Table 3-7: Pollutant Load Reductions for Treatment Train 2

Parameter	A Post-Development Results (without treatment controls)	B Post-Development Results (with treatment controls)	% Reduction ((A-B)/A)*100	Target % Reduction
Flow (ML/yr)	14.6	11.4	21.6	
TSS (kg/yr)	3060	229	92.5	85
TP (kg/yr)	5.67	1.41	75.1	65
TN (kg/yr)	33.2	18.1	45.4	45
Gross Pollutants	347	0	100	

Table 3-8: Pollutant Load Reductions for Treatment Train 3

Parameter	A Post-Development Results (without treatment controls)	B Post-Development Results (with treatment controls)	% Reduction ((A-B)/A)*100	Target % Reduction
Flow (ML/yr)	14.6	8.2	43.8	
TSS (kg/yr)	3060	453	85.2	85
TP (kg/yr)	5.67	1.14	79.8	65
TN (kg/yr)	33.2	12.4	62.5	45
Gross Pollutants	347	0	100	

Table 3-9: Pollutant Load Reductions for Treatment Train 4

Parameter	A Post-Development Results (without treatment controls)	B Post-Development Results (with treatment controls)	% Reduction ((A-B)/A)*100	Target % Reduction
Flow (ML/yr)	14.6	9.93	31.9	
TSS (kg/yr)	3060	295	90.3	85
TP (kg/yr)	5.67	1.47	74.1	65
TN (kg/yr)	33.2	18	45.9	45
Gross Pollutants	347	0	100	

3.4.2. Water quality strategy

3.4.2.1. Indicative layout

Using the results of modelling and in recognition of Council's preference for low maintenance, a water strategy has been devised. It includes indicative locations for Gross Pollutant Traps and bioretention systems (Figure 3-5), as well as the five existing GPTs on the eastern boundary of the study area. Note that locations for bioretention are generally intended to be end-of–line devices that will have some form of pre-treatment such as a sediment/litter forebay or GPT. Bioretention has been applied on a sub catchment basis to provide the modelled requirement of 46m^2/Ha of new development.

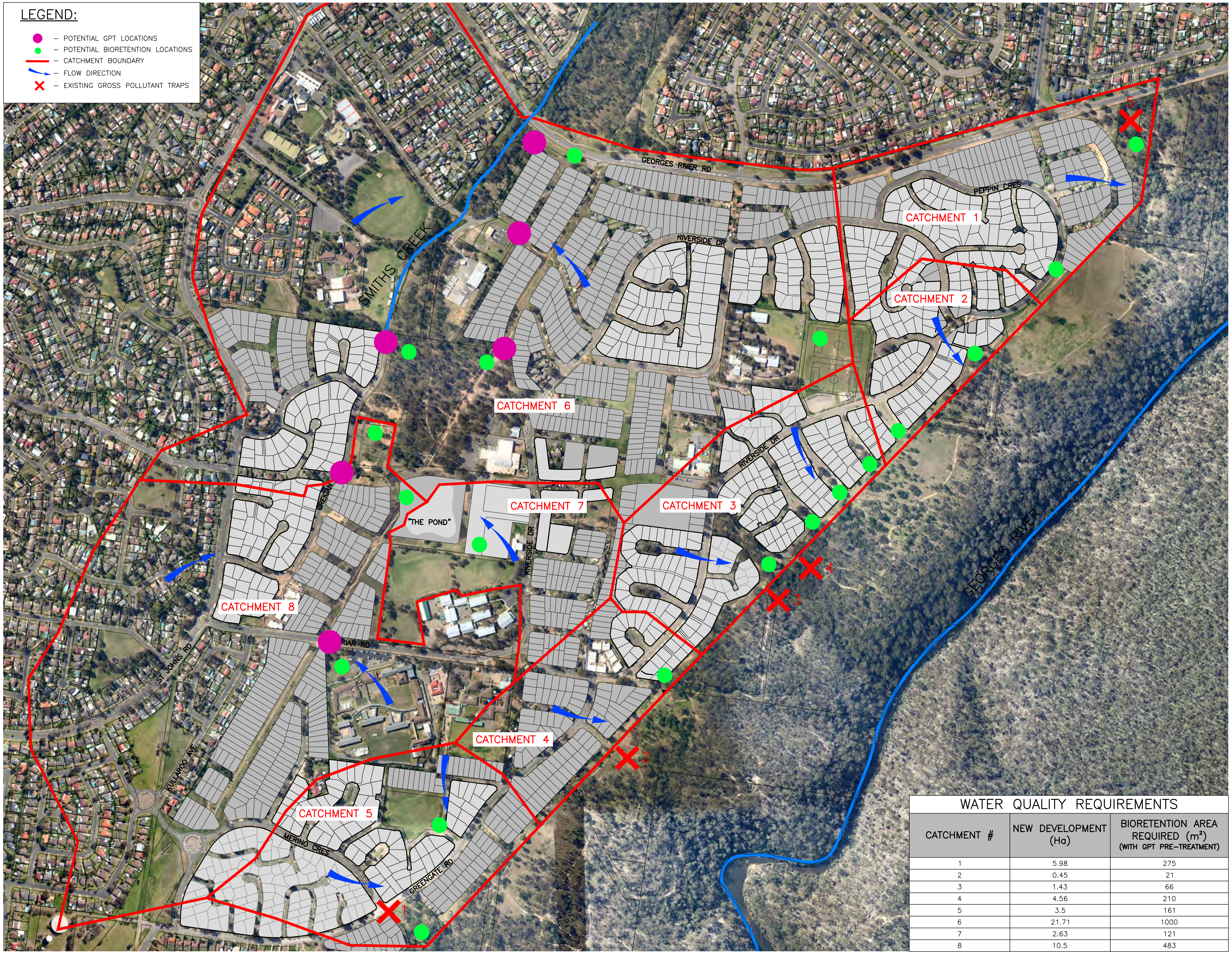
In relation to the five existing GPTs on the eastern boundary of the study area, some of these have poor access which means they need to be cleaned manually. Devices numbered 1, 3 and 4 on Figure 3-5 need to have access tracks and maintenance pads provided to facilitate maintenance and GPT performance.

3.4.2.2. Best Planning Practices for water quality

Best Planning Practices relates to non-structural means of improving or maintaining water quality. This can take the form of pollution prevention or at source pollution controls.

Pollution prevention is generally achieved through educational/consultation and regulatory measures. The State Government runs pollution education campaigns and Councils can tap into and build on these to promote localised messages, including the potential for community participation in monitoring and managing certain pollution control infrastructure. Council officers tasked with an enforcement role can issue fines for littering and pollution.

At source pollution control typically includes street sweeping to prevent pollutants being washed into the drainage system



WATER QUALITY REQUIREMENTS		
CATCHMENT #	NEW DEVELOPMENT (Ha)	BIORETENTION AREA REQUIRED (m²) (WITH GPT PRE-TREATMENT)
1	5.98	275
2	0.45	21
3	1.43	66
4	4.56	210
5	3.5	161
6	21.71	1000
7	2.63	121
8	10.5	483

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WATER QUALITY STRATEGY - INDICATIVE LAYOUT

Date 11.03.10

Figure 3-5

3.5. Stormwater Harvesting

Beyond the consideration of rainwater tanks for individual lots, initial investigations into potential precinct scale stormwater harvesting and reuse opportunities have been undertaken. A preliminary water balance has been prepared to highlight indicative harvesting potential based on varying catchment areas, irrigable areas and storage sizes.

Irrigation of the two proposed playing fields within the Smiths Creek Catchment, provide the greatest potential stormwater harvesting opportunity. There is a significant contributing catchment to this location which would provide high reliability of supply (refer **Figure 3-6**).

The other proposed playing fields within the development are at Riley Park. Stormwater harvesting at this location is unlikely to be feasible as it is located at the upper extents of a catchment (i.e. on a ridge). With a limited catchment, there would be very low reliability of supply from stormwater harvesting unless significant pumping from further down in the catchment was used.

There are possibly other opportunities for stormwater harvesting in this area, such as for the playing field within Airds High School, however, these have not been included within the scope of this study.

3.5.1. Water Balance Model

A water balance model was developed for the new playing fields within the Smiths Creek Bypass Corridor. The catchment area to this location was estimated to be 10.1 Ha.

The following assumptions were used:

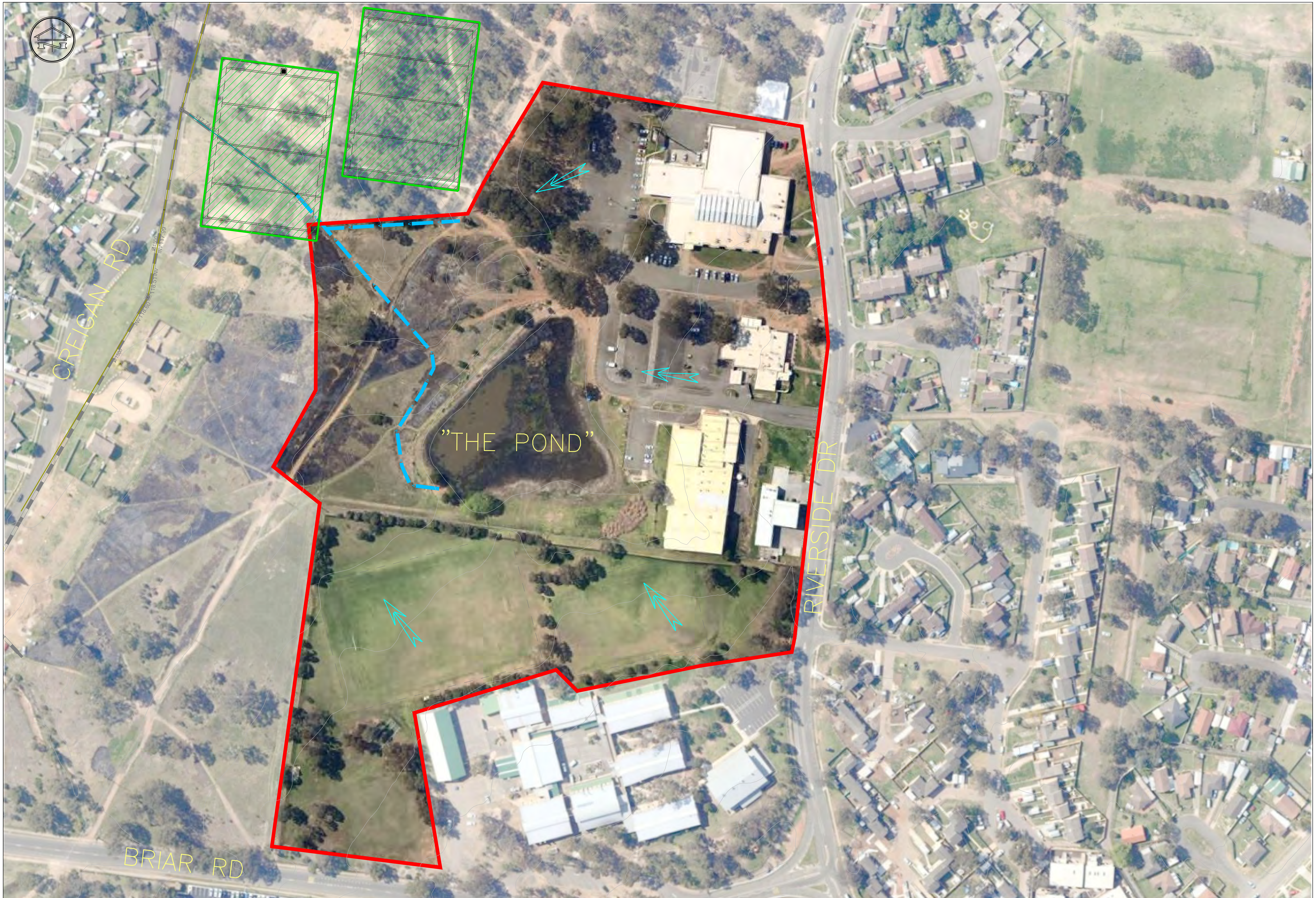
- Rainfall data from Campbelltown (BOM station no. 68257) between 2006 and 2009 was used for this analysis;
- 70% impervious area (includes roads/pavements/roof areas – typical for a suburban area);
- 2mm initial loss from surface areas;
- Irrigation demand = 3.5 ML/yr/Ha (based on previous STORM experience for irrigation of Council sporting fields); and
- Total irrigable area = 1 Ha.

The modelling results and assumptions are considered to be conservative (pervious areas have not been included in the runoff model) and are subject to further detailed modelling following the finalisation of sporting field and storage configurations.

3.5.2. Treatment process

The following treatment process has been successfully applied to other stormwater harvesting projects in Sydney.

Gross pollutant trap – Sand filter – Storage - UV disinfection - Irrigation



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STORMWATER HARVESTING CATCHMENT

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Figure 3-6

In **Figure 3-7,** the optimal tank size is represented by the point where an increase in tank size delivers a diminishing return in tank yield. The results of the sensitivity analysis indicate that a tank size of 400-500kL is appropriate. A 500 kL tank would supply approximately 3.41 ML/yr (a yield of 98%).

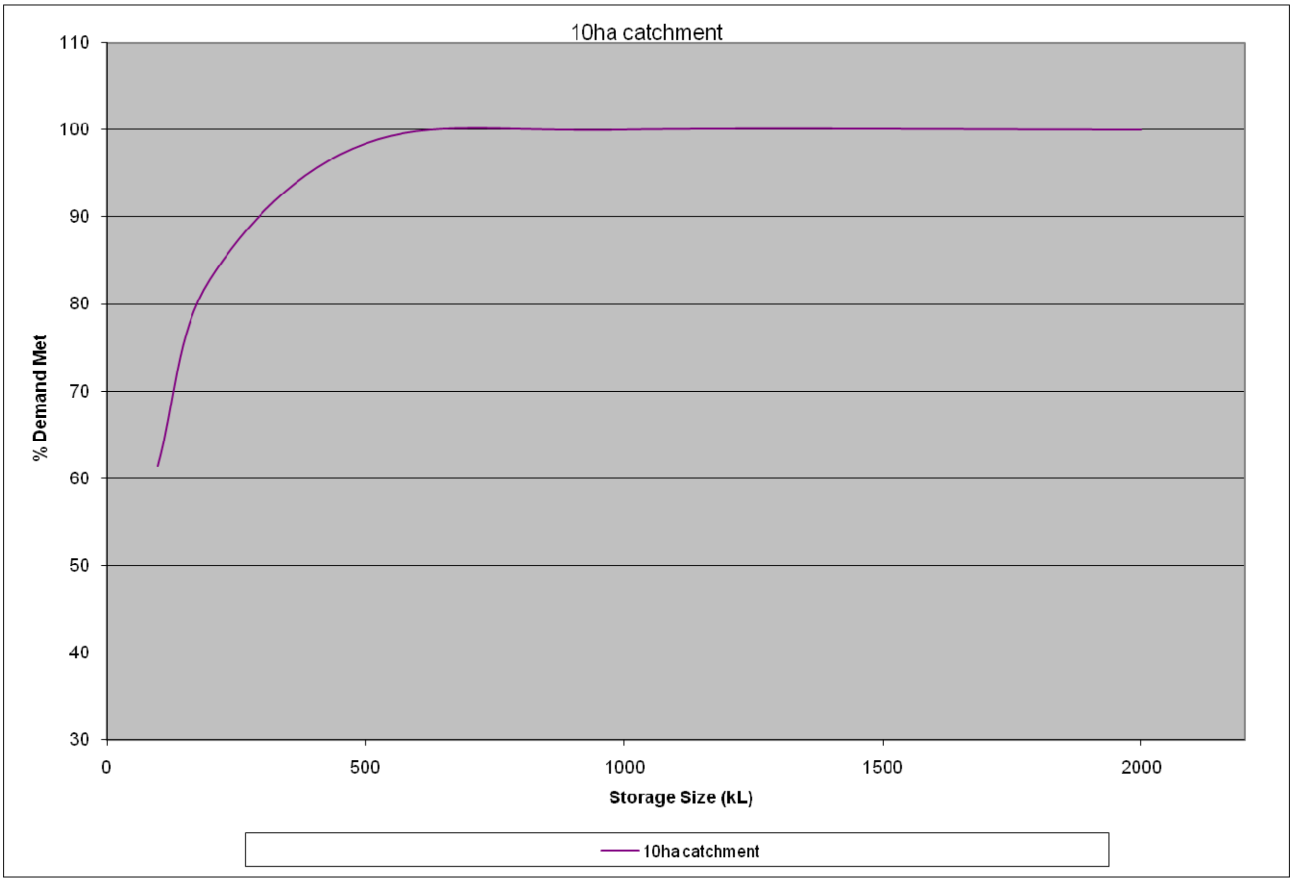

Figure 3-7: Stormwater Harvesting Yield Analysis Results

Tank configurations may include below ground storage tanks (e.g. underground concrete storage tank, modular cells) or above ground configurations (pending space availability). 'The Pond' could also potentially be incorporated as storage within the proposed scheme; however, this would make it subject to significant water level fluctuations which may impact on visual amenity and plant health.

3.5.3. Stormwater harvesting scheme operation

Council would operate and maintain any stormwater harvesting scheme. This would include the maintenance of water quality by cleaning out screening/treatment devices, cleaning UV disinfection unit, maintaining pumps and associated fixtures and fittings, maintaining the irrigation system. Real-time water quality monitoring would be required supported by system telemetry. Other water quality monitoring would be required to report on the presence of pathogens. Many Councils across Sydney have installed and now operate stormwater harvesting schemes for playing field irrigation, with examples shown in Figure 3-8.

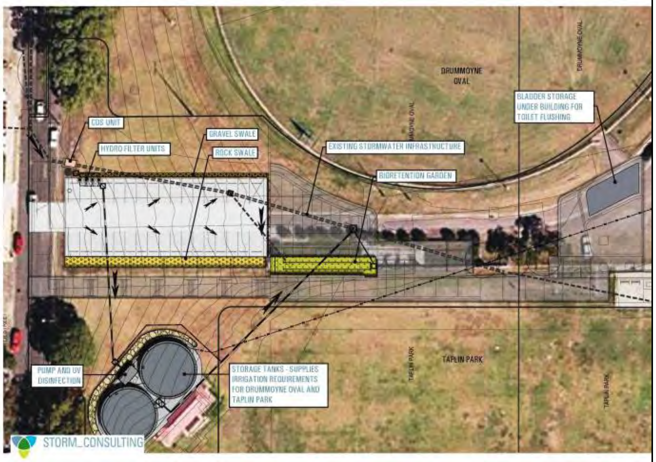

Figure 3-8: Example stormwater harvesting schemes in Sydney

3.5.4. Benefits of stormwater harvesting

The most obvious benefit of stormwater harvesting is associated with the substitution of potable water. This provides a cost benefit as well as a broad sustainability benefit.

The abstraction of stormwater in the context of the development would provide a dual benefit of reducing peak flows, and improving water quality. However, note that these benefits have not been reported in any of the water quality or quantity modelling undertaken in this study.

3.6. Stream and riparian restoration/rehabilitation

The riparian corridor of Smiths Creek is degraded by the presence of weeds, and from active erosion occurring from the stormwater outlet at the northern end of Creigan Road.

The eroding channel needs to be rehabilitated by employing the Natural Channel Design Guidelines (Brisbane City Council, 2003). Combinations of rock armouring balanced with vegetation will stabilise the stream.

The weeds in the corridor need to be removed, commencing with noxious weeds and followed by environmental weeds. A revegetation plan will allow for the introduction of enhanced biodiversity, however, this must not increase the stream roughness above acceptable levels for flooding.

3.7. Maintenance requirements

The maintenance requirements for the water cycle elements selected are shown indicatively in Table 3-10.

Table 3-10: Indicative maintenance requirements for water cycle elements

Item	Maintenance tasks	Frequency
Culverts, pipes, pits	Remove obstructions and blockages	As required after major rain events, based on inspection
GPTs (existing and proposed)	Remove accumulated materials	Quarterly
Bioretention devices	Remove accumulated materials from sediment forebay Remove weeds Replace filter media	Bi-annually Annually Every 10-15 years
Riparian corridor	Weed removal	Annually
The Pond	Litter, Sediment, Weed removal	Annually
Stormwater harvesting	Pre-treatment GPT Treatment filter UV disinfection Pumps Monitoring	Quarterly Monthly Quarterly Annually Quarterly

4.0 FLOODING

4.1. Background and Context

There are two main catchments within the study area; Smiths Creek and Georges River (Appendix B). A ridge line runs approximately north east to south west, dividing the study area into these two sub-catchments. Areas to the west of the ridge drain to Smiths Creek and to the east they drain to Georges River.

Georges River flows to the north east and ultimately discharges to Botany Bay. Smiths Creek is a tributary of Bow Bowing Creek, joining approximately 4 km downstream of Georges River Road, before meeting Georges River approximately 20 km downstream at Glenfield.

The majority of the new development is in the Smiths Creek catchment (Appendix B). Only minor new development is proposed for the Georges River (eastern) catchments, with associated runoff increases expected to be relatively insignificant. Therefore, detention modelling has only been performed for the Smiths Creek catchment.

The Smiths Creek trunk drainage system is divided into two sections. A piped drainage network following Kullaroo Avenue and Creigan Road conveys flows from the upper areas of the catchment. The piped drainage network then discharges into Smiths Creek at the northern end of Creigan Road where flows are conveyed in the creek, along with additional flows from local catchments, to the downstream boundary of the study area at Georges River Road.

A number of assessments have been undertaken in relation to flooding for this study. These include:

- Creigan Road drainage capacity assessment;
- Smiths Creek detention and floodplain assessment; and
- Overland flow assessment.

4.2. Creigan Road Drainage Capacity Assessment

DRAINS modelling software was used to assess the capacity of the existing trunk drainage system in Kullaroo Avenue and Creigan Road.

4.2.1. Model Inputs

The ILSAX hydrologic model was used within DRAINS. The main parameters for this model are:

- IFD data was obtained from the Bureau of Meteorology (BoM) for Airds. 5 year, 20 year and 100 year ARI storm events for durations of 10 minutes to 3 hours were extracted.
- Catchment areas were derived from contours, pipe network information and a visual assessment during the site inspection. The total catchment areas are 77.3 Ha to the northern end of Creigan Road and an additional 106.5 Ha to Georges River Road, giving a total catchment area of 183.8 Ha.
- Percentage Impervious was estimated for each sub-catchment from aerial photographs. The overall percent impervious was 55% which reflects the current low density of development and significant open space areas.
- Depression Storage: typical values for urban areas were used, 1 mm for pervious surfaces and 5 mm for impervious surfaces.

- Soil Type: a value of 3 was applied, which corresponds to soils with limited infiltration capacity. Soils in urban areas are often compacted and therefore have limited infiltration capacity. This value can also represent high antecedent moisture conditions.

For the hydraulic model component of DRAINS, the pipe network in Creigan Road and Kullaroo Avenue was built from survey information. The survey included pit inverts, lid/grate levels, pipe inverts and pipe sizes.

4.2.2. Results

Campbelltown City Council's standard for piped drainage network design is to provide capacity for the 5 year ARI event. The modelling showed that the trunk drainage network in Creigan Road and Kullaroo Avenue currently has insufficient capacity to convey this flow.

An existing area of concern is at the southern extents of the pipe drainage network. An overland flow path conveys flows to the rear of 34 Kullaroo Avenue where a number of pits collect the minor system flows which are then conveyed in the piped drainage system to Kullaroo Avenue. However, there is limited, if any, overland flow capacity in this location leading to a high risk of flooding.

Any new development or redevelopment in this area should consider rectification of this situation by providing appropriate overland flow path capacity, or, at a minimum, providing pit inlet and pipe capacity for the 100 year ARI event. Impacts on the system downstream would also need to be considered.

Model outputs are included in Appendix C.

4.3. Smiths Creek Detention and Floodplain Assessment

4.3.1. Existing Land use

- The Smiths Creek catchment was divided into 3 sub catchments (6, 7 and 8) within the site derived from contour mapping.
- Catchments 6 and 7 extend to the northern end of Creigan Road, while Catchment 8 includes those areas either side of Smiths Creek.
- Catchment areas, land use and impervious % are presented in Table 4-1 below.
- Existing land use within each catchment was estimated for each sub catchment from aerial photographs and categorised as residential or green space.
- The total residential area is 125.6 Ha and the total green space areas are 58.5 Ha.
- Green space, residential and high density residential areas were assigned impervious percents of 0%, 80% respectively.
- The total impervious area was calculated to be 100.45 Ha and the total pervious area within the site was calculated as 83.36 Ha.
- The overall area of the site that is classified as impervious is 55% and reflects the current medium density land use with significant open space areas.

Table 4-1: Existing Land use and % Imperviousness

Catchment No.	Land Use	Area (ha)	% Impervious	Total Impervious Area (ha)	Total Pervious Area (ha)	Total Impervious Area (%)
6	Residential	69.46	80	55.57	50.89	52
	Green Space	37	0			
7	Residential	8.77	80	7.02	7.08	50
	Green Space	5.33	0			
8	Residential	47.33	80	37.87	25.38	60
	Green Space	15.92	0			
TOTAL		**183.81**		**100.45**	**83.36**	**55**

4.3.2. Post Development Land use

- Post development land use within each catchment was estimated for each sub catchment based on the proposed concept plan (Appendix A).
- Within the site areas of high density development is proposed. High density development is characterised as those lots with an area of less than 400 m^2 and totals approximately 18.2 Ha.
- Normal residential and green space land use areas were assigned an impervious percent of 80% and 0% consistent with pre development rates. Land use categorised as high density was assigned an impervious percent of 90%.
- The overall area of the site that is classified as impervious is 66% and reflects higher density development than pre-development.
- The total impervious area was calculated as 121.92 Ha and the total pervious area within the site was calculated as 61.89 Ha (Table 4-2).These numbers indicate that there is an overall increase in pervious area post development by approximately 22 Ha.

Table 4-2: Post Development Land use and % Imperviousness

Catchment No.	Land Use	Area (ha)	% Impervious	Total Impervious Area (ha)	Total Pervious Area (ha)	Total Impervious Area (%)
6	Residential	73.11	80	68.61	37.85	64
	High Density Residential	11.25	90			
	Green Space	22.10	0			
7	Residential	6.98	80	7.51	6.59	53
	High Density Residential	2.14	90			
	Green Space	4.98	0			
8	Residential	51.85	80	45.80	17.45	72
	High Density Residential	4.80	90			
	Green Space	6.60	0			
TOTAL		**183.81**		**121.92**	**61.89**	**66**

4.3.3. XP RAFTS Modelling

An XP-RAFTS hydrologic model was used to calculate pre-development and post-development runoff hydrographs.

Only minor new development is proposed for the Georges River (eastern) catchments and these have therefore not been included in the calculations. The majority of the new development is in the Smiths Creek catchment (Catchments 6, 7, and 8) and this has therefore been the focus of detention modelling.

Detention was calculated in accordance with Council's DCP which requires a full range of storm durations and frequencies to be analysed.

- Within the model the pervious and impervious areas were modelled as separate sub catchments.
- Pervious and impervious areas were assigned a Mannings's n roughness values of 0.025 and 0.015 respectively.
- A catchment slope of 3% was used across each sub catchment.
- Impervious areas were assigned an initial rainfall loss of 1.5 mm with no continuing loss. Pervious areas were assigned an initial rainfall loss of 15 mm with an absolute rainfall loss of 2.5 mm/hr.
- Manning's n roughness values of 0.05 for Smith Creek channel was selected to represent the dense vegetation present here. A Manning's n value of 0.045 was selected for the overbank area to represent mixed grass and dense vegetation cover.
- Rainfall intensities (IFD Data) were obtained from Appendix B of Council's DCP (Volume 2 : Engineering Design for Development, 2009);
- The XP RAFTS model was run for the 2, 5, 20, 50 and 100 yr ARI storm events.

- A range of storm durations were run in the model and the 90min storm duration was found to be the critical event.
- Peak flow rates at Smiths Creek just upstream of Georges River Rd crossing are presented in Table 4-3 below.

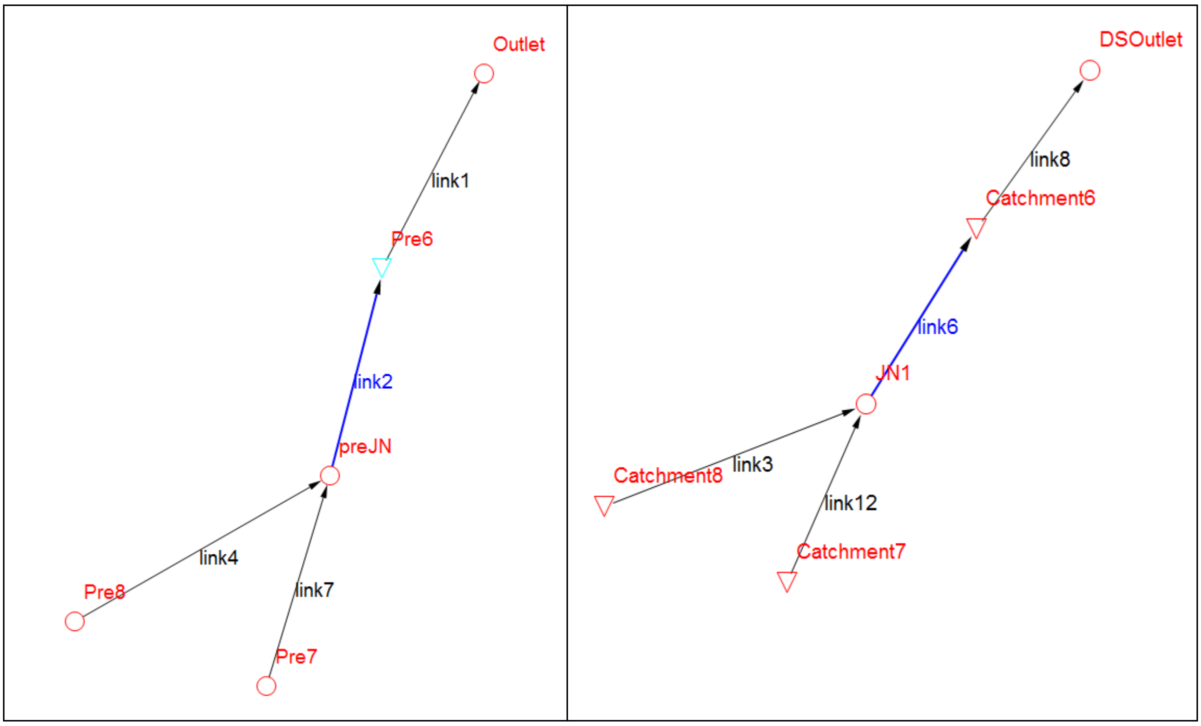

Figure 4-1: XP Rafts Pre (LHS) and Post Development Catchment Model

Table 4-3: Peak Flow at Smiths Creek upstream of Georges River Road Crossing

ARI Storm Event (yr)	Duration (Min)	Peak Flow (m3/sec)	
		Existing Conditions	Post Development
2	60	24.27	29.49
	90*	26.05	31.41
	120	23.66	28.52
5	60	32.63	40.04
	90*	36.56	43.08
	120	31.96	39.22
20	60	44.83	53.1
	90*	49.29	57.6
	120	44.34	52.61
50	60	49.82	53.15
	90*	56.45	65.024
	120	51.07	59.68
100	60	56.98	66.204
	90*	62.6	71.81
	120	56.33	65.59

*Peak flows for each ARI event.

4.3.4. XP STORM Modelling

- Pre-development and post-development models were created using XP Storm software to determine flow rates under Georges River Road crossing and the extent of flooding within Smiths Creek.
- The XP Storm model was selected because it takes into consideration stormwater storage and changes in flow rates. The HecRAS model was not selected because it assumes a constant flow rate and does not take into account changes related to storage. XP RAFTS was not used because of its limited capacity to model multiple culverts of different dimensions and levels, as are present.

XP Storm - Existing Conditions

- Existing culvert dimensions and Georges River Rd crossing levels (Table 4-5) were input in the pre-development model.
- Stage to storage relationships were determined from the Digital Terrain Model (DTM) which was built using AutoCAD from detailed topographic survey of the creek.
- Stage-Storage values were input into the XP Storm model to replicate storage within Smiths Creek upstream of Georges River Rd (Table 4-4).
- Pre-development peak flow hydrographs generated in the XP RAFTS model within Smiths Creek adjacent to Georges River Road Crossing were imported into the XP Storm model.
- The pre-development model was run for the 2, 5, 20, 50 and 100 yr ARI event and the top levels within Smiths Creek and peak flow rates under Georges River Rd crossing determined (Table 4-5).
- The pre-development results indicate a 100 yr top water level of 111.39m AHD, which is approximately 2.18 m below Georges River Rd crossing and adjacent residential lot levels.

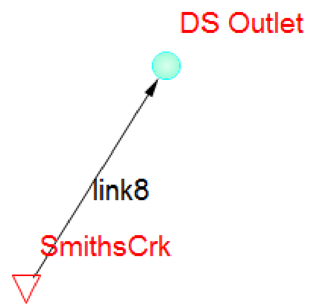

Figure 4-2: XP Storm Pre- and Post-Development Smiths Creek Retention Model

Table 4-4: Smiths Creek Stage - Storage Relationship

Elevation	Depth	Area	Volume
m AHD	m	m2	m3
107.25	0	2.9	0
107.75	0.5	35.11	8
108.25	1	168	55
108.75	1.5	416	196
109.25	2	736	480
109.75	2.5	1126.98	943
110.25	3	1581.62	1617
110.75	3.5	2052.54	2522
111.25	4	2679.09	3702
111.75	4.5	3512.97	5245
112.25	5	4637.35	7276
112.75	5.5	6296.33	9999
113.25	6	8966.24	13795
113.75	6.5	13478.55	19368

Table 4-5: Existing Flow Conditions at Georges River Road Crossing, Smiths Creek

Peak Flow Rate (m^3/sec)						
Culvert Type	Dimensions (m)	2 yr ARI	5 yr ARI	20 yr ARI	50 yr ARI	100 yr ARI
Circular	0.85	4.58	4.86	5.24	5.33	5.4
Box	2.14 x 2.5	20.16	29.14	40.34	46.96	53.32
Over Road		0	0	0	0	0
Total Flow		24.74	34	45.58	52.29	58.72
Top Water Level (m AHD)		109.98	110.43	111.02	111.22	111.39

XP Storm – Post-development

- Post-development peak flow hydrographs generated in the XP RAFTS models within Smiths Creek adjacent to Georges River Road Crossing for each ARI event were imported into the XP Storm model.
- Post-development peak flow hydrographs had higher peak flows associated with higher impervious areas post development.
- To ensure that peak discharge from the site does not increase, the existing culverts under Georges River Rd were reduced in size (Figure 4-3, Table 4-7).
- The post-development model was run for each ARI event and the top levels within Smiths Creek and peak flow rates under Georges River Rd crossing determined (Figure 4-3, Table 4-7).
- The results show that post-development peak flows in the 2 and 5 yr ARI events are slightly less than pre-development; and peak flows in the 20, 50 and 100 yr ARI events are considerably less than pre development (Figure 4-3, Table 4-7).
- The top water level within Smiths Creek post-development is greater than in the pre-development scenario. This can be attributed to higher impervious areas and reduction in culvert size in the post-development scenario.
- The post-development model estimates a 100 year top water of approximately 113.68 m AHD. This level is slightly higher than the lowest point on Georges River Rd Crossing of 113.57 m AHD.
- Further post-development modelling was performed with a built up minimum road level of 113.7 m AHD. The results indicate that in this scenario there will be no flow over Georges River Rd and no further rise in the flood level.
- The post-development 100 yr flood extent is shown in Figure 3-1. The post-development flood level of 113.7 m AHD is generally lower than adjacent residential lots except for one property. This property can be afforded protection by the construction of a wall 0.2m high along the allotment boundary (Figure 3-1).

Table 4-6: Post Development Conditions at Georges River Road Crossing, Smiths Creek

Peak Flow Rate (m^3/sec)						
Culvert Type	Dimensions (m)	2 yr ARI	5 yr ARI	20 yr ARI	50 yr ARI	100 yr ARI
Circular	0.75	4.23	4.63	5.06	5.24	5.4
Box	1.45 x 1.45	20.21	24.77	29.11	30.82	32.31
Over Road		0	0	0	0	0
Total Flow		24.44	29.4	34.17	36.06	37.71
Top Water Level (m AHD)		111.34	112.11	112.96	113.34	113.68

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FLOOD EXTENTS - POST DEV 100YR ARI

Date 11.03.11

Figure 4-3

Table 4-7: Existing vs. Post-Development Flow Rates and water levels at Georges River Road Crossing, Smiths Creek

	Peak Flow Rate (m^3/sec)				
	2 yr ARI	5 yr ARI	20 yr ARI	50 yr ARI	100 yr ARI
Existing (Pre-development) Conditions	24.74	34	45.58	52.29	58.72
Post-development	24.44	29.4	34.17	36.06	37.71
Reduction in Flow Post-Development	0.3	4.6	11.41	16.23	21.01
Increase in water level post – pre-development (m)	1.36	1.68	1.94	2.12	2.29

4.3.5. Summary of Key Findings

- Currently the 100 yr ARI storm is contained within Smiths Creek and with no flooding over Georges River Rd crossing or within residential lots.
- If the culverts under Georges River Rd crossing are reduced in size post-development the pre-development 2 and 5 yr flow rates can be maintained, however this will cause a reduction in the 20, 50 and 100 yr ARI events peak flow rates.
- Smiths Creek currently has the capacity to detain up to the 50 yr ARI event in the post-development scenario without flooding of adjacent residential lots or Georges River Rd crossing.
- If a barrier/wall is installed above Georges River Road, or alternatively if Georges River Road is built up to a minimum of 113.7m AHD, the post development 100 yr ARI event can be detained within Smiths Creek corridor without flooding of Georges River Road.
- Raising of Georges River Rd crossing to 113.7m AHD may cause very minor flooding of a lot boundary in the 100 yr storm (Figure 3-1). Placement of a 0.2m high wall along the allotment boundary will avert flooding of this property in the 100 yr storm event.

4.4. Overland Flow Assessment

A basic hydraulic assessment of the main drainage corridors was undertaken, to ensure that overland flow for the 100 year ARI event can drain freely and safely through the site.

Within the Smiths Creek catchment the existing drainage corridors were assessed as to their capacity to safely convey post development peak flows during the 100 year ARI storm event.

Areas along the eastern boundary of the site which drain directly to Georges River will require overland flow paths to be defined. Basic hydraulic modelling was undertaken for these areas in order to define the required flow path dimensions.

4.4.1. Modelling

XP-RAFTS was used to generate the runoff hydrographs for the Smiths Creek and Georges River catchments for the 100 year ARI storm. The output hydrographs were subsequently fed as inputs into a basic hydraulic model constructed in DRAINS. The hydraulic model was utilised to simulate routing of catchment runoff through the existing drainage corridors.

Survey and GIS data supplied was used as the basis for these models. Limited information for the existing and proposed drainage network was supplied; as such no piped flow has been accounted for in the assessment of overland flow paths 1 to 12 and 15 to 17 as delineated in Figure 4-4.

4.4.2. Results and Discussion

In determining the overland capacity, risk to pedestrians or vehicles is calculated by multiplying the depth of flow by velocity as summarised in Table 4-8. Our adopted criteria for overland flow path capacity is a maximum flow depth of 0.2m and a maximum velocity/depth product of 0.4m^2/s.

Table 4-8: Overland flow path assessment

OVERLAND FLOW PATHS (Georges River Catchment)						
Overland Flow Path ID	Base Width Required (m)	Batter Slopes	Road Width (m)	Max Depth (m)	Max VxD (m2/s)	Comments
OF1**	-	-	14	0.302	1.02	Further hydraulic assessment required
OF2*	7	1in6	-	< 0.2	< 0.4	Sufficient Capacity
OF3*	16	1in6	-	< 0.2	< 0.4	Sufficient Capacity
OF4*	0.75	1in6	-	< 0.2	< 0.4	Sufficient Capacity
OF5*	2.5	1in6	-	< 0.2	< 0.4	Sufficient Capacity
OF6*	5.5	1in6	-	< 0.2	< 0.4	Sufficient Capacity
OF7*	4.5	1in6	-	< 0.2	< 0.4	Sufficient Capacity
OF8*	22	1in6	-	< 0.2	< 0.4	Sufficient Capacity
OF9*	8	1in6	-	< 0.2	< 0.4	Sufficient Capacity
OF10**	-	-	14	0.25	0.66	Further hydraulic assessment required
OF11**	-	-	14	< 0.2	< 0.4	Sufficient Capacity
OF12*	40	1in6	-	< 0.2	< 0.4	Sufficient Capacity
OF13**	-	-	18	1	0.62	Further hydraulic assessment required
OF14**	-	-	18	1.2	0.88	Further hydraulic assessment required
OF15**	-	-	10	0.9	0.5	Further hydraulic assessment required
OF16**	-	-	14	1.14	0.81	Further hydraulic assessment required
OF17**	-	-	14	0.91	0.51	Further hydraulic assessment required

*Proposed drainage corridors **Existing drainage corridors

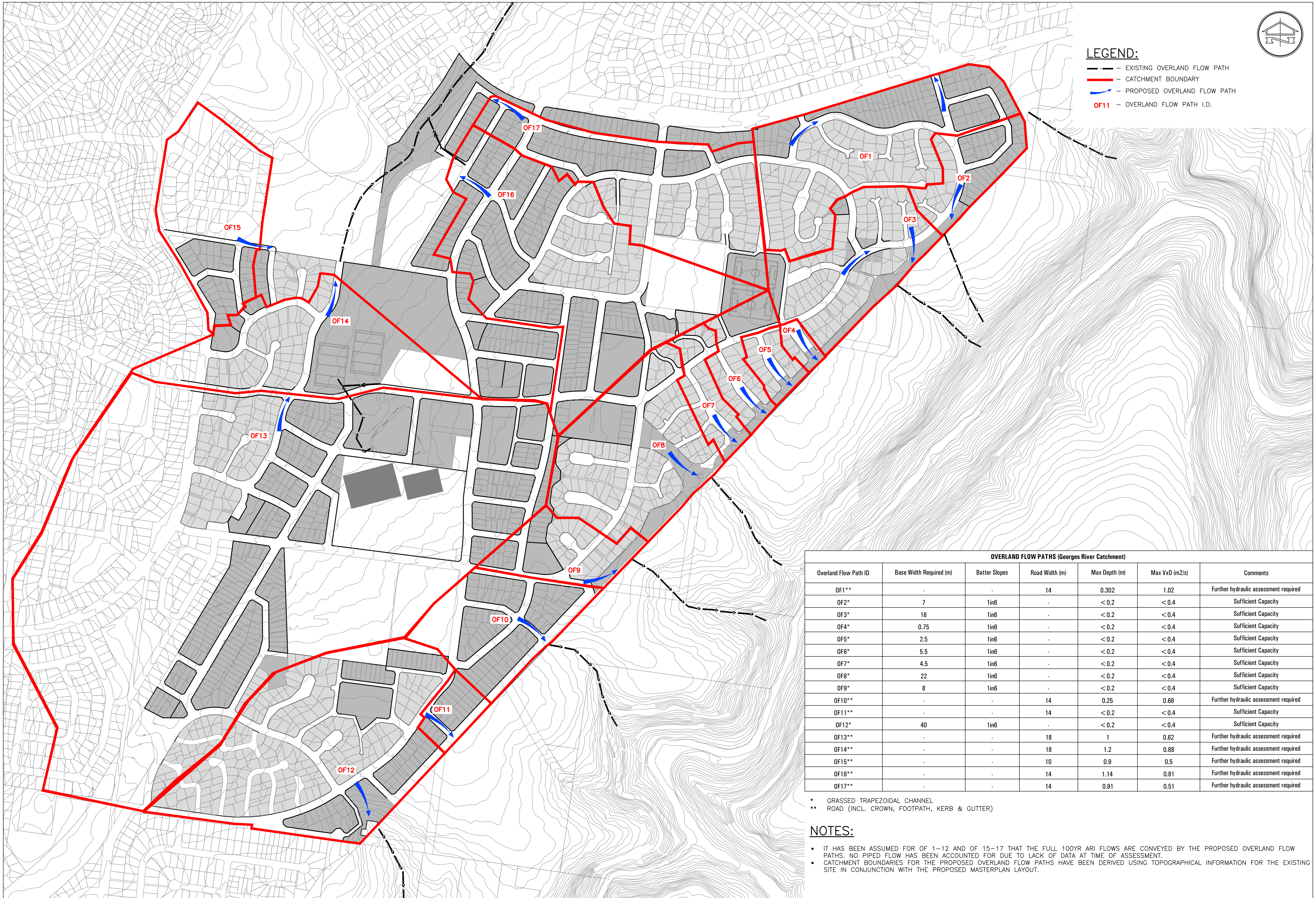
The model results suggest that the *existing* drainage corridors are undersized to convey flows for the 100 year ARI storm event. The hydraulic modelling takes a conservative approach excluding flow through the piped drainage network in all but three of the existing drainage corridors.

To increase model accuracy additional hydraulic investigations should be undertaken to include flow through the piped drainage system in conjunction with overland flow.

The model results suggest that the *proposed* overland flow paths for the Georges River catchment have sufficient capacity to convey flows for the 100 year ARI storm event.

Where Table 4-8 states that further hydraulic assessment is required, the ultimate solutions (where required) may include combinations of the following:

- Regrade existing roads to divert flows
- Augmenting sub-surface drainage infrastructure
- Increase the capacity of the road reserve



OVERLAND FLOW PATHS (Georges River Catchment)

Overland Flow Path ID	Base Width Required (m)	Batter Slopes	Road Width (m)	Max Depth (m)	Max VxD (m2/s)	Comments
OF1**	-	-	14	0.302	1.02	Further hydraulic assessment required
OF2*	7	1in6	-	< 0.2	< 0.4	Sufficient Capacity
OF3*	16	1in6	-	< 0.2	< 0.4	Sufficient Capacity
OF4*	0.75	1in6	-	< 0.2	< 0.4	Sufficient Capacity
OF5*	2.5	1in6	-	< 0.2	< 0.4	Sufficient Capacity
OF6*	5.5	1in6	-	< 0.2	< 0.4	Sufficient Capacity
OF7*	4.5	1in6	-	< 0.2	< 0.4	Sufficient Capacity
OF8*	22	1in6	-	< 0.2	< 0.4	Sufficient Capacity
OF9*	8	1in6	-	< 0.2	< 0.4	Sufficient Capacity
OF10**	-	-	14	0.25	0.66	Further hydraulic assessment required
OF11**	-	-	14	< 0.2	< 0.4	Sufficient Capacity
OF12*	40	1in6	-	< 0.2	< 0.4	Sufficient Capacity
OF13**	-	-	18	1	0.62	Further hydraulic assessment required
OF14**	-	-	18	1.2	0.88	Further hydraulic assessment required
OF15**	-	-	10	0.9	0.5	Further hydraulic assessment required
OF16**	-	-	14	1.14	0.81	Further hydraulic assessment required
OF17**	-	-	14	0.91	0.51	Further hydraulic assessment required

* GRASSED TRAPEZOIDAL CHANNEL
** ROAD (INCL. CROWN, FOOTPATH, KERB & GUTTER)

NOTES:

- IT HAS BEEN ASSUMED FOR OF 1–12 AND OF 15–17 THAT THE FULL 100YR ARI FLOWS ARE CONVEYED BY THE PROPOSED OVERLAND FLOW PATHS. NO PIPED FLOW HAS BEEN ACCOUNTED FOR DUE TO LACK OF DATA AT TIME OF ASSESSMENT.
- CATCHMENT BOUNDARIES FOR THE PROPOSED OVERLAND FLOW PATHS HAVE BEEN DERIVED USING TOPOGRAPHICAL INFORMATION FOR THE EXISTING SITE IN CONJUNCTION WITH THE PROPOSED MASTERPLAN LAYOUT.

STORM_CONSULTING
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OVERLAND FLOW PATH ASSESSMENT

Date 17.03.11

Figure 4-4

5.0 COSTINGS

The water cycle elements referred to in this plan and which are reflected in the recommendations have had cost estimates applied as indicated in Table 5-1.

Table 5-1: Indicative costings of water cycle elements

Item	Water cycle element	Indicative cost ($2011, includes design)
Water quality	Total area of bioretention 2337m2 x $370 /m2	$865,000
	2 major GPTs	$660,000
	Existing GPT access tracks and maintenance pads for three GPTs	$90,000
Environmental restoration/rehabilitation	Creek rehabilitation	$200,000
	Creek restoration (initial bush regeneration and plantings)	$25,000
	Refurbish “The Pond”	$100,000
Flood mitigation	Barrier on Georges River Road and properties adjoining Smiths Creek reserve	$60,000
	Overland flow paths - amplify drainage corridors/infrastructure	Unknown
Potable water substitution	Stormwater harvesting scheme	$400,000