	52.6	23.7	45
Catch3	17.1	7.7	45
Catch4	35.7	16.1	45
Catch5	35.3	15.9	45
Catch6	14.7	6.6	45
Catch7	14.1	6.4	45
Catch8	9.0	3.1	35
External Catch1	7.6	3.4	45
External Catch2	7.9	3.6	45

6.4 Proposed Water Quality Treatment Initiatives

The key details for each of the proposed wetlands is presented in Table 7.

Table 7 Wetland Key Details

	High Flow By-Pass (m^3/s)	Inlet Pond Volume (m^3)	Surface Area (m^2)	Extended detention depth (m)	Permanent Pool Volume (m^3)	Equivalent pipe diameter (mm)
Horseshoe Bend Rd Dev North Wetland (Catch1)	0.91	406	2435	0.5	1170	53
Southern Dev Wetland (Catch2)	1.13	500	4500	0.5	2250	74
South Beach Rd Dev East Wetland (Catch3)	0.72	289	1735	0.5	833	45
South Beach Rd Dev West Wetland (Catch4)	0.85	333	3000	0.5	1500	59
Surf Coast Hwy Dev Wetland (Catch5)	1.74	900	5400	0.5	2590	80
Horseshoe Bend Rd Dev South Wetland (Catch6)	0.35	133	1200	0.5	600	38
South Beach Rd Dev North Wetland (Catch7)	0.41	238	1429	0.5	686	41

While the above wetlands have been sited at locations where there are proposed open spaces, Council has advised that the wetlands would themselves not be considered as open space and developers would need to account for this separately.

Assumptions:

- High flow by-pass: Flow based on RORB 1-yr ARI flow;
- Surface Area: Based on a Pond: Wetland ratio of 10:90;
- Permanent Pond Volume: Based on a Wetland depth of 0.3 m; and
- Equivalent Pipe Diameter: Calibrated for approximately 72 hours detention.

6.5 Gross Pollutant Traps

GPT's downstream of the catchments entering the adjacent existing development are represented as CDS (continuous deflective separation) Units. Through discussions with Council, the following treatment performance is assumed:

- 52% TSS;
- 17% TP;
- 0% TN; and
- 98% Gross Pollutants (> 5 mm).

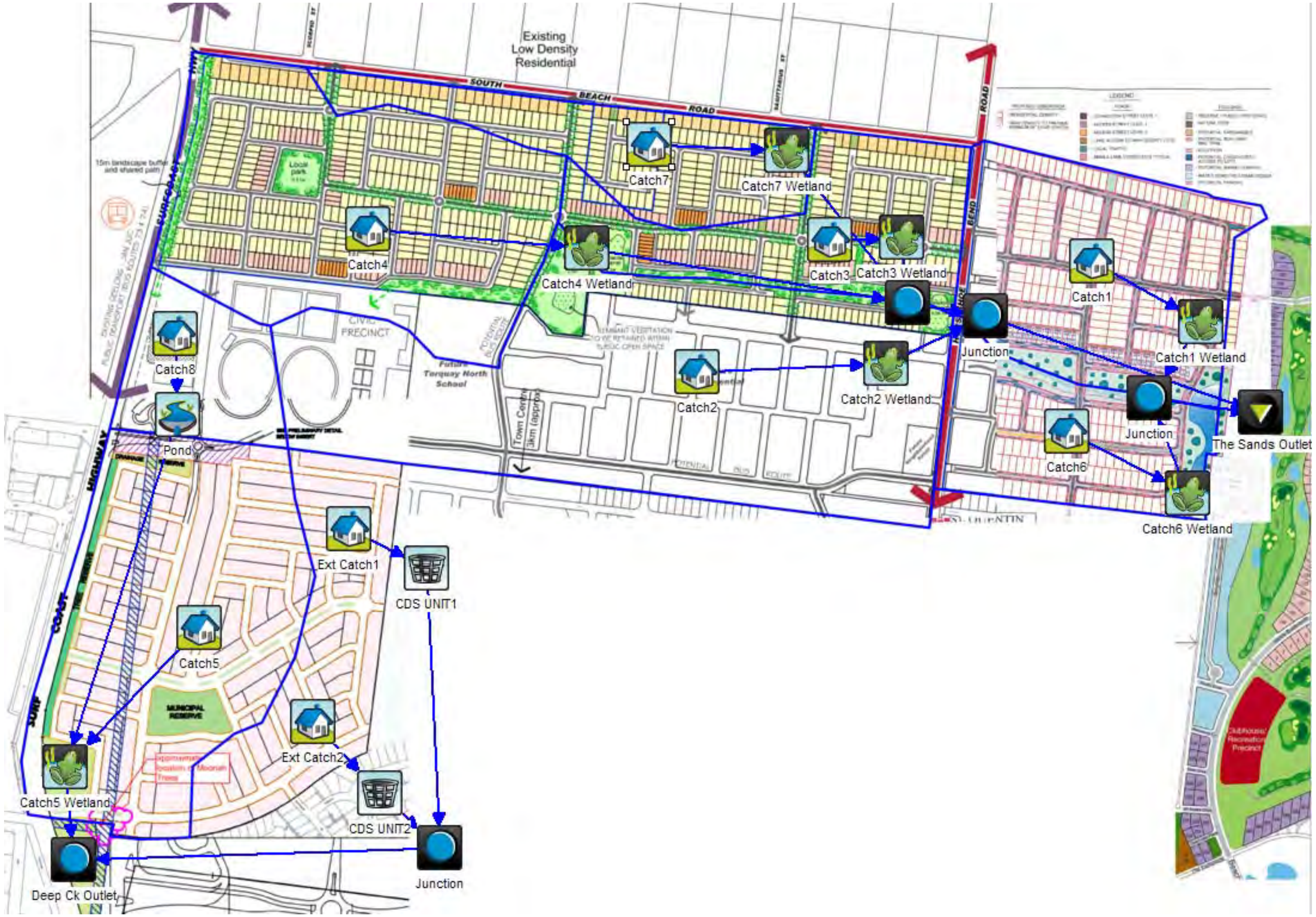
Further MUSIC modelling has shown that BPEMG targets for the Surf Coast Hwy Development could be met if the CDS unit has a minimum treatment performance of:

- 45% TSS;
- 0% TP;
- 0% TN; and
- 98% Gross Pollutants (> 5 mm).

For the purpose of the MUSIC modelling the following CDS unit was adopted:

- CDS P1015 unit for the two outlets to the existing Quay Development.

Figure 6-1 MUSIC Model Layout



6.5.1 MUSIC Assessment Results

The modelled performance of the stormwater treatment train is summarised in Table 8. Based on the MUSIC assessment, the proposed stormwater treatment train approach described in Section 6.3.4 is estimated to achieve the Best Practice Design Guidelines for Stormwater Treatment.

Table 8 Performance of Water Quality Elements

Pollutant	Total Load (kg / yr)	Residual Load (kg / yr)	Load Reduction (%)	Load Reduction (kg / yr)
Horseshoe Bend Rd Dev North Wetland (Catch1)				
Suspended Solids	12200	2290	81	9910
Phosphorous	23	6	72	17
Nitrogen	155	75	52	80
Gross Pollutants	2600	3	100	2597
Southern Dev Wetland (Catch2)				
Suspended Solids	19600	3490	82	16110
Phosphorous	47	16	66	31
Nitrogen	344	185	46	159
Gross Pollutants	5680	31	99	5649
South Beach Rd Dev East Wetland (Catch3)				
Suspended Solids	6500	1080	83	5420
Phosphorous	14	4	72	10
Nitrogen	114	62	46	52
Gross Pollutants	1850	1	100	1849
South Beach Rd Dev West Wetland (Catch4)				
Suspended Solids	15100	3460	77	11640
Phosphorous	33	12	65	22
Nitrogen	226	118	48	108
Gross Pollutants	3860	16	100	3844
Horseshoe Bend Rd Dev South Wetland (Catch6)				
Suspended Solids	6100	1240	80	4860
Phosphorous	12	4	65	8
Nitrogen	92	51	45	42

Pollutant	Total Load (kg / yr)	Residual Load (kg / yr)	Load Reduction (%)	Load Reduction (kg / yr)
Gross Pollutants	1590	7	100	1583
South Beach Rd Dev North Wetland (Catch7)				
Suspended Solids	7210	1260	83	5950
Phosphorous	13	4	72	9
Nitrogen	88	43	51	45
Gross Pollutants	1530	3	100	1527
Northern Catchment OUTLET				
Suspended Solids	66700	12800	81	53900
Phosphorous	142	45.3	68	97
Nitrogen	1020	533	48	487
Gross Pollutants	17100	61	100	17039
Surf Coast Hwy Dev Wetland (Catch5)				
Suspended Solids	15000	1160	92	13840
Phosphorous	33.2	6.71	80	26.49
Nitrogen	224	96.3	57	127.7
Gross Pollutants	3820	0	100	3820
Deep Ck Catchment OUTLET				
Suspended Solids	23100	3960	83	19140
Phosphorous	53	19	65	35
Nitrogen	360	194	46	166
Gross Pollutants	6260	33	100	6227

7. Stormwater Management Plan

7.1 Overview

The stormwater management plan is presented in Appendix E and consists of the following physical components:

- Retarding Basins;
- Wetlands systems (including GPTs and sediment basins);
- Gross Polutant Traps (GPTs);
- Open Channels;
- Culverts; and
- Third Pipe.

This section provides a summary of the details for each of the above components.

7.2 Retarding Basins

Four retarding basins are proposed. Two retarding basins are located within the South Beach Road development (east and west), one is located within the Southern development and one is located within the Surf Coast Highway development. No retarding basins are proposed within the Horseshoe Bend Road development.

The objectives of the retarding basins would be to achieve no increase in the peak 100-year ARI flood flows from existing conditions at:

- Horseshoe Bend Road;
- The outlet from the northern catchment to the Sands Development; and
- At the outlet from the south east catchment to Deep Creek.

The South Beach Road development east and Southern development west retarding basins would be offline. The other two retarding basins would be online. Flows would enter the retarding basins from the local stormwater drainage network and overland flows from either open channels or roads. The local drainage within each sub-catchment would therefore need to be designed to pass through the retarding basins and roads would need to be graded to allow overlands flows to also be directed towards the retarding basins (see arrows provided on SMP for guidance).

Further details on the retarding basins are provided in Section 4.5 of this report.

7.3 Wetland Systems

Seven wetland systems are proposed as part of this SMP. Two are located within the Horseshoe Bend Road development, three within the South Beach Road development, one in the Southern development and one within the Surf Coast Highway development. All four proposed retarding basins would have wetlands within their footprints.

The wetlands have been designed to achieve the Best Practice Environmental Management Guideline objectives in the northern and Deep Creek catchments. Wetlands were not used in the separate catchment covering the east part of the Surf Coast Highway development, due to its size. Instead, GPTs were used (see Section 7.4) and the wetland within the west part of the Surf Coast Highway development was designed to partly compensate.

Each wetland systems would include a GPT and sediment basin at their inlet.

Further details on the wetlands are provided in Section 6 of this report.

7.4 Gross Pollutant Traps

Two Gross Pollutant Traps (GPTs) are proposed within the catchment covering the east part of the Surf Coast Shire Highway development. These are located at existing drainage connections into the local drainage network.

For the purpose of the water quality modelling for this SMP the following CDS unit was adopted:

- CDS P1015 unit for the two outlets to the existing Quay Development.

Further details on the GPTs are provided in Section 6 of this report.

7.5 Open Channels

An open channel has been shown along what are considered to be the main drainage paths through the northern and Deep Creek catchments.

In the Northern catchment, the open channel flows from the boundary of the Civic precinct, through the South Beach Road development west retarding basin (online), in between Beach Road development east retarding basin (offline) and Southern development retarding basin (offline), before flowing beneath Horseshoe Bend Road and through the Horseshoe Bend Road development towards the existing Sands development.

In the Deep Creek catchment, the open channel flows from the Civic Precinct south through the Surf Coast Highway development towards the catchment outlet to Deep Creek. It provides the formal drainage paths for the existing low points within the Civic Precinct and the Surf Coast Highway development.

The alignment of the open channels is indicative and within reason can be adjusted to fit within the eventual layout design of the future developments.

The open channels should be designed to convey the 100-year ARI flows.

7.6 Culverts

Culverts have been used within the SMP to pass flows from the open channels beneath known proposed roads. The number of culverts required therefore depends on the eventual layout design of the future developments.

The culverts should be designed to pass the 100-year ARI peak design flows.

7.7 Third Pipe

Opportunities to harvest stormwater and/or roofwater to meet household non-potable water demand are today a common component of stormwater master plans. It is understood that for the Torquay North precinct, the Surf Coast Shire Council have made a commitment to connect the precinct to a third pipe system, which will supply non-potable water from the Armstrong Creek catchment to each lot within the precinct. Based on the assumption that the supply of water from this third pipe system will be enough to meet future non-potable water demand within the precinct, the need for harvesting initiatives is negated. However, developers and/or individual lot owners could still choose to pursue separate harvesting initiatives if they desired.

Further discussion on stormwater harvesting is provided in Section 5 of this report.

8. References

Engineers Australia (2005) Australian Runoff Quality – A guide to WSUD (pre-production version)

EPA (2000) Best Practice Environmental Management Guidelines for Urban Stormwater

GHD (2010a), Stormwater Master Plan for Torquay North, for Surf Coast Shire, November 2010

GHD (2010b), Report for Stormwater Master Plan – Torquay North, Master Plan Maintenance Guidelines, for Surf Coast Shire, November 2010.

Melbourne Water (2005) WSUD, Engineering Procedures: Stormwater, CSIRO Publishing

Melbourne Water (2005) Constructed Wetland Systems – Design Guidelines for Developers.

Neil M Craigie and Pat Condina (2001) Torquay Sands Development, Torquay, Victoria, Surface Water Management System, Draft Final Report, Concept for management of quality and quantity of surface waters for irrigation supply and feature lakes and wetlands, 22 July 2001.

Appendix A

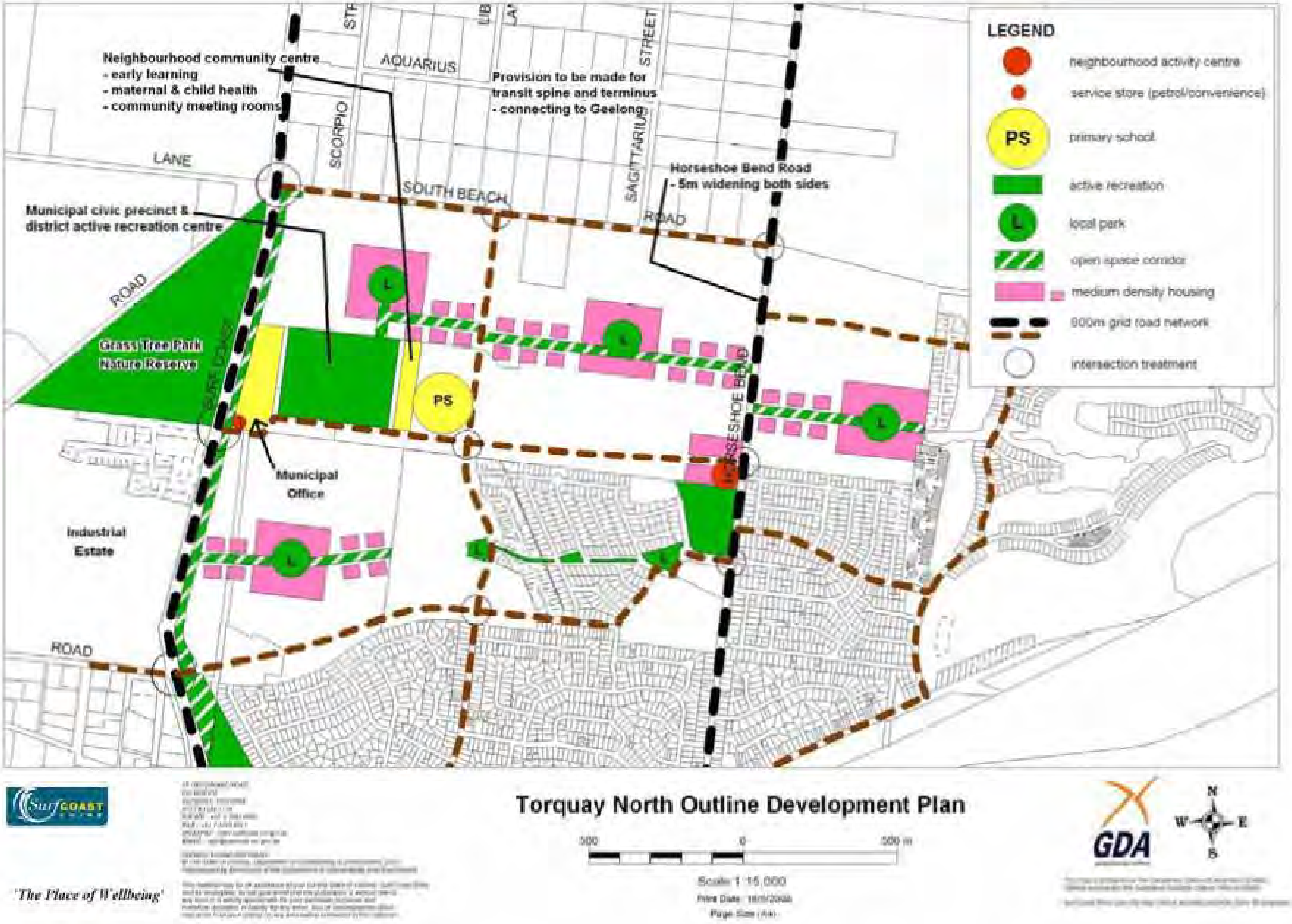
Disclaimers

For Figures 1-1, 2-1 and 2-2

Appendix B

Outline Development Plan

figure 11: torquay north outline development plan



Appendix C

Stakeholder Consultation

House Address	Street Name	Locality	Contact	Address			Status	Contact Type
1535	Surf Coast Highway	Torquay	Estate of Late FA Dwyer & Estate of Late MV Dwyer	C/- Tony Dwyer	79 Lincoln Road	Essendon VIC 3040	Owner	Contacted by Phone 10/11/2010
21A	Glengarry Drive	Torquay	HW McCann & BJ Callan & RJ McCann & JE McVey	C/- PO Box 262	Torquay VIC 3228		Owner	Meeting at Surf Coast Shire Offices 04/11/2010
				C/- Sam Ravida, Reeds Consulting	GPO Box 2240	Melbourne VIC 3001	Consultant for owner	
90	South Beach Road	Torquay	AL & WAP Lyon	PO Box 483	Torquay VIC 3228		Owner	Contacted by Phone 10/11/2010
1095	Horseshoe Bend Road	Torquay	GDV Developments Pty Ltd & Others	C/- D Draper Draper Group	PO Box 287	Belmont VIC 3216	Owner	Meeting at GHD Offices 05/10/2010
				C/- C Marshall TGM Group	Level 1, 27-31 Myers Street	Geelong VIC 3220	Consultant for Owner	

House Address	Street Name	Locality	Contact	Address			Status	Contact Type
110	South Beach Road	Torquay	LM White & JS Harding	C/- Roy Morris	PO Box 201	Torquay VIC 3228	Owner	Second Contact by phone. To receive call back. 10/11/2010
				C/- S Harding Willana Associates	PO Box 170	Randwick NSW 2031	Owner	
				C/- D Joiner, Bosco Jonson	PO Box 5075	South Melbourne VIC 3053	Consultant for Owner	
1445	Surf Coast Highway	Torquay	CA & JR Santospirito	C/- M Tomkinson LDC Pty Ltd	Suite 20, The Clocktower 255 Drummond Street	Carlton VIC 3053	Owner	Meeting at GHD Offices 08/10/2010
2	Sands Boulevard	Torquay	Nathan Bennett	The Sands, Torquay	2 Sands Boulevard	Torquay VIC 3228	Course Superinten dent	Meeting at The Sands 27/09/2010

Appendix D
Hydrology

Appendix D1 RORB Overview

RORB (Laurenson et al 2005) is a non-linear rainfall runoff and streamflow routing model for calculation of flow hydrographs in drainage and stream networks.

The model requires catchments to be subdivided into subareas, connected by a series of conceptual reach storages. Design storm rainfall is input to the centroid of each subarea. Specified losses are then deducted, and the excess routed through the reach network.

Each reach is assumed to have storage characteristics as follows:

$$S = 3600kQ^m$$

Where:

S is storage (m^3);

Q is outflow discharge (m^3/s); and

k and m are dimensionless parameters.

The coefficient k is the product of two factors:

$$K = k_c.k_r$$

Where:

k_c is an empirical coefficient applicable to the entire catchment, and

k_r is the relative delay time applicable to each reach.

The relative delay time for each reach, k_{ri}, is determined as follows:

$k_{ri} = F_i*(L_i/d_{av})$

where:

L_i is the reach length (km),

d_{av} is the average distance along the reach network from each subareas' centroid to the catchment outlet (km), and

F_i is an empirical factor, and a function of reach type as follows:

for natural reaches, F_i=1.0;

for excavated but unlined reaches, F_i=1/($3S_c$0.25);

for lined or piped reaches, F_i=1/($9S_c$0.5); and

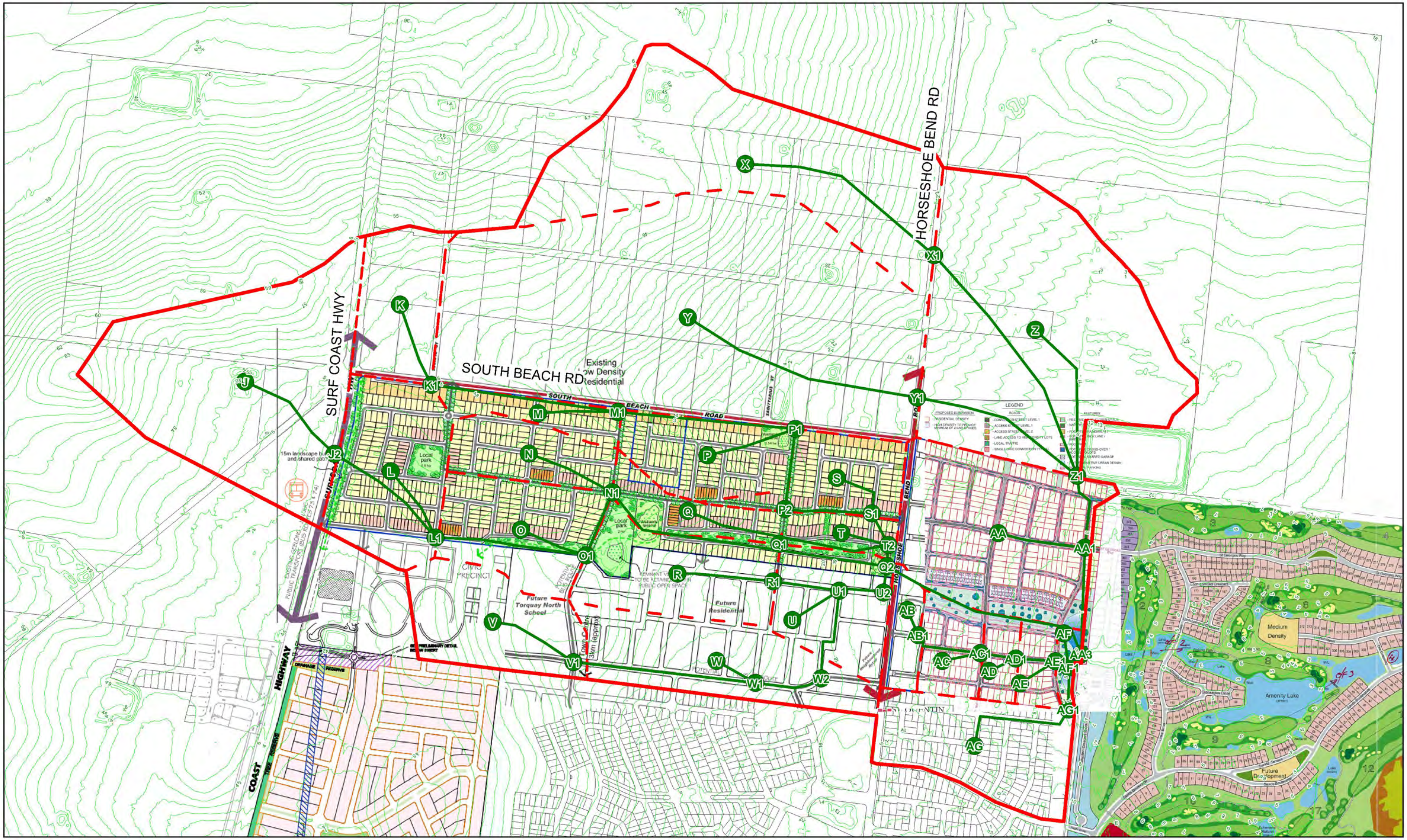
for drowned reaches, F_i=0.0.

where S_c is reach slope (%).

The model is also able to simulate:

- Lakes, retarding basins and similar storages; and
- Concentrated and distributed inflows and outflows.

Appendix D2 Northern Catchment RORB Model Reach and Sub-Catchment Plan



1:10,000 (at A3)

m 100 0 100 200 300

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid Of Australia, Zone 55

N

LEGEND

RORB Catchment Boundary

RORB Subcatchment Boundary

RORB Reaches

RORB Nodes

1m Contours

GHD

CLIENTS | PEOPLE | PERFORMANCE

Surf Coast Shire

Surf COAST SHIRE

RORB Model Layout
Northern Catchment

Job Number 31-26765
Revision
Date Nov 2010

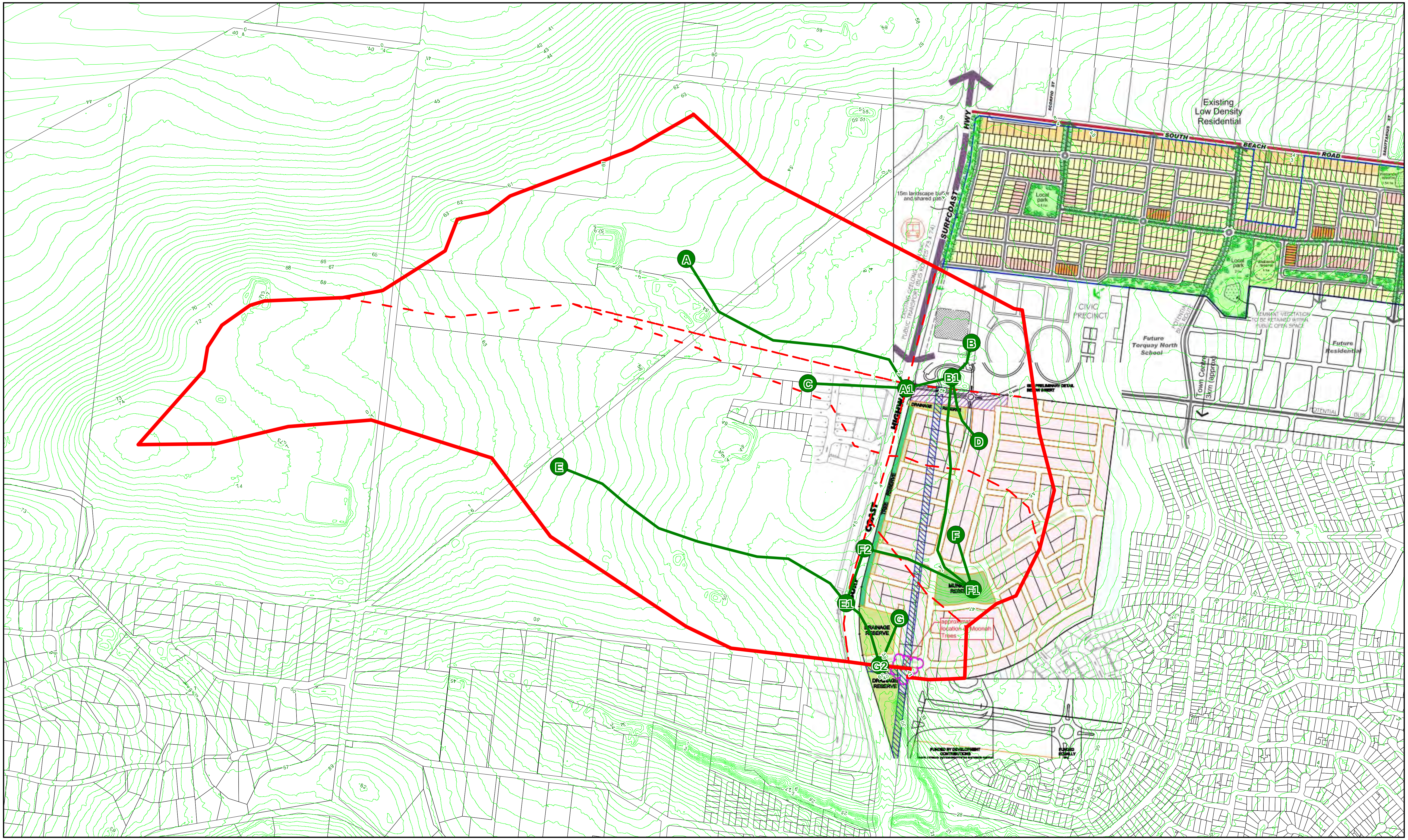
Appendix D2

G:\31\26765\RORB_Model_Layout.WOR

Data source: Cadastre, road names, contours supplied by Surf Coast Shire, Sept 2010. Created by: KEW

8/180 Lonsdale St Melbourne VIC 3000 Australia T 61 3 8687 8000 F 61 3 8687 8111 E melmail@ghd.com.au W www.ghd.com.au

Appendix D3 Deep Creek RORB Model Reach and Sub-Catchment Plan



1:10,000 (at A3)

m 100 0 100 200 300

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid Of Australia, Zone 55

LEGEND

- RORB Catchment Boundary
- RORB Subcatchment Boundary
- RORB Reaches
- RORB Nodes
- 1m Contours

GHD
CLIENTS | PEOPLE | PERFORMANCE

Surf Coast Shire

Surf Coast Shire

Job Number 31-26765
Revision
Date Oct 2010

RORB Model Layout
Deep Creek Catchment

Appendix D3

G:\31\26765\RORB_Model_Layout.WOR

Data source: Cadastre, road names, contours supplied by Surf Coast Shire, Sept 2010. Created by: KEW

8/180 Lonsdale St Melbourne VIC 3000 Australia T 61 3 8687 8000 F 61 3 8687 8111 E melmail@ghd.com.au W www.ghd.com.au

Appendix D4 Model Run Parameters

RORB's initial and continuing loss model was used throughout the study. The values used, which were selected based on past experience and engineering judgement, are as follows for all ARIs:

- 15 mm (initial loss);
- 2.5 mm (continuing loss).

The RORB model sets the following parameters for impervious areas:

- Initial loss - 0 mm; and
- Runoff coefficient - 0.9.

A value of 0.8 was adopted for the model exponent, m, throughout. The design storms used in the modelling were based on:

- Pattern Filter = Filtered; and
- Areal Reduction Factor = Siriwardena and Weinmann (applied to the outlet).

Appendix D5 Design Rainfall Intensities

Design rainfall intensities were determined based on the methods prescribed in Book 2 of the 1997 Edition of Australian Rainfall and Runoff (IEAust 1997). The Intensity-Frequency-Duration (IFD) table used for the Northern and Deep Ck catchments are shown as Table E4.1, and is based on the following parameters:

1 HR DUR 2-year ARI	17.97	mm/hr
12 HR DUR 2-year ARI	3.33	mm/hr
72 HR DUR 2-year ARI	0.9	mm/hr
1 HR DUR 50-year ARI	34.01	mm/hr
12 HR DUR 50-year ARI	5.97	mm/hr
72 HR DUR 50-year ARI	1.69	mm/hr
G (skewness)	0.43	
F2 Geo factor 2-year ARI	4.28	
F50 Geo factor 50-year ARI	14.82	

Table D5.1 Intensity-Frequency-Duration Table for Torquay North

Duration		Design Rainfalls for Average Recurrence Intervals (Years)						
		1	2	5	10	20	50	100
(min)	(hr)	(mm/hr)	(mm/hr)	(mm/hr)	(mm/hr)	(mm/hr)	(mm/hr)	(mm/hr)
5	0.083	44.89	59.77	81.41	96.42	116.57	145.92	170.54
10	0.167	34.19	45.29	60.93	71.66	86.10	107.00	124.43
15	0.250	28.43	37.54	50.08	58.62	70.14	86.74	100.52
20	0.333	24.68	32.50	43.08	50.24	59.93	73.83	85.33
25	0.417	21.99	28.90	38.10	44.31	52.71	64.73	74.66
30	0.500	19.94	26.16	34.34	39.83	47.28	57.92	66.68
45	0.75	13.44	17.50	22.57	25.91	30.48	36.94	42.22
60	1.000	10.30	13.39	17.20	19.71	23.14	27.99	31.94
90	1.500	8.49	11.03	14.13	16.17	18.96	22.90	26.10
120	2.000	6.45	8.37	10.68	12.19	14.27	17.19	19.57
180	3.000	5.31	6.87	8.75	9.97	11.65	14.02	15.94
240	4.000	4.56	5.90	7.49	8.53	9.96	11.97	13.59
300	5.000	4.03	5.21	6.60	7.51	8.76	10.52	11.94
360	6.000	3.63	4.69	5.94	6.74	7.86	9.43	10.70
420	7.000	3.31	4.28	5.41	6.15	7.16	8.58	9.73
480	8.000	3.06	3.95	4.99	5.66	6.59	7.90	8.95
540	9.000	2.85	3.68	4.64	5.26	6.13	7.33	8.31
600	10.000	2.52	3.25	4.09	4.64	5.39	6.45	7.30
720	12.000	2.26	2.92	3.69	4.18	4.87	5.83	6.60
840	14.000	2.07	2.67	3.37	3.82	4.45	5.33	6.05
960	16.000	1.90	2.46	3.11	3.53	4.12	4.94	5.60
1080	18.000	1.77	2.29	2.90	3.29	3.84	4.60	5.22
1200	20.000	1.56	2.01	2.55	2.91	3.39	4.07	4.62
1440	24.000	1.16	1.51	1.92	2.19	2.56	3.08	3.51
2160	36.000	0.94	1.21	1.55	1.77	2.08	2.51	2.86
2880	48.000	0.67	0.88	1.13	1.29	1.52	1.83	2.09
4320	72.000	44.89	59.77	81.41	96.42	116.57	145.92	170.54

Appendix D6 Calibration

D6.1 Rural Rational Method (Vicroads)

Flood flows were estimated at the outfall of the catchment for the 2, 5, 10, 20, 50 and 100-year ARI events. These estimates were prepared using the Rural Rational Method as detailed in the VicRoads Design Guidelines Section 7.2 (VicRoads, 2003). The Rural Rational formula is as follows:

$$Q_Y = 0.278 \times P_Y \times I_{t_c Y} \times A$$

Where:

Q_Y = Peak flow rate (m^3/s) of average recurrence interval (ARI) of Y years;

P_Y = the design discharge factor for ARI of Y years;

A = Area of catchment (km^2); and

I_{tcY} = Average rainfall intensity (mm/h) for design duration of t_c hours and AR of Y years.

The design discharge factor is calculated from:

$P_Y = P_{10}\ F_Y\ F_A$ where:

P_{10} = the 10 year ARI runoff coefficient

F_Y = an ARI factor

F_A = an area size factor.

The runoff coefficient values have been plotted on a map of Victoria and were based on flood discharge data from 325 gauge catchments having 10 or more years of continuous records. VicRoads have found that the Rational Method typically underestimates the discharge for a given storm event for smaller catchments. It is for this reason that VicRoads adopt an area factor (F_A).

For Victoria, the time of concentration was calculated as follows:

$$t_c = 0.76 \times A^{0.38}$$

D6.2 Rural Rational Method 100-Year ARI Flow Estimate

The Rational Method 100-year ARI flow calculations and estimates are presented in Table C6-1.

Table D6-1 Rational Method Calculations for Natural Model

Catchment	Input Fields				Calculated Output		
	ARI (years)	Area (ha)	Impervious Fraction (%)	t_c (mins)	Interpolated Intensity (mm/hr)	C10	Estimated Flow (m^3/s)
Northern	100	381	10	76	36.06	0.1	9.6
Deep Ck	100	221	10	63	41.56	0.1	6.6

Notes:

D6.3 RORB Model Calibration Details

The RORB parameters used to calibrate the RORB models to the Rational Method flows calculated above, are presented in Table C6-2.

Table D6-2 Calibration k_c and d_{av}

	k_c	d_{av} (km)	k_c/d_{av}
Northern Catchment	3.77	1.52	2.5
Deep Ck Catchment	2.53	1.27	2.0

Appendix D7 RORB Results

RORBWin Batch Run Summary
****

Program version 6.15 (last updated 30th March 2010)

Date run: 05 Nov 2010 14:03

Catchment file : G:\31\26765\Tech\RORB\Deep_Ck_Catch\Existing\RORB_Deep_Ck_Ex.catg
Rainfall location: Torquay
Temporal pattern : AR&R87 Volume 2 for zone 1 (filtered)
Spatial pattern : Uniform
Areal Red. Fact. : Based on Siriwardena and Weinmann formulation
Loss factors : Constant with ARI

Parameters: kc = 2.53 m = 0.80

Loss parameters	Initial loss (mm)	Cont. loss (mm/h)
	15.00	2.50

Peak	Description
01	Calculated hydrograph, Flow at A1
02	Special storage : Ex1 - Outflow
03	Special storage : Ex1 - Inflow
04	Special storage : Ex2 - Outflow
05	Special storage : Ex2 - Inflow
06	Calculated hydrograph, Deep Creek Outlet

Run	Dur	ARI	Rain(mm)	ARF	Peak0001	Peak0002	Peak0003	Peak0004	Peak0005	Peak0006
1	10m	100y	20.76	0.91	0.5159	0.4678	0.5998	0.4549	0.5679	0.6937
2	15m	100y	25.13	0.91	1.0045	0.9185	1.0954	0.8665	1.0998	1.3236
3	20m	100y	28.44	0.92	1.3343	1.2681	1.4579	1.1789	1.5071	1.8108
4	25m	100y	31.12	0.92	1.6247	1.5964	1.8119	1.4705	1.8929	2.2691
5	30m	100y	33.35	0.92	1.8217	1.8431	2.0774	1.6917	2.1732	2.6216
6	45m	100y	38.46	0.93	2.2473	2.3978	2.6530	2.1945	2.8215	3.4370
7	1h	100y	42.23	0.93	2.3992	2.7812	2.9889	2.5673	3.2717	4.0645
8	1.5h	100y	47.92	0.94	2.4397	3.0175	3.1256	3.0386	3.5674	4.9164
9	2h	100y	52.21	0.94	2.5221	3.1404	3.2706	3.2776	3.7129	5.5730
10	3h	100y	58.72	0.95	2.3008	2.9595	2.9971	3.2571	3.4968	5.9601
11	4.5h	100y	65.95	0.96	2.1384	2.7088	2.7318	3.0243	3.1891	5.8174
12	6h	100y	71.64	0.96	2.2650	2.7709	2.9729	2.9988	3.3263	5.7443
13	9h	100y	80.56	0.97	2.5479	3.2382	3.3082	3.5169	3.8153	6.6085
14	12h	100y	87.59	0.97	2.2035	2.6765	2.8564	2.7606	3.2027	5.2901
15	18h	100y	100.75	0.98	1.4870	1.8360	1.9354	2.1361	2.1948	4.5445
16	24h	100y	111.00	0.99	1.8901	2.3153	2.4397	2.4172	2.7630	4.9368
17	30h	100y	119.33	0.99	1.3181	1.6979	1.7313	1.8889	2.0056	3.9414
18	36h	100y	126.26	1.00	1.4057	1.7757	1.8248	1.9362	2.1033	4.0198
19	48h	100y	137.07	1.00	1.3697	1.6374	1.7344	1.9207	1.9714	4.1494
20	72h	100y	150.75	1.00	0.7112	0.9430	0.9476	1.0859	1.1020	2.4990

Elapsed Run Time (hh:mm:ss) = 00:00:00

RORBWin Batch Run Summary
****

Program version 6.15 (last updated 30th March 2010)

Date run: 05 Nov 2010 16:47

Catchment file : G:\31\26765\Tech\RORB\Deep_Ck_Catch\Mitigation\RORB_Deep_Ck_Miti.catg
Rainfall location: Torquay
Temporal pattern : AR&R87 Volume 2 for zone 1 (filtered)
Spatial pattern : Uniform
Areal Red. Fact. : Based on Siriwardena and Weinmann formulation
Loss factors : Constant with ARI

Parameters: kc = 2.53 m = 0.80

Loss parameters	Initial loss (mm)	Cont. loss (mm/h)
	15.00	2.50

Peak	Description
01	Calculated hydrograph, Flow at A1
02	Special storage : Dev Stor1 - Outflow
03	Special storage : Dev Stor1 - Inflow
04	Special storage : Dev Stor2 - Outflow
05	Special storage : Dev Stor2 - Inflow
06	Special storage : DeepCk RB(RB5) - Outflow
07	Special storage : DeepCk RB(RB5) - Inflow
08	Calculated hydrograph, Deep Creek Outlet

Run	Dur	ARI	Rain(mm)	ARF	Peak0001	Peak0002	Peak0003	Peak0004	Peak0005	Peak0006	Peak0007	Peak0008
1	10m	100y	20.76	1.00	0.8901	1.6123	3.3614	1.1887	1.9301	0.7417	2.4244	0.7417
2	15m	100y	25.13	1.00	1.5015	2.2042	3.7413	1.6876	2.3455	1.3920	3.0937	1.3920
3	20m	100y	28.44	1.00	1.9089	2.6656	3.8014	2.0943	2.6550	1.9501	4.0104	1.9501
4	25m	100y	31.12	1.00	2.2266	3.0428	4.0598	2.3781	2.6997	2.4293	4.7425	2.4293
5	30m	100y	33.35	1.00	2.4687	3.3474	3.9915	2.6807	2.8061	2.8548	5.3715	2.8548
6	45m	100y	38.46	1.00	2.9444	3.9810	4.3708	3.3718	3.3927	3.6700	6.7467	3.6700
7	1h	100y	42.23	1.00	3.0968	4.2440	4.5340	3.8634	3.9324	4.2796	7.7369	4.2796
8	1.5h	100y	47.92	1.00	3.0651	4.1810	4.3975	4.2120	4.2609	5.0718	8.3737	5.0718
9	2h	100y	52.21	1.00	3.1059	4.2130	4.4177	4.3327	4.3925	5.6127	8.6396	5.6127
10	3h	100y	58.72	1.00	2.7785	3.7080	3.9124	4.0349	4.0606	5.9693	8.2190	5.9693
11	4.5h	100y	65.95	1.00	2.6243	3.4291	3.6751	3.6890	3.7244	5.8392	7.5550	5.8392
12	6h	100y	71.64	1.00	2.6244	3.5043	3.6274	3.6457	3.7298	5.7850	7.6599	5.7850
13	9h	100y	80.56	1.00	2.8883	3.6677	4.0060	4.0464	4.1057	6.5994	8.4773	6.5994
14	12h	100y	87.59	1.00	2.4600	3.2046	3.2260	3.3567	3.4643	5.3962	7.0852	5.3962
15	18h	100y	100.75	1.00	1.6537	2.1117	2.1663	2.3626	2.4215	4.6875	4.9512	4.6875
16	24h	100y	111.00	1.00	2.0778	2.6619	2.7528	2.9509	3.0306	5.0240	6.2431	5.0240
17	30h	100y	119.33	1.00	1.3852	1.7851	1.7968	2.1305	2.1503	3.9128	4.5470	3.9128
18	36h	100y	126.26	1.00	1.4898	1.9220	1.9564	2.2478	2.2809	3.9960	4.7578	3.9960
19	48h	100y	137.07	1.00	1.4747	1.9222	2.0386	2.0795	2.1438	4.1220	4.3894	4.1220
20	72h	100y	150.75	1.00	0.7288	1.0121	1.0452	1.1905	1.1945	2.4050	2.5461	2.4050

Elapsed Run Time (hh:mm:ss) = 00:00:01

RORBWin Batch Run Summary
****

Program version 6.15 (last updated 30th March 2010)
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Date run: 26 Oct 2010 16:08

Catchment file : G:\31\26765\Tech\RORB\The_Sands_Catch\Existing\RORB_The_Sands_Ex.catg
Rainfall location: Torquay
Temporal pattern : AR&R87 Volume 2 for zone 1 (filtered)
Spatial pattern : Uniform
Areal Red. Fact. : Based on Siriwardena and Weinmann formulation
Loss factors : Constant with ARI

Parameters: kc = 3.77 m = 0.80

Loss parameters	Initial loss (mm)	Cont. loss (mm/h)
	15.00	2.50

Peak	Description
01	Calculated hydrograph, Flow at T2
02	Calculated hydrograph, Flow at U2
03	Calculated hydrograph, Flow at N1
04	Calculated hydrograph, Flow Horseshoe Bend Road
05	Calculated hydrograph, Flow at AE1
06	Calculated hydrograph, Flow at AA1
07	Calculated hydrograph, The Sands Outlet

Run	Dur	ARI	Rain(mm)	ARF	Peak0001	Peak0002	Peak0003	Peak0004	Peak0005	Peak0006	Peak0007
1	10m	100y	20.76	1.00	0.1721	0.2777	0.2931	0.5455	0.1406	0.7737	1.1006
2	15m	100y	25.13	1.00	0.3053	0.4926	0.5136	0.9637	0.2494	1.3290	1.9116
3	20m	100y	28.44	1.00	0.4123	0.6683	0.6916	1.3041	0.3369	1.7804	2.5601
4	25m	100y	31.12	1.00	0.5030	0.8158	0.8415	1.5915	0.4106	2.1620	3.1111
5	30m	100y	33.35	1.00	0.5805	0.9499	0.9712	1.8515	0.4750	2.4996	3.5979
6	45m	100y	38.46	1.00	0.7394	1.2305	1.2723	2.4148	0.6061	3.2550	4.6894
7	1h	100y	42.23	1.00	0.8330	1.4388	1.4973	2.8428	0.6882	3.8216	5.5213
8	1.5h	100y	47.92	1.00	0.8781	1.6492	1.7894	3.3875	0.7055	4.5394	6.6449
9	2h	100y	52.21	1.00	0.9097	1.7376	1.9903	3.7562	0.7231	4.9073	7.4614
10	3h	100y	58.72	1.00	0.9333	1.7187	2.1024	4.0248	0.6452	5.0493	8.2303
11	4.5h	100y	65.95	1.00	0.9013	1.5865	2.0281	3.9701	0.5813	4.8758	8.4681
12	6h	100y	71.64	1.00	0.8906	1.6143	2.0016	3.9387	0.6243	4.8326	8.4541
13	9h	100y	80.56	1.00	1.0887	1.8141	2.2997	4.5594	0.6222	5.5771	9.5974
14	12h	100y	87.59	1.00	0.9646	1.4600	1.8382	3.9934	0.5431	4.5714	8.7729
15	18h	100y	100.75	1.00	0.8054	1.1263	1.5933	3.4061	0.3666	3.8827	7.5553
16	24h	100y	111.00	1.00	0.8140	1.2922	1.7261	3.5838	0.4402	4.1144	7.4968
17	30h	100y	119.33	1.00	0.7219	1.0202	1.3416	2.8750	0.2950	3.4216	6.2726
18	36h	100y	126.26	1.00	0.7052	1.0417	1.3781	2.9551	0.3087	3.4576	6.6500
19	48h	100y	137.07	1.00	0.7126	1.0562	1.4000	3.0214	0.2979	3.4592	6.5388
20	72h	100y	150.75	1.00	0.4117	0.6111	0.8346	1.7806	0.1478	2.0426	3.8550

Elapsed Run Time (hh:mm:ss) = 00:00:01

RORBWin Batch Run Summary
****

Program version 6.15 (last updated 30th March 2010)

Date run: 18 Nov 2010 16:38

Catchment file : G:\31\26765\Tech\RORB\The_Sands_Catch\Mitigation\RORB_The_Sands_Miti.catg
Rainfall location: Torquay
Temporal pattern : AR&R87 Volume 2 for zone 1 (filtered)
Spatial pattern : Uniform
Areal Red. Fact. : Based on Siriwardena and Weinmann formulation
Loss factors : Constant with ARI

Parameters: kc = 3.77 m = 0.80

Loss parameters	Initial loss (mm)	Cont. loss (mm/h)
	15.00	2.50

Peak	Description
01	Calculated hydrograph, Flow at P1
02	Special storage : RB3 - Outflow
03	Special storage : RB3 - Inflow
04	Special storage : RB2 - Outflow
05	Special storage : RB2 - Inflow
06	Calculated hydrograph, Flow at N1
07	Special storage : RB4 - Outflow
08	Special storage : RB4 - Inflow
09	Calculated hydrograph, Flow at Horseshoe Bend rd
10	Calculated hydrograph, Flow AE1
11	Calculated hydrograph, Flow at AA1
12	Calculated hydrograph, The Sands Outlet

Run	Dur	ARI	Rain(mm)	ARF	Peak0001	Peak0002	Peak0003	Peak0004	Peak0005	Peak0006	Peak0007	Peak0008	Peak0009	Peak0010	Peak0011	Peak0012
1	10m	100y	20.76	1.00	1.8244	0.3498	2.3262	0.4004	4.3909	1.5082	0.1967	1.5082	0.8128	1.6464	6.7639	5.5915
2	15m	100y	25.13	1.00	2.2341	0.5403	2.9414	0.6135	5.7317	2.1326	0.3328	2.1326	1.2730	2.1145	7.3700	7.6534
3	20m	100y	28.44	1.00	2.4713	0.6925	3.3748	0.7864	6.3084	2.5911	0.4435	2.5911	1.6539	2.3100	6.9344	7.9540
4	25m	100y	31.12	1.00	2.5232	0.7478	3.5771	0.8871	6.7344	2.9513	0.5375	2.9513	1.9047	2.2948	6.5826	9.0308
5	30m	100y	33.35	1.00	2.3105	0.7954	3.6386	0.9689	6.3928	3.2561	0.6185	3.2561	2.0960	2.1397	6.0390	8.5295
6	45m	100y	38.46	1.00	2.3282	0.8908	3.8584	1.1005	6.4739	3.9743	0.7463	3.9743	2.5229	2.0446	6.0558	8.0537
7	1h	100y	42.23	1.00	2.5506	0.9489	4.0181	1.1736	7.1117	4.3039	0.8135	4.3039	2.7358	2.2941	5.7663	9.3185
8	1.5h	100y	47.92	1.00	2.6526	1.0092	3.8745	1.2389	6.8850	4.3036	0.8889	4.3036	2.9834	2.3408	5.8979	9.0121
9	2h	100y	52.21	1.00	2.6383	1.0412	4.0149	1.2717	7.2959	4.3241	0.9407	4.3241	3.1360	2.3497	6.4073	9.6306
10	3h	100y	58.72	1.00	1.7361	1.0450	2.8479	1.2747	4.8517	3.7641	0.9878	3.7641	3.2232	1.4336	5.1500	8.6640
11	4.5h	100y	65.95	1.00	1.8727	1.0225	3.0222	1.2414	4.9616	3.5081	1.0149	3.5081	3.2065	1.4510	4.9100	8.5098
12	6h	100y	71.64	1.00	1.5338	1.0195	2.7031	1.2388	3.9978	3.5544	1.0274	3.5544	3.2178	1.0253	4.8711	8.5477
13	9h	100y	80.56	1.00	1.4318	1.0729	2.4471	1.3304	3.4585	3.4620	1.0837	3.4620	3.4056	0.9122	5.5186	9.4561
14	12h	100y	87.59	1.00	1.2140	0.9750	1.9906	1.2193	2.8652	3.0756	1.0769	3.0756	3.2207	0.7986	4.7039	8.9334
15	18h	100y	100.75	1.00	0.7419	0.8818	1.2478	1.1002	1.7154	2.0913	1.0197	2.0913	2.9399	0.4879	3.9900	7.6248
16	24h	100y	111.00	1.00	0.8543	0.9245	1.5007	1.1474	1.9577	2.4890	0.9682	2.4890	2.9884	0.5041	4.3857	7.8189
17	30h	100y	119.33	1.00	0.5935	0.7966	0.9836	1.0243	1.4044	1.6730	0.9446	1.6730	2.7069	0.3898	3.4080	6.6217
18	36h	100y	126.26	1.00	0.5738	0.7994	1.0182	1.0188	1.2961	1.7593	0.9547	1.7593	2.7279	0.3452	3.5528	6.7568
19	48h	100y	137.07	1.00	0.7004	0.8173	1.1989	1.0327	1.6597	1.7564	0.9268	1.7564	2.7764	0.4364	3.3323	6.5545
20	72h	100y	150.75	1.00	0.3795	0.4962	0.6268	0.6226	0.8835	0.8870	0.6839	0.8870	1.7883	0.2434	1.9589	4.0747

Elapsed Run Time (hh:mm:ss) = 00:00:03

Appendix E

Stormwater Master Plan

This plan should be read in conjunction with the latest revision of the Reports entitled "Stormwater Master Plan –Torquay North: Technical Report (Document Number 31\26765\187528) and "Stormwater Master Plan – Torquay North: Master Plan Guidelines (Document Number 31\26765\188692) and is subject to the assumptions and qualifications therein.

RETARDING BASIN & WETLAND KEY DETAILS

	Northern Catchment						Deep Ck Catchment
	Horseshoe Bend Road Development North Wetland	Horseshoe Bend Road Development South Wetland	Southern Development RB & Wetland	South Beach Road Development East RB & Wetland	South Beach Road Development North Wetland	South Beach Road Development West RB & Wetland	Surf Coast Highway Development RB & Wetland
RB Required Volume (m^3)	n/a	n/a	19,840	12,800	n/a	22,240	39,720
RB Plan Area (m^2)	n/a	n/a	11,150	7,570	n/a	12,280	22,560
RB Outlet Arrangement	n/a	n/a	1 X 675 mm diameter pipe	1 x 600 mm diameter pipe	n/a	1 x 600 mm diameter pipe	1,200 mm diameter pipe and 1,350 mm diameter pipe
Wetland Plan Area (m^2)	2,841	1,333	5,000	2,024	1,667	3,333	6,300

SURF COAST SHIRE

STORMWATER MASTERPLAN FOR TORQUAY NORTH

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