WHEATBELT NRM

Background Document - Water Management Plan

Stormwater Assessment - Shire of York

May 2011

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Executive Summary

On average the Avon River contributes approximately 69% of total annual nitrogen (TN) and 43% of total annual phosphorous (TP) load to the Swan - Canning Estuary. Avon River pools and riparian vegetation of the river and its tributaries are important in buffering water quality, including cycling of nutrients and controlling sediment loads within the river.

Stormwater from Avon Arc towns carries a range of pollutants including suspended sediment, hydrocarbons, nutrients and metals. River pools downstream of key urban areas within the Avon Arc are typically eutrophic or are reported to contain nutrient enriched sediments. The York Shire contains a relatively high proportion of Avon River pools considered to retain high environmental values. A number of these pools are impacted by poor water quality including excessive nutrient discharge, likely to be exacerbated by proposed future development.

A daily time-step hydrology and water quality model was developed for 38 subcatchents within the town of York using MUSIC V4 (eWater 2010) for the period 1999 – 2009, coinciding with the available nutrient monitoring data for the Avon River. Six minute time step modelling was also undertaken to assess peak flows for critical stormwater nodes.

Modelling undertaken indicates that the York townsite currently contributes in the order of 6.3% (145 kg/yr) and 1.5% (1,650 kg/yr) of TP and TN loads respectively, when compared to estimated nutrient loads within the Avon River at the York townsite. This translates to approximately 0.56% and 0.66% of the TP and TN loads entering the Swan – Canning Estuary.

Modelling undertaken indicates that proposed new development within the town of York is likely to result in a 120% increase in TP and a 68% increase in TN discharging to the Avon River, over and above from estimated 1999 -- 2008 discharge levels.

More detailed assessment of individual stormwater catchments within York is presented. The assessment includes hydrologic, hydraulic and water quality analysis of current and projected catchment conditions.

Presented are recommendations for infrastructure works to mitigate potential impacts associated with proposed urban development within York. Recommendations are preliminary, and focus on mitigation of both hydraulic and water quality issues arising from proposed development.

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1 Introduction

Stormwater generated within the Avon Arc towns discharges directly to the Avon River and or its tributaries. The Avon River represents a regionally significant environmental asset, in addition to being socially and culturally important to many inhabitants within the Avon region.

The Avon River impacts the health of the downstream Swan - Canning Estuary. The Avon currently contributes approximately 69% and 43% of total annual nitrogen (TN) and phosphorous loads (TP) respectively to the Swan - Canning Estuary *(DOW 2009a)*.

Riparian vegetation and river pools represent the primary environmental assets of the Avon River, providing important habitat for the aquatic and terrestrial flora and fauna that make-up the ecological communities of the river. In addition, river pools and riparian vegetation are important in buffering water quality, including cycling of nutrients and controlling sediment loads within the river. Protection of these environmental assets is essential not only to the health and wellbeing of the region, but also the downstream Swan - Canning Estuary.

Managing water quality within the Avon River is a high environmental priority, and there is increasing desire within Local Government and the broader community to better manage this important environmental and cultural asset.

Presented are outcomes of a background study considering the impact of the key urban catchments within the town of York on downstream environmental water assets. Specifically the investigation considers current and future potential water quality issues arising for the town of York..

Information presented is central in understanding the likely threat that future development may represent to downstream environmental water assets, and in informing policy and plans to minimise environmental impacts of current and future development.

2 Background

Changes to landuse represent potential hazards to aquatic receiving environments. Risks to environmental water assets resulting from development include direct impacts of removal and disturbance of native vegetation and wetland environments, to changes in hydrology and water quality.

2.1 Urban

Increases in residential density and development of commercial and industrial estates may result in significant increases in contaminates associated with stormwater. Appropriate planning controls are necessary to ensure that new developments and infill development do not result in additional environmental pressure impacting sensitive downstream environmental assets.

Presented is background information intended to assist in identifying potential threatening processes associated with changes in land use.

The contaminants in stormwater are typically grouped according to their water quality impacts.

- Suspended solids.
- Nutrients, primarily nitrogen and phosphorous.
- Biological and chemical oxygen demanding materials.
- Microganisms.
- Toxic organics.
- Trace organics.
- Toxic trace metals.
- Oils and surfactants.
- Litter.

Nutrients, metals and organic matter represents the most common contaminants contained within stormwater. Potential sources of nutrients include:

- Sewage overflows.
- Industrial discharges.
- Animal wastes.
- Fertilisers - . domestic and agricultural
- Domestic detergents.
- Seepage from septic tanks.
- Discharge from wastewater treatment plants.
- Landfill and refuse sites.
- Feedlots, stockyards and sale yards.
- Abattoirs.
- Intensive animal operations, including piggeries and feedlots.

Excessive nutrients, such as nitrogen and phosphorous, can promote rapid growth of aquatic plants, including toxic and non-toxic algae. Excessive aquatic growth results in excessive organic production during daylight hours followed by excessive organic consumption during the night, resulting in large fluctuations in available dissolved oxygen, potentially resulting in anoxic conditions. Variations in environmental conditions often leads to unstable environments, potentially impacting ecosystem diversity and robustness (WBM 2003).

Up to 85% of phosphorus and 70 - 80% of nitrogen can be in particulate form within stormwater, however relative concentrations vary depending on the nature of the catchment and stormwater events resulting in stormwater discharge (WBM 2003). Often relatively effective removal of nutrients from stormwater can be achieved by settling out the silt and clay particles, to which nutrients attach. It is considered likely that the majority of particulate matter containing nutrients currently contained within stormwater settle out in river pools orientated downstream of the stormwater catchments on the Avon River. River pools downstream of key urban areas within the Avon Arc are typically eutrophic or are reported to contain nutrient rich sediments.

2.2 Rural

Changes in landuse associated with rural catchments may have influenced the hydrology and water quality of catchment discharge. Most significant impacts are likely to result from:

- *Increased grazing pressure, particularly of watercourse areas resulting in a loss of riparian vegetation and/or groundcover.*
- *Clearing of native vegetation, resulting in a loss of biodiversity and potentially resulting in increased salinity and sedimentation.*
- *Revegetation, potentially resulting in reduced run-off, however revegetation may also have positive hydrologic impacts.*
- *Increase in catchment water storage (dams), potentially resulting in a reduction in the overall catchment discharge, leading to increased concentration of contaminants through reduced dilution.*
- *Groundwater extraction, resulting in decreased fresh groundwater discharge to the Avon River, and/or impacting surface - groundwater interactions resulting and potential changes to surface water hydrology within the catchment.*
- *Irrigation, resulting in potential changes to catchment surface and groundwater hydrology.*

Changes in landuse within subcatchments discharging directly to high value environmental assets, including river pools, presents a particular environmental risk to specific river pools and downstream environments.

Proposed landuse change within priority subcatchment, identified as those discharging directly to high-value river pools, should be assessed to determine their potential impact on Avon River flows. In particular, activities likely to result in increased contaminants or reduced runoff should identify risk management strategies to minimise potential negative downstream environmental impacts. Identified subcatchment areas are highlighted in the Map Accompanying this report ("*Shire of York River Pools*").

2.2.1 Risk Factors

A common pathway for nutrients entering waterways is associated with particulate matter entering tributaries resulting from erosion. The following risk factors are identified:

- *Grazing of tributaries and river banks.*
- *Poor groundcover leading to wind or water erosion removing topsoil.*
- *Sandy textured soils with high permeability increasing the risk of leaching.*
- *Soil loss in close proximity (<50m) to drainage line.*
- *Agricultural activity in the floodplain where there is a risk of soil loss or sediment removal of alluvial soils.*
- *Channel and gully erosion within the riparian zone, and/or erosion of alluvial and other depositional soils.*
- *Areas prone to waterlogging or groundwater discharge (including salt-affected land).*
- *Fertiliser applied at rates higher than required for plant use, or where there are high soil nutrient levels.*
- *Uncontrolled access stock to water supplies, waterways and/or wetlands.*
- *High levels of organic matter built up within or near to drainage lines.*
- *Riparian vegetation in poor health (especially inadequate groundcover).*
- *Storage of bulk fertiliser storage and/or other material with high nutrient leaching potential.*
- *Application of fertiliser across drainage lines or seasonal watercourses.*
- *High nutrient potential point source activities (including piggeries, stockyard, feedlot or wastewater treatment systems, abattoirs, refuge sites etc).*

3 Environmental Assets

The Avon River and its tributaries represent the key environmental assets likely to be influenced by water management within Avon Arc towns. River pools and riparian vegetation are broadly accepted as the primary environmental building blocks of the Avon River, providing the primary habitat supporting various ecosystems in addition to providing drought refuge and performing an important role in the cycling of nutrients and other contaminants.

3.1 Avon River

No formal environmental flow provisions exist for the Avon River. However, relevant background documentation, including priorities for river management and recovery have previously been developed by the Department of Water (Read 1999, WRC 1999), in addition to a preliminary environmental flow report commissioned by Wheatbelt NRM (formally the Avon Catchment Council) (GHD 2008b). Background documents relevant to the Shire of York include:

- *River Recovery Plan Sections 7, 8, 9 - Mile Pool to Spencers Brook (Read 1999)*
- *River Recovery Plan Section 10 (York) (WRC 1999)*
- *Draft Environmental Flow Requirements - Avon River (GHD 2008b)*

3.2 River Pools

There are 12 Avon River pools identified within the Shire of York, of which seven are considered to be of high environmental value. The environmental values of individual river pools were previously determined through consideration of available data describing physical attributes and ecological condition of individual river pools. In addition, sections of the Avon River within the Shire of York have particular conservation value, including a relatively undisturbed section between Balladong and Railway Bridges known as Parkers Reach (Read 1999).

Table 1. Avon River Pools – Shire of York ***(GHD 2008 b, WNRM 2009)***

Pool
* Wilberforce
Church
Little
* Tipperary
* Mears
* One Mile
* Blands (Town)
* Railway
Cold Harbour
Mt Hardy
* Gwambygine
Oakover

** High environmental significance.*

Additional information of river pools is presented in Appendix A, with detailed background information presented in WNRM 2009.

3.2.1 Wilberforce Pool

Wilberforce pool remains largely free of sediment, primarily due to Church Pool, which is located approximately 3 km upstream, trapping the majority of course sediment. Riparian vegetation associated with Wilberforce Pool is minimal with little or no understory. Grazing by domestic stock and significant weed infestations are considered to be primary threatening processes impacting the pool.

3.2.2 Church Pool

Also referred to as Mackies Pool, it is known locally as church pool due to a church previously located on the bank. The pool receives course sediment and 59% of the pool was filled with sediment during a 1996 survey.

Ongoing sedimentation of the pool represents its primary environmental risk.

3.2.3 Little Pool

Little pool, originally approximately 1 km in length, was reported to have filled with sediment by 1976.

3.2.4 Tipperary Pool

Formerly a substantial pool, it is now filled with over 148,000 m^3 of sediment. The pool is under future risk of additional sedimentation. Riparian vegetation associated it with this river pool is minimal, however revegetation of adjacent agricultural land has previously been undertaken.

3.2.5 Mears Pool

Mears pool suffers from significant sedimentation, with the pool now considered quite shallow. The pool has minimal fringing vegetation and water quality monitoring of the pool during the late 1990 showed high levels of nitrogen and phosphorous. Algal blooms were also recorded during this period. The pool is relatively attractive and suitable for public access from Mackies Crossing, located at the downstream extent.

3.2.6 Three Mile Pool

Little information is available about Three Mile Pool, other than it is considered to be significantly filled with sediment.

3.2.7 Mile Pool

Mile Pool has significantly reduced in length due to sediment to infill, however remains relatively deep and is locally popular for picnics. The pool is also considered eutrophic and highly polluted, and suffers from regular algal blooms.

3.2.8 Blands (Town) Pool

Blands Pool, also known as Town Pool was once a site for swimming carnivals, however today is so polluted that swimming is banned. The pool receives stormwater discharge directly from York and is eutrophic, suffering regular algal blooms. Future risks to the pool include upstream sedimentation.

Management of the town pool, an urban park setting, includes addressing key issues including fertiliser use, structures in the river, raising of a water level by the downstream weir, management of mosquitoes and safety issues.

3.2.9 Railway Pool

Railway pool is considered to be rapidly filling with sediment. Management of sediment within Railway Pool is considered to be a priority and is vital to protect the pristine area located immediately downstream.

3.2.10 Cold Harbour Pool

Cold Harbour pool is now completely filled with sediment. Development of a sediment traps at the foot of Cold Harbour pool is essential to stop sediment moving in to the York townsite.

3.2.11 Mt Hardy Pool

Mt Hardy pool is completely filled with sediment.

3.2.12 Gwambygine Pool

Gwambygine Pool is one of the few Avon River pools remaining in good condition. The pool has been previously impacted by unconsolidated sediment, with some sediment previously removed. The pool has been the focus of interest of the River Conservation Society and a management plan for the pool was developed.

3.2.13 Oakover Pool

Oakover pools is reported to have filled with sediment within two years of the river training scheme. Water quality is considered to be relatively good, with low phosphorus and salinity levels, however remains relatively shallow.

3.2.14 Threatening Processes

Key threatening processes potentially impacting Avon River pools include:

- *Grazing of the river and tributaries by domestic stock.*
- *Fire threatens individual reaches of the river and specific species, and exacerbates related issues including control of grassy weeds.*
- *Erosion to river beds and banks and sedimentation of river pools.*
- *Nutrient enrichment (especially phosphorus and nitrogen) and organic matter, resulting in eutrophication of Avon River pools in addition to contributing to downstream nutrient load to the Swan Estuary.*
- *General water quality pollution including metals (associated with vehicles and commercial/industrial byproducts), hydrocarbons (predominantly from vehicles, car parks and service stations) and range of nutrients associated with domestic and agricultural fertilisers (Read 1999).*
- *Episodic saline flows, particularly associated with discharge from the Yenyening Lakes, presents threat to river health, including impacts on sensitive biota and ecosystem stability. Both the salinity and frequency of saline flow events threaten river health. Potential future upstream groundwater drainage presents an additional salinity risk to the river (GHD Unpublished).*
- *The potential episodic changes to pH represents a risk and to biota within the Avon River. Specifically, periods of flow where pH below 6.5. Potential low pH discharge from upstream catchments including discharge from the Yenyening Lakes in association with potential future*

upstream groundwater discharge presents a potential risk of episodic low pH flow events (GHD Unpublished).

The most significant threats to river pools are considered to include sedimentation and nutrient enrichment, generated from local catchments that discharge directly, or upstream of river pools. Stormwater from the York townsite discharges directly into the Blands and Mile pool and upstream of Mears and Tipperary Pools. Stormwater discharge from the York townsite carries pollutants to river pools including suspended sediment, hydrocarbons, nutrients and dissolved metals.

Current and proposed rural -- residential developments extend south of the York townsite potentially impacting Mt Hardy, Cold Harbour, and Railway river pools. In addition, contaminants including nutrients and organic matter discharging from agricultural land also represent risks to environmental assets of the Avon River.

3.3 Tributaries

Main tributaries to the Avon River within the Shire of York include the *Mackie River, Thirteen Mile Brook, Warranine Brook, Mortlock River South.*

3.3.1 Mackie River

The Mackie River is the only major tributary discharging directly to the Avon River within the Shire of York. The Mackie River is approximately 46 km in length, fed by a catchment of approximately 326.5 km^2, located predominantly within the shires of York and Beverley. The Mackie River is fed by a series of tributaries including, Doctors Brook, Balley Balley Brook and Mungerding Brook.

The Mackie River delivers saline inflow to the Avon River, however, salt loads have not been quantified. Historically, the Mackie River contained a series of deep river pools, however these pools have become shallow as a result of sediment deposition and no longer provide important ecological refuges.

The banks of the Mackie River are dominated by York gum (*Eucalyptus loxophleba*), flooded gum (*Eucalyptus rudis*) and Jam tree (*Acacia acuminata*). Areas of secondary salinity and significant weed infestation are common along the length of the Mackie River.

Land use is predominantly agricultural, with a focus on sheep and wheat, however there is an increasing tendency towards hobby farming or subdivision of rural farms into smaller lots.

A survey of bank stability undertaken during 1995 indicates at approximately 70% of the banks of the Mackie River are classified as being in poor condition and subject to erosion. Erosion and sedimentation along the river links is common and the Mackie River is considered to be a significant source of sediment, influencing downstream Avon river pools.

3.3.2 Thirteen Mile and Warranine Brooks

The Thirteen Mile and Warranine Brooks feed the downstream Spencers Brook, discharging to the Avon River within the Shire of Northam.

Spencers Brook is a relatively minor tributary, draining an area of approximately 36,000 ha, although it is considered to contribute reasonable salt load to the Avon River. Anecdotal evidence suggests that prior to clearing, there were deep seasonal pools located within Spencers Brook, however pools have subsequently been filled with sediment. Spencers Brook responses to a high intensity relatively short duration rainfall events causing sharp peak flows resulting in bank erosion and downstream sedimentation (WRC 2002 c).

3.3.3 Mortock River

The upper reaches of the Mortock River are contained within the shire of York, providing flow to the downstream Mortock East River Branch.

Whilst the Mortlock East contributes a relatively small volume of flow to the Avon River it contributes significant nutrient and salt loads.

4 Stormwater Assessment

4.1 Background

The average annual discharge within the Avon River at York is estimated to be approximately 96 GL. Monitoring of nutrient and metal concentrations at Northam has been undertaken for the period 1998 -- 2009 by the Department of Water. Monitoring is undertaken opportunistically during the flow period, with the number of samples taken per year ranging between 2 and 16, for the period of monitoring. Average number of samples collected is 7.3 / annum.

Nutrient loads discharging from the Avon River at the Great Northern Highway (east of the Perth Metropolitan area) is reported by the Department of Water. It is estimated by the Department of Water that approximately 43% and 69% of total phosphorus and total nitrogen respectively entering the Swan Estuary are derived from the Avon River (SRT 2009).

Water quality data collected by the Department of Water indicates that approximately 32% and 39% of total phosphorus and nitrogen discharging at the Great Northern Highway is contained within Avon River flows at the York townsite (refer Table 2).

Table 2 Comparison of Estimated Annual Flow and Nutrient Loads within the Avon River at York and Great Northern Highway

	Gt Northern Hwy	*York*	*Proportion (York / GN Hwy)*
Discharge (GL)	280	95	34%
TP (tonnes)	7.8	2.54	33%
TN (tonnes)	282	121	42%

** Analysis of nutrient loads for the Avon River at York based on median nutrient concentrations recorded for each year of monitoring, adjusted to better reflect nutrient concentrations at Northam Weir.*

Stormwater hydrology / water quality modeling was undertaken for the York townsite using MUSIC V4 (eWater 2010) to provide an indication of nutrient load discharging from the York townsite. Modelling consisted of daily time step nutrient and flow model for 38 urban subcatchents within the town of York. The model was run using daily rainfall data from the Bureau of Meteorology for the period 1999 – 2006, to coincide with the available nutrient monitoring data within the Avon River.

Modelling undertaken indicates that the York townsite currently contributes in the order of 6.3% (145 kg/yr) and 1.5% (1650 kg/yr) of TP and TN loads respectively, when compared to estimated nutrient loads within the Avon River at the York townsite (refer Table 3). More broadly, it is estimate that the Town of York contributes the equivalent of 0.56% and 0.66% of the TP and TN loads entering the Swan - Canning Estuary, assuming TP and TN loads to the Swan – Canning Estuary are 26 t/yr and 250 t/yr respectively (SRT 2009).

Nutrient and flow modeling for the town of York was further developed to predict the potential increases in TP and TN likely to discharge resulting from infill development planned throughout current residential, commercial and industrial precincts within town. In addition, an assessment of the potential increase in nutrient discharge associated with the planned Daliak Development was undertaken (refer Table 3).

Table 3 Estimated Potential Increase in Nutrient Discharge-York Townsite Stormwater

	TP (kg/annum)	TN (kg/annum)
Current Estimated Discharge from town of York	145	1,650
Estimated Increase Resulting from Infill Development	94	423
Estimated discharge from the Daliak Development	79	680

Modelling indicates that infill development within York could result in a 65% increase in TP discharge and that the Daliak development could result in the additional 55% increase in TP discharge to the Avon River, assuming no nutrient abatement strategies are adopted.

Whilst modelling is considered preliminary, with models uncalibrated due to limited monitoring data, the analysis indicates that stormwater discharging from the York townsite is a significant contributor of nutrients to the Avon River, particularly phosphorus. Planned development within the town of York is likely to result in a considerable increase in nutrient discharge to the Avon River unless nutrient abatement strategies are adopted.

In addition to residential and commercial developments within town, there is strong demand within the Shire of York for new rural - residential development. No nutrient modelling of the potential impact of planned rural - residential development was able to be undertaken due to underlying modelling constraints. However, planned rural - residential development may present additional hazards to downstream environments associated with increased nutrient and total suspended sediment discharge resulting from the intended landuse change.

A more detailed assessment of issues impacting individual subcatchments is presented in the following section. The assessment includes potential issues arising from proposed developments and preliminary planning recommendations in addition to recommendation of works where considered appropriate.

4.2 Mt Hardy – Gwambygine

The Mt Hardy to Gwamygine river reach is located south of the York townsite. This area of the Avon River is characterised by particularly high value environmental assets including environmentally significant river pools and areas of relatively pristine riparian vegetation. This area of the Avon River is considered to be of regional environmental and cultural significance, and is associated with industrial infrastructure and low density rural – residential development.

Existing potential high impact nutrient sources associated with the Cold Harbour – Gwambygine river reach include (refer Figure 1):

- *Piggery*
- *CBH grain terminal*
- *Wastewater treatment plant*
- *Hay sheds*

No specific assessment of the nutrient management implications of the above-mentioned industrial sites has been undertaken in the development of this report. Due to the proximity to high value environmental assets and the potential for nutrient and organic contamination associated with the above-mentioned infrastructure, an appropriate level of assessment including monitoring of flow discharge is highly recommended.

There are also proposed areas of rural - residential development associated with this section of the Avon River, with much of the development proposed to occur directly adjacent to the river itself. In addition to proposed development immediately adjacent to the river, a larger, longer term rural - residential development associated with the Mt Hardy area is proposed (refer Figure 1).

A range of issues potentially arise from development of rural - residential precincts adjacent to major waterways including:

- *Flooding hazard, resulting from the large episodic flow events.*
- *Increase nutrient and total suspended sediment associated with potential reduced groundcover resulting from more intensive grazing, particularly in areas of high slope.*
- *Potential impacts on native vegetation and riparian vegetation.*
- *Increase nutrient discharge associated with waste disposal.*

The 1:100 year flood level has previously been mapped by the Department of Water (DoW 2008), and is illustrated in Figure 1.

Typically, reductions in nutrients and total suspended sediment entering the river can be achieved through the establishment of revegetated buffer zones adjacent to the river. Vegetated buffer zones are recommended as a mechanism of filtering nutrients and total suspended sediments originating from rural - residential developments located adjacent to waterways. Due to the close proximity of the proposed rural - residential development of the river, water quality management and potential treatment will need to be undertaken on individual properties.

The proposed future rural – residential development south of Cold Harbour is identified in the Shire of York Local Planning Strategy. A preliminary assessment was undertaken of the Cold Harbour rural - residential development and identified the following hazards:

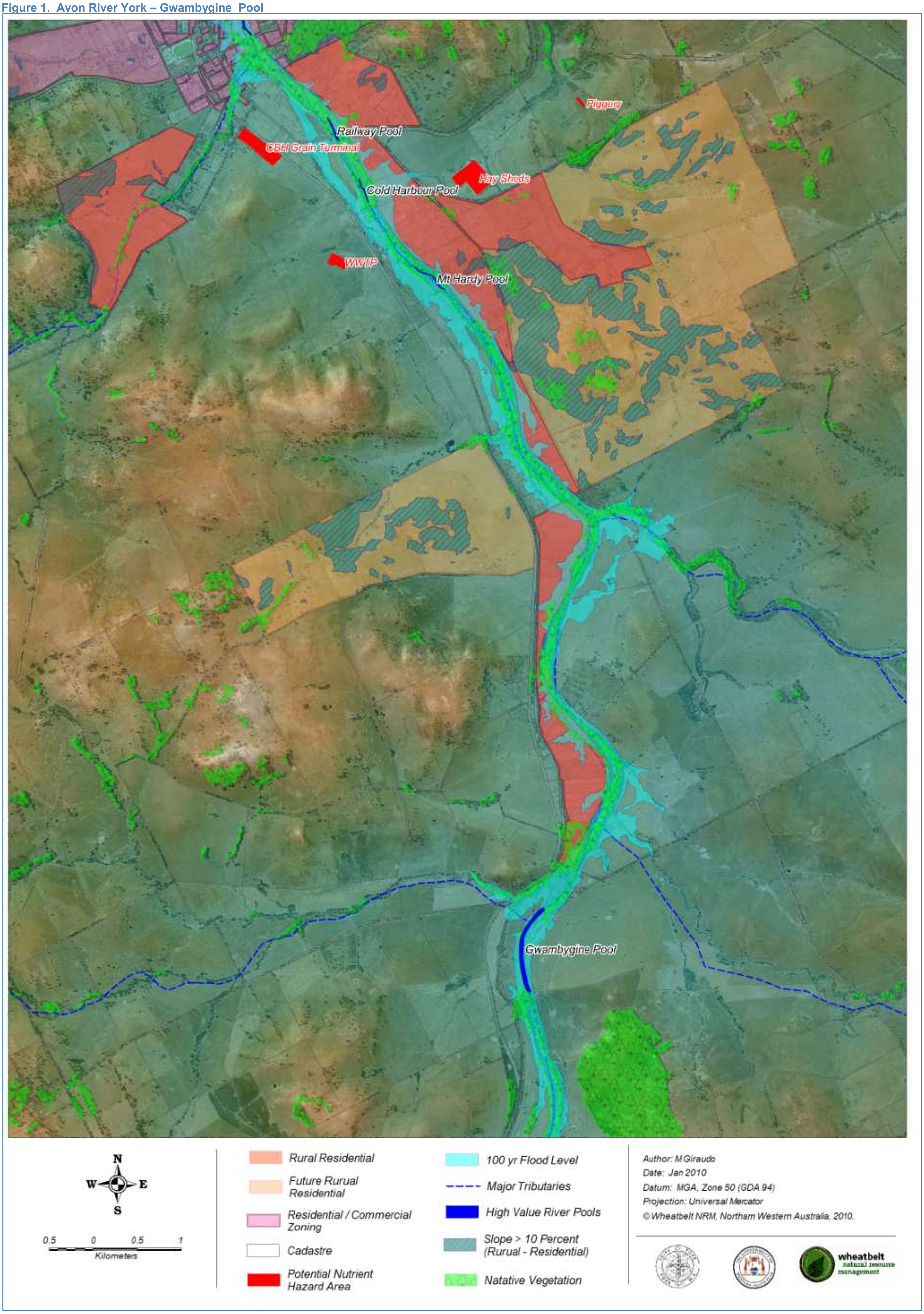
- *Approximately 15% of the proposed land area identified for development has a slope of greater than 10%, presenting specific risks of erosion. Control measures to reduce potential nutrient and sediment impacts associated with erosion of high slope areas should be undertaken to mitigate potential negative environmental impacts associated with the development.*
- *Flow originating from the Cold Harbour rural - residential development area will discharge to the Mt Hardy River Pool. Discharge from the proposed future rural - residential development presents potential nutrient and sediment hazards to downstream river pools, including Railway and Blands pools as Mt Hardy and Cold Harbour Pools, located immediately downstream of the proposed development, are already full of sediment.*

4.2.1 Recommendations

Control mechanisms to mitigate potential negative impacts of the proposed Cold Harbour rural - residential development on downstream river pools is recommended. Due to the proximity of the proposed development to sensitive environmental assets associated with the Avon River, it is recommended that on-site nutrient mitigation mechanisms are adopted, including:

- *Revegetation of waterways and creeklines, with suitable sedges and reeds to filter nutrients.*
- *Vegetated buffer zones developed immediately adjacent to the river to protect riparian vegetation from adjacent land-use impacts.*
- *Appropriate restriction to stocking rates.*

Figure 1. Avon River York – Gwambygine Pool



4.3 Equine Precinct

The equine precinct is a rural - residential development located between the railway line and Mt Blakewell on the northern margin of the York townsite. This rural - residential precinct is located on the lower slopes of Mount Blackwell, and is characterised by areas of steep slopes (greater than 10%), multiple streams originating on the slopes of Mount Blackwell and a relatively short conveyance across the adjacent railway line prior to discharge to the Avon River. Flow from the equine precinct discharges to the Avon River immediately upstream of Mears Pool.

Mears Pool is considered to have both high environmental and social values. It is an attractive pool with public access, however it is approximately 70% filled with sediment. The pool has limited riparian vegetation and high levels of nutrients resulting in regular algal blooms. High nutrient levels recorded within Mears Pool are likely to be a direct result of nutrient enriched stormwater discharging from the York townsite. The potential increase in nutrients discharging from the equine rural - residential development represents an additional environmental hazard to Mears Pool, and associated downstream Avon River environments.

No water quality modelling was undertaken of the equine precinct due to technical modeling and data constraints, however the intended change in land use of land within the equine precinct from agricultural to rural - residential presents the following risks:

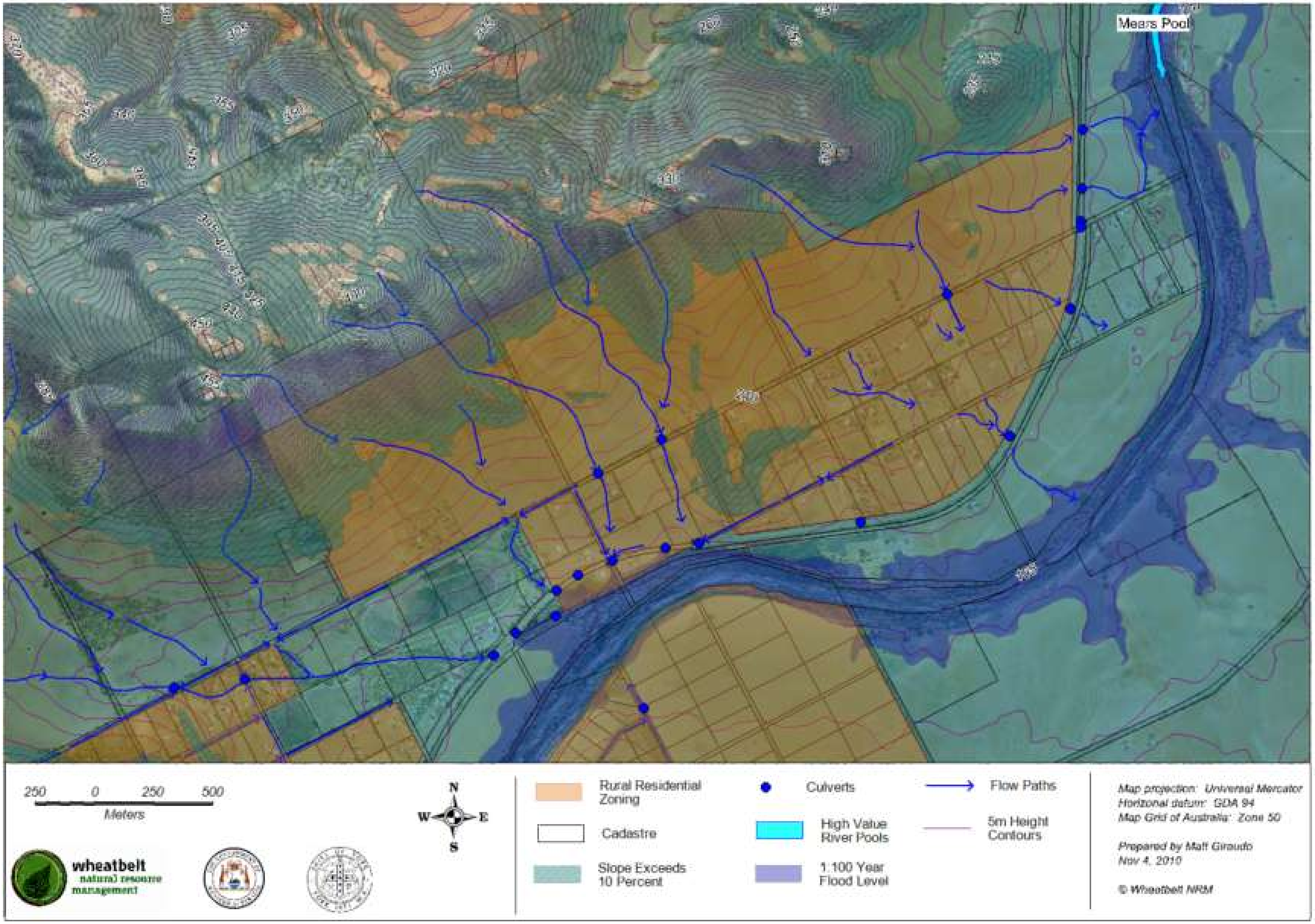
- *Increase nutrient and total suspended sediment associated with potential reduced groundcover associated with more intensive grazing, particularly in areas of high slopes.*
- *Increase nutrient discharge associated with waste disposal.*

4.3.1 Recommendations

Due to the relatively short conveyance between the equine precinct and the Avon River, and multiple discharge points, it is recommended that water quality treatment be views as the responsibility of individual landholders and be undertaken within property boundaries.

Vegetated swales and vegetated buffer zones associated with flow paths are highly recommended, with settling ponds and/or nutrient filtering ponds employed in circumstances where high risk nutrient discharge activities are being undertaken (refer Section 2.2.1). Appropriate control of stocking rates will be critical to maintaining the health of the downstream environment.

Figure 2. Equine Precinct



4.4 North West Precinct

The North West precinct contains a mix of rural - residential, R2.5, R5 and R 10/30 residential zones. There is potential for increased stormwater discharge from this precinct due to infill development as determined by the current zoning.

Hydrologic and water quality modelling was undertaken using MUSIC V4 (e-water 2010) to determine potential increases in flow and nutrient discharge as a result of proposed infill development within the North West precinct. A summary of results is presented below.

4.4.1 Peak Flows

Large peak flows within the North West precinct are dominated by flows generated from the upstream 1,510 ha agricultural catchment. The catchment is characterised by steep slopes and shallow granitic soils generating sharp peak flows following high intensity rainfall events. Estimated 1:10 ARI peak flow is presented in Table 4. Modelling was undertaken assuming current development conditions, and those resulting from infill development reflecting the current zoning within the precinct.

Modelling indicates that proposed infill development will not significantly influence peak flows within the main flow path of the North West precinct, as large peak flows are dominated by the upstream agricultural catchment. However, peak flows at Carolin Mokie Rd (location C in Figure 3) will increase from approximately 0.2 m^3/s to 1.1 m^3/s as a result of infill development within the upstream catchment (refer Table 4).

Table 4 Modelled 1:10 ARI Peak Flow - North West Precinct

	Map Ref	Current Conditions (m^3/s)	Infill Development (m^3/s)
Rural Catchments	A	15.7	15.8
Tenth Ave	B	15.7	15.8
Carolin Mokie Rd	C	0.22	1.1
Outlet	D	15.8	15.8

Culverts with inadequate capacity to effectively convey the modeled 1:10 ARI peak flow have been highlighted in red within **Error! Reference source not found.** including culverts under 10th Avenue and hose associated with a drainage spur leading to the upstream area of R 10/30 zone, located in the southern extent of the precinct.

Other than the identified the culverts, it is not anticipated that infill development will result in significant impacts to drainage infrastructure due to the proposed relatively low density development.

4.4.2 Nutrients

An increase in the total suspended sediment and nutrient discharge is predicted by MUSIC modeling undertaken within the North Western precinct, arising from the projected infill development.

Analysis included a daily timestep (MUSIC V4) model of the North West precinct catchment using daily rainfall recorded by the Bureau of Meteorology, for the period 1999 -- 2006, to coincide with nutrient monitoring undertaken within the Avon River by the Department of Water. Results of modelling undertaken are presented in Table 5.

Table 5. Modelled Average Annual Nutrient Load - North West Precinct

	Flow (ML/yr)	TSS (kg/yr)	TP (kg/yr)	TN (kg/yr)
Current Conditions	204	24,700	24.9	420
Infill Development	254	35,700	52.0	505
Proportional Increase	*25%*	*45%*	*109%*	*20%*

Modelling undertaken indicates that proposed infill development within the North West precinct is likely to result in a 109% increase in TP discharging from the catchment. Modelling also indicated a 45% increase in total TSS arising from the proposed infill development.

Due to the predicted increase in TP and TSS likely to result from the proposed development, nutrient abatement works are recommended. Preliminary assessment was undertaken for the incorporation of a vegetated swale approximately 350m in length near to the outlet of the catchment. The dimensions of the swale used in the analysis are presented in Table 6.

Table 6. Vegetated Swale Dimensions – NW Precinct

Length	350m
Bed Width	2.5 m
Top Width	5.5 m
Grade	1.1%
Depth	0.3m
Vegetation height	0.2

Daily time-step MUSIC modelling undertaken indicates that a correctly constructed and maintained vegetated swale as outlined in Table 6 will result in approximately a 30% reduction in TP, a 78% reduction in TSS and a 10% reduction in TN.

In addition to the daily time step model discussed above, a six minute interval model was developed to predict the likely impact of treatment options for the 1 yr / 1 hr flow event. Modelled output is presented in Table 7 comparing predevelopment and post development flows (reflecting that of the proposed infill development).

Table 7. Modelled Nutrient Concentrations - North Western Precinct

Outlet	Pre - development	Post development (No treatment)	Post development (Vegetated Swales)
Peak Flow (m3/s)	0.312	1.38	1.38
TSS (mg/L)	29.3	35.1	13.0
TP (mg/L)	0.062	0.140	0.08
TN (mg/L)	1.46	1.63	1.52

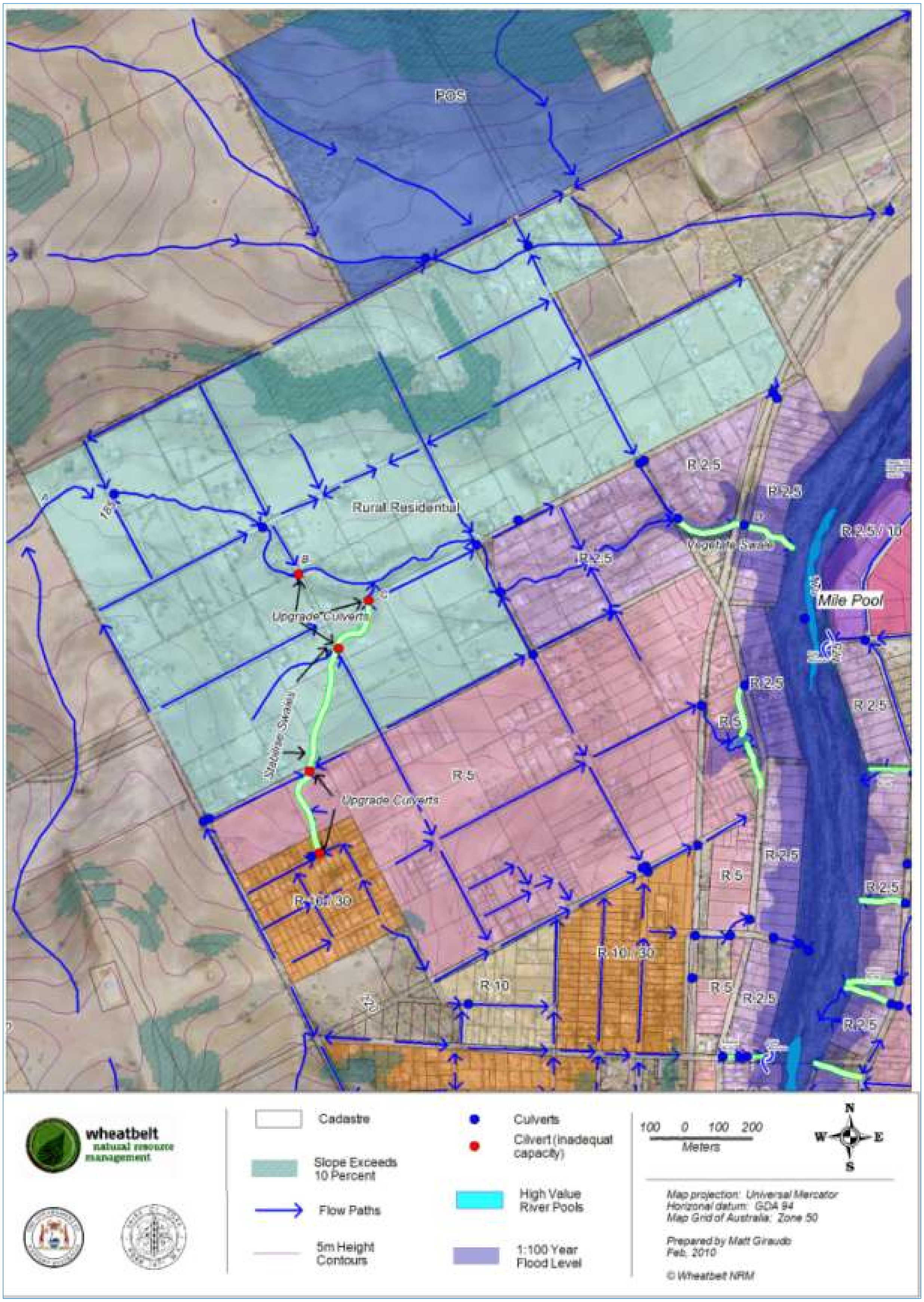
The analysis undertaken indicates that the incorporation of a vegetated swale of approximate length of 350m upstream of the discharge point with the Avon River, will result in post development concentrations within stormwater associated with 1yr – 1hr event similar to that modelled for predevelopment conditions (refer Table 7).

4.4.3 Recommendations

The following recommendations are presented based on the analysis undertaken for the North West precinct:

- *Upgrade of culverts on Tenth Avenue.*
- *Upgrade of culverts under Carolin Mokie Rd and upstream crossings.*
- *Development of vegetated swales throughout the major flow path, particularly within the 300 m immediately upstream of discharge to the Avon River.*

Figure 3. Northwest Precinct



4.5 West Central Residential Precinct

The western - central residential precinct is a 134 ha urban catchment discharging to the Avon River via the Ford, River and Knight Street outfalls. Discharge to the river occurs into Blands Pool and immediately upstream of a Mile Pool.

Blands (town) Pool contains sand sediment near to the centre of the pool, and whilst its banks remain relatively stable, the pool is eutrophic, resulting from high nutrient stormwater discharge from the York townsite. Mile Pool is reported to be a popular picnic spot although partially filled with sediment and at risk of further filling. Mile Pool is also reported to be eutrophic (WNRM 2009).

Daily time step modelling of the central west residential precinct was undertaken to assess potential stormwater impacts of proposed infill residential development within the precinct. The analysis undertaken indicates that identified infill development is likely to result an 85% increase in total suspended sediments and a 98% increase in TP discharging from the catchment (refer Table 8).

Table 8. Predicted Increase in Average Annual Nutrient Load - West Central Residential Precinct

	Flow (ML)	TSS (kg)	TP (kg)	TN (kg)
Current Conditions	131.0	17,180	23.8	258
Infill Development	181.0	31,720	47.1	398
Predicted Increase	38%	85%	98%	54%

Due to the nature of the proposed development within the central-west residential precinct and the limit transit distance between the urban catchment and the receiving body, there exist limited opportunities for stormwater polishing prior to discharge to the Avon River.

Previous investigations have identified a potential stormwater polishing site associated with a natural depression located between Knight and Brunswick Streets (WNRM 2009b). It may be possible to improve or expand the capacity of this natural depression to assist in reducing the projected increases in nutrient concentrations within stormwater discharge associated with proposed infill development.

Modelling was undertaken to determine the likely impact of incorporation of a pond and a vegetated swale (130 m in length) for reducing nutrient discharge associated with the Knight Street outfall. Dimensions of the pond used in the analysis are presented in Table 9.

Table 9. Pond Dimensions – Knight St

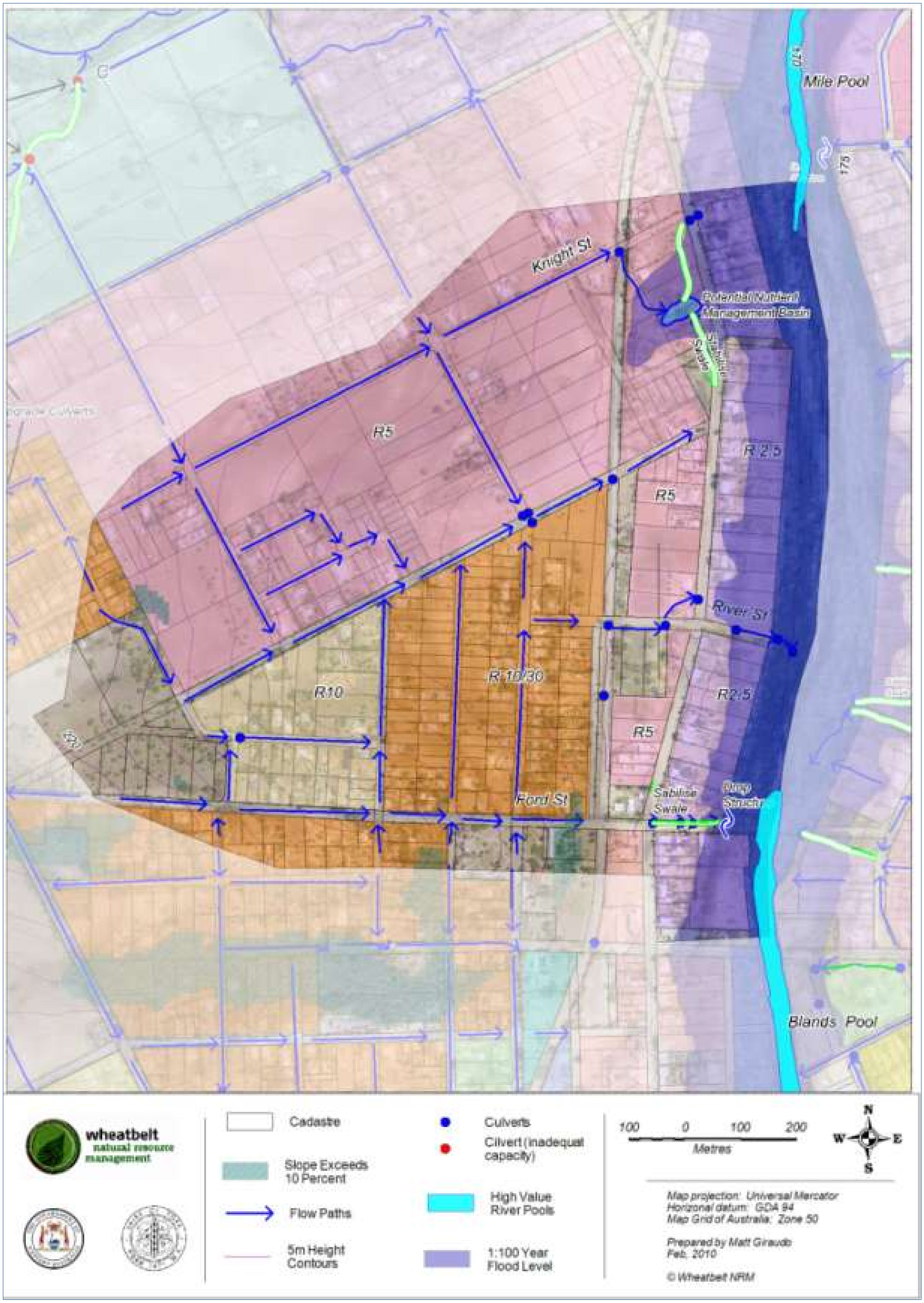
Surface Area	1940 sqm
Ave depth	1.5 m
Permanent detention volume	1,000 kL
Total volume	2910 kL
Outlet pipe diameter	200 mm
Nominal detention time	7 hrs

Modelling undertaken indicates that the combination of the pond and swale would result in a 66% reduction in TSS, a 39% reduction in TP and a 17% reduction in TN from predicted future stormwater discharge from the catchment. This is roughly equivalent to the predicted increase in TSS and TP resulting from the proposed infill development.

4.5.1 Recommendations

- *Stabilisation of swales associated with River St and Ford St prior to discharge to the Avon River.*
- *Assessment of potential water quality polishing opportunities associated with a small detention area located upstream with the Knight Street discharge.*
- *Installation of centripetal drop structures at outlets to the Avon River, to reduce total suspended sediment load to downstream river pools.*

Figure 4. Central West Residential Precinct



4.6 Commercial Precinct

The commercial precinct is an 83 ha urban catchment containing the majority of the York commercial district and an associated upstream residential areas. Stormwater from the commercial precinct discharges directly to Blands Pool, which is eutrophic, most likely as a result of nutrient enriched stormwater discharge from the York townsite.

4.6.1 Nutrient Load

A daily time step hydrology and water quality model (MUSIC V4) was used to estimate likely increases in average annual nutrient load resulting from proposed infill development within commercial and associated residential areas. Modelling was undertaken for the period 1999 – 2008, coinciding with available nutrient monitoring data within the Avon River.

Results of the analysis (presented in Table 10) indicate only a marginal (10% – 15%) predicted increase in nutrient load. The relatively small predicted increase in flow and nutrient discharge from the commercial and associated residential district is reflective of the relatively limited capacity for further infill development within the modelled area.

Table 10. Predicted Increase Average Annual Nutrient Load-Commercial Precinct

	Flow (ML)	TSS (kg)	TP (kg)	TN (kg)
Current Conditions	130	24,700	35.7	287
Proposed Infill Development	144	28,000	40.9	316
Predicted Increase	11%	13%	15%	10%

Modelling indicates that the commercial precinct catchment contributes approximately 24% of TP discharge from the York townsite. This highly urbanised catchment is also likely to contribute a significant proportion of hydrocarbons and dissolved metals contained within stormwater due to its relatively high traffic load. Construction of a swale downstream of the commercial catchment is recommended and was modelled to assess potential for reducing nutrient and sediment discharge. Detail of the dimensions of the swale used in the analysis is contained within Table 11.

Table 11. Assumed Swale Dimensions – CBD catchment

Swale Length	230 m
Bed Width	2.5 m
Top width	5.5 m
Depth	0.3m
Grade	0.8%
Vegetation height	0.2 m

Modelling undertaken indicates that the construction of a 230 m vegetated swale would result in a 65% reduction TSS, a 34% reduction in TP and a 10% reduction in TN. It is estimated that the swale would reduce sediment and nutrient loads to below current levels, assuming infill development up to that permissible under the current zoning for the subcatchment.

4.6.2 Peak Flows

Peak flow from the commercial precinct and upstream catchment were estimated using MUSIC V4. The HEC-RAS (USGS 2010) hydraulic model was also employed to estimate the hydraulic capacity of the main flow path within the commercial precinct. The assessment was undertaken to determine the capacity of the current stormwater system, identify potential choke points, and to aid in assessing the potential impact of the proposed upstream Daliak development, refer Section 4.7.

The commercial precinct currently receives flow from an upstream agricultural catchment of approximately 880 ha. The catchment is characterised by steep sloping shallow rocky soils, with approximately 35% of the catchment greater than 10% slope, and 85% of the catchment greater than 4% slope. The catchment generates sharp peak flows during high intensity rainfall events, presenting particular challenges for managing stormwater within the downstream commercial precinct.

Peak flows entering the town are buffered by a town dam which has an area of inundation of approximately 1 ha (at full capacity), with an estimated capacity of 25 ML. Simulation of peak flows from the upstream catchment undertaken using MUSIC V4 indicates that unregulated peak flow (excluding the influence of the town dam) is currently approximately 9.0 m^3/s, during the 1:10 ARI (2 hr) rainfall event. Assuming 2 m (depth) of storage capacity within the town dam (~ 17 ML), the estimated peak flow crossing Ulster Rd and entering the town commercial catchment is approximately 3.0 m^3/s during the 1:10 ARI, 2hr rainfall event. Figure 6 illustrates the impact of the town dam in reducing the peak flow from 9 m^3/s to 3 m^3/s during the 1:10 ARR rainfall event described above.

Figure 5. Commercial Precinct

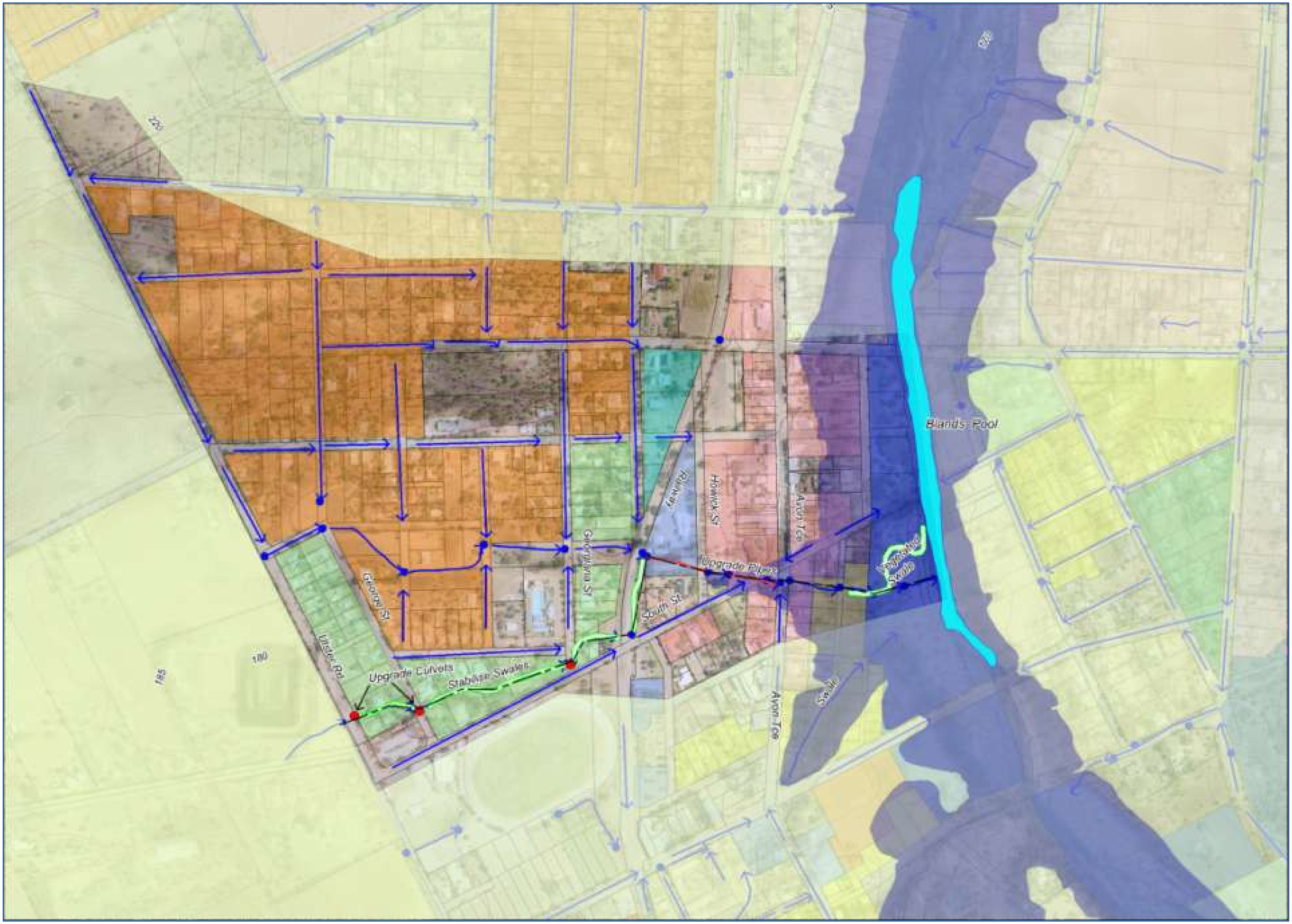
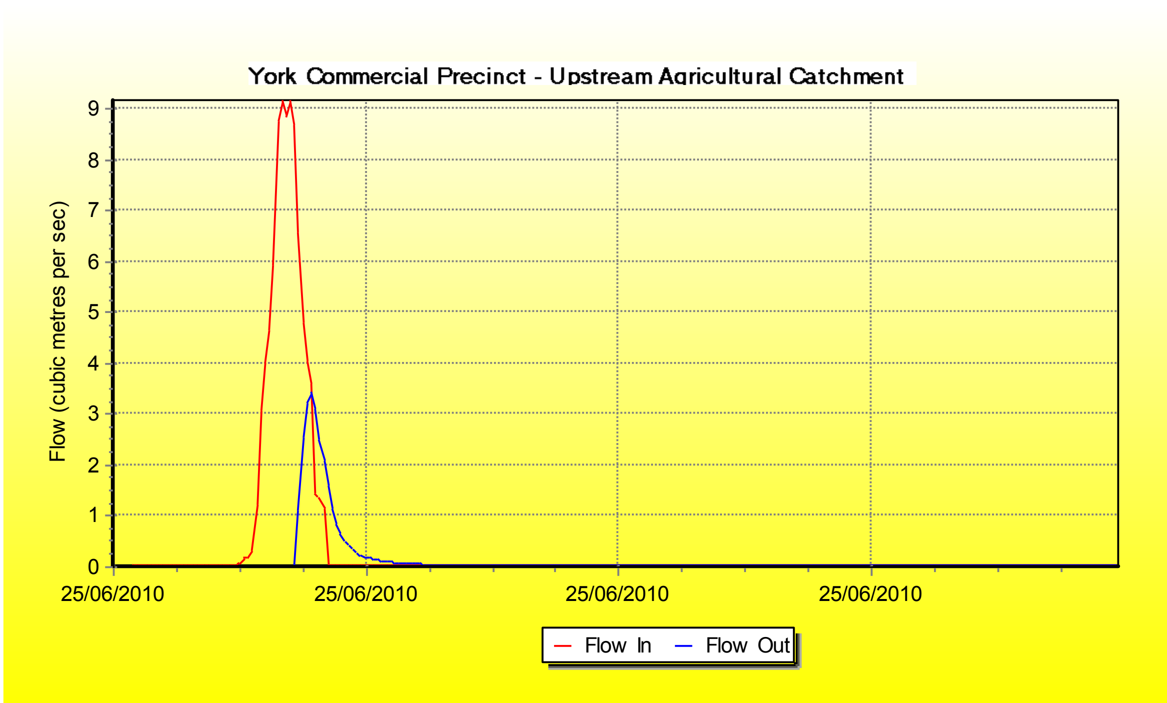


Figure 6. Modelled Peak Flow Hydrograph – Uster Rd York (Inflow and outflow - Town Dam)



Available dam storage capacity is a critical factor in determining the effectiveness of the dam in reducing peak flows discharging from the upstream catchment. Peak flows entering the York townsite (from the upstream rural catchment) under Ulster Road are largely dependent on the available capacity within the town dam during large flow events.

Currently the dam retains flow which is subsequently used to supplement reused water from the York wastewater treatment plant for watering of the town oval. Whilst use of the water for irrigation of the town oval is an effective water conservation strategy, it in turn reduces the potential effectiveness of the town dam in buffering the magnitude of peak flows discharging from the upstream agricultural catchment.

4.6.3 HECRAS Modelling

Hydraulic simulation was undertaken (using HEC-RAS – USGS 2010) to determine the capacity of the main flow path through the York commercial precinct. The flow simulation undertaken is considered preliminary as the topographical data used to populate the HEC-RAS model was derived from the available DEM of the town, which has an accuracy of approximately +/- 0.6 m. Ultimately, a more accurate topographical survey is recommended to provide a more robust assessment the capacity of the stormwater network. However, the assessment undertaken herein is considered suitable for the purposes of characterising overall system capacity and identifying choke points.

Simulations undertaken indicate that the overall flow capacity of current stormwater infrastructure between Ulster Road and Avon River is approximately 2.0 m^3/s. A flow of magnitude 2.0 m^3/s is predicted to exceed the capacity of the pipe located under South St, highlighting the primary choke point. Graphical outputs from HEC-RAS modelling (2, 4 & 8 m^3/s) are presented in Appendix A of this report. The capacity of most crossings between Ulster Road and Avon River is approximately 2.0 m^3/s, however culverts under Avon Terrace and the railway have a flow capacity exceeding 4 m^3/s and 8 m^3/s respectively.

Whilst the analysis undertaken is preliminary, it highlights the importance of the town dam located upstream of the York commercial precinct in regulating stormwater discharge from the upstream catchment. The analysis suggests the when the dam has sufficient capacity, it is largely effective in preventing flooding of areas adjacent to the flow path, which would otherwise occur during even moderate rainfall events. However, there is a degree of chance associated with the function of the town dam in protecting the downstream catchment from flooding. Under circumstances where a significant rainfall event occurs when the town dam was already at capacity, then significant inundation of areas adjacent to the main flow paths can be expected.

4.6.4 Recommendations

- *Undertake more detailed hydraulic modelling of the stormwater network capacity, including detailed topographical survey of stormwater network.*
- *In the absence of additional hydraulic modeling, restrict upstream catchment discharge to 2.0 m³/s.*
- *Develop vegetated swale network (and increase capacity of swales to assist in conveying and polishing stormwater prior to discharge to Bland's Pool.*
- *New stormwater infrastructure developed on the primary flow path should have a flow capacity of no less than 5.0 m³/,s consistent with the capacity of the culvert under Avon Terrace.*

4.7 Daliak Development

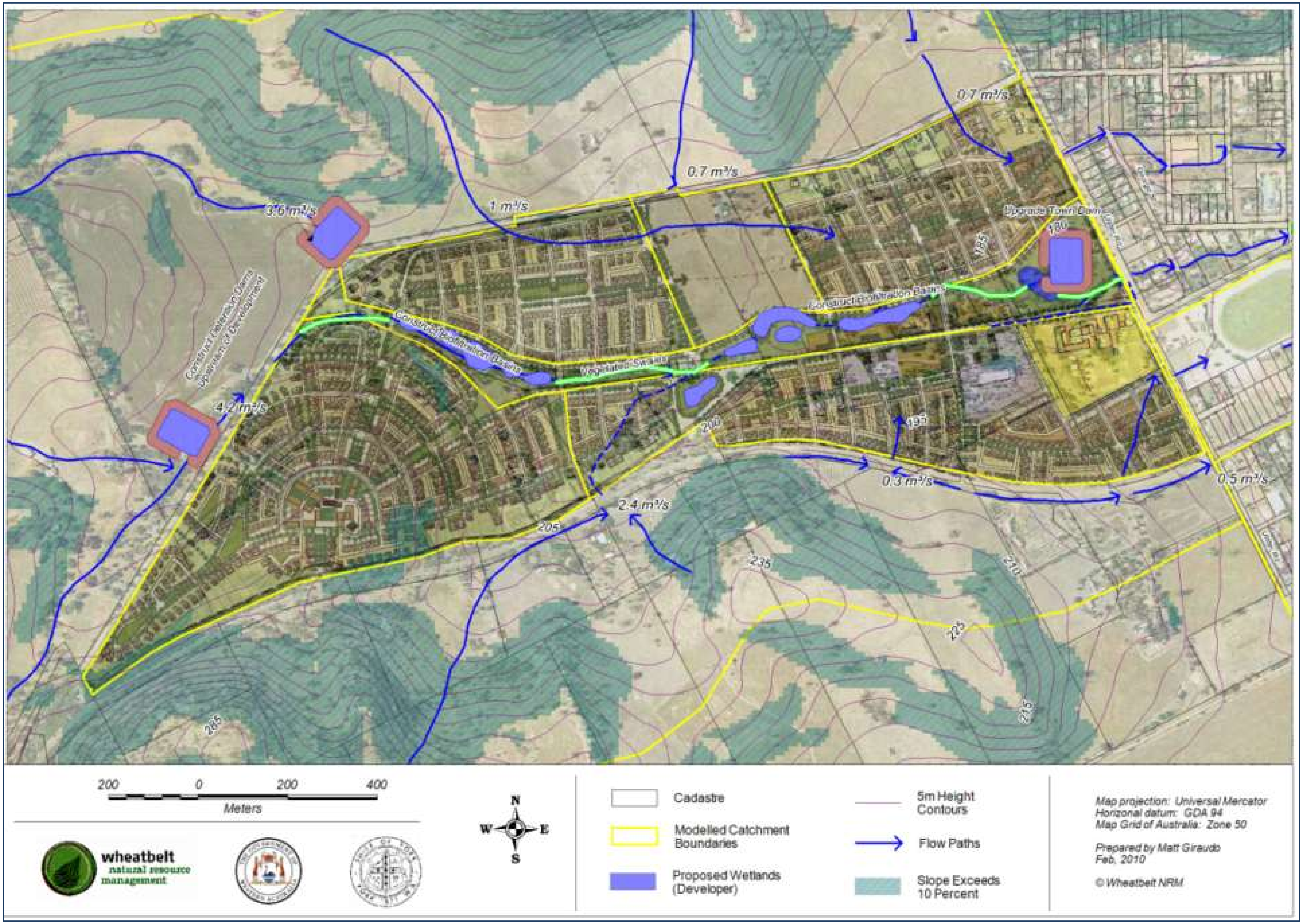
4.7.1 Background

Daliak is a proposed 142 ha residential / commercial development located immediately upstream of the York commercial catchment. Stormwater generated from the proposed development will discharge to the stormwater network downstream of Ulster Road. The Daliak development has the potential to increase flooding within the downstream commercial precinct, unless appropriate stormwater control mechanisms are adopted within the development. Stormwater generated from the proposed Daliak development will also generate additional nutrient and sediment load, presenting an additional hazard to downstream river pools including Bland and Mile Pools.

Appropriate stormwater infrastructure will need to be included within the development to ensure that peak flows discharging under Ulster Road do not exceed the recommended 2.0 m³/s identified in section 4.6.3 of this report. The Daliak development is contained within an 880 ha agricultural catchment, and receives inflow from the surrounding catchment from seven (7) separate points on its boundary. Hydrology modeling of the catchment was undertaken to estimate the likely 1:10 ARI peak flow entering the proposed Daliak development from the surrounding catchment. Estimated peak flows vary between 0.3 -- 4.2 m³ per second, presented in Figure 7.

Stormwater management associated with the Daliak development will need to take into account off-site stormwater discharging from the surrounding agricultural catchment to prevent flooding occurring within the development itself. Additional stormwater infrastructure will be required to reduce the impact of stormwater generated within the development on downstream assets.

Figure 7. Daliak Development



4.7.2 Nutrients

The Daliak development is characterised by relatively high density residential areas in addition to significant supporting services including medical and retail facilities. Daily time step modeling (MUSIC V4) for the proposed Daliak development was undertaken to assess likely annual flow and nutrient loads. Modelling indicates that the Daliak development is likely to generate more than twice the flow and nutrient loads compared to the downstream commercial/residential precinct, presenting considerable additional risks to the receiving environment. Results of the analysis are presented in Table 12.

Table 12. Model Flow and Nutrient Loads– Daliak Development

	Flow (ML/yr)	TP (kg/yr)	TN (kg/Yr)
Commercial Precinct	130	35.7	287.0
Daliak Development	281	79.3	635

Stormwater polishing of flows generated from regular small rainfall events will be essential in managing water quality within the downstream high value Blands Pool. Blands Pool is already considered eutrophic, and potential additional nutrient discharge from the Daliak development presents significant additional environmental risks to Bland and other downstream river pools.

Establishment of biofiltration basins with the capacity to filter the 1 year / 1 hour flow will be essential in protecting sensitive downstream environments from likely negative impacts associated with the development. Preliminary modelling indicates that the biofiltration pond(s) should have a capacity of approximately 10 ML, equivalent to the modelled discharge resulting from a 1 year / 1 hour rainfall event.

Water quality targets for stormwater discharge from the Daliak development should be 0.1 mg/L and 1.0 mg/L for TP and TN respectively, consistent with targets set by Wheatbelt NRM (WNRM 2010). It is considered that purpose built nutrient stripping infrastructure will be essential in achieving recommended water quality discharge targets.

4.7.3 Peak Flows

Management of peak flows discharging from the Daliak development will be essential in protecting downstream infrastructure from additional flooding associated with stormwater discharge from the proposed development.

Peak flow modelling undertaken for the Daliak development indicate that the 1:10 ARI stormwater discharge from the development itself (assuming no discharge from the surrounding agricultural catchment) would be approximately 6.0 m^3/s for the 1 hour storm event. If modelling includes discharge for the surrounding agricultural catchment, then peak flow discharging for a 1:10 ARI event is estimated to exceed 8.0 m^3/s. The 1:1 ARI event is estimated to generate 2.4 m^3/s, which is likely to exceed the capacity of the downstream stormwater network (refer Section 4.6.3).

If allowed to discharge unregulated, stormwater from the Daliak development would swamp the downstream stormwater network resulting in frequent and severe flooding of the downstream residential and commercial precinct.

Preliminary hydraulic modelling undertaken indicates that additional detention storage associated with the Daliak development will be required to protect downstream residential and commercial properties from additional flooding. It is estimated that two detention structures, in the order of 40 -- 45 ML will be required upstream of the development, to reduce peak flows discharging from the upstream agricultural catchments (refer Figure 7).

An additional 45 – 60 ML detention storage is estimated to be required downstream of the development, and upstream of Ulster Road to further regulate discharge from the proposed development and upstream agricultural catchments. Detention storages are assumed to discharge over a 24 -- 72 hour period, allowing full capacity for regulation of subsequent rainfall events.

More detailed hydrologic modelling is recommended during subsequent planning phases of the proposed subdivision. However, it is recommended that discharge from the development, including that from the upstream agricultural catchment should not exceed 2.0 m³/s, consistent with the current estimated downstream flow capacity.

4.7.4 Recommendations

- *Discharge from the Daliak development, including that from the upstream agricultural catchment should not exceed 2.0 m³/s.*
- *Water quality targets for stormwater discharge from the Daliak development should be 0.1 mg/L and 1.0 mg/L for total phosphorus and total nitrogen respectively.*

4.8 Henrietta Street Catchment

The Henrietta St subcatchment contains approximately 50 ha of residential and light industrial areas, in addition to a small upstream agricultural catchment of approximately 38 ha.

Preliminary MUSIC (daily time step) modelling indicates that proposed infill development within the Henrietta St subcatchment will result in approximately a 15% increase in nutrient discharge. The relatively low percentage increase in nutrient discharge from the subcatchment is a function of the limited capacity for infill development within the Henrietta St subcatchment (refer Table 13).

Table 13. Modelled Average Annual Flow and Nutrient Load- Henrietta Street Catchment

	Flow (ML)	TSS (kg)	TP (kg)	TN (kg)
Pre	70	12,600	18.9	155
Post	76	15,100	20.9	179
Increase	9%	20%	11%	15%

Currently, flow discharging from culverts under South Street enters a 350 m swale prior to discharging to the Avon River at Blands Pool. Extension of this swale to produce a meandering flow path prior to discharging to the Avon River is recommended. Enhancement of the current swale will provide a mechanism for stormwater polishing flows discharging from the upstream light industrial area.

Modelling undertaken indicates that enhancement of the current swale would result in a 90% reduction in TSS, a 50% reduction in TP and a 26% reduction in TN. Given that this catchment contains an industrial precinct it is considered that flows are likely to contain a range of potential contaminant above and a beyond those modelled. It is considered that the swale is likely to be reasonably effective in removing a range of contaminants due to its capacity to remove TSS, a function of the length of the swale itself.

4.8.1 Recommendations

- Enhancement of the 350 m swale located between South St and the river.

Figure 8 Henrietta St Stormwater Catchment

4.9 Eastern Residential Precincts

Preliminary nutrient and hydrology modelling was undertaken of the residential stormwater catchments located east of the Avon River. The analysis was undertaken as a means of assessing the potential impact of protected infill development east of the Avon River. Modelling included daily time step MUSIC model, for the period 1999 -- 2006 to coincide with the period of water quality monitoring undertaken within the Avon River by the Department of Water.

The eastern residential subcatchments within York are characterised by a series of parallel discrete stormwater catchments discharging to the Avon River. For the purposes of presentation, modelling results are presented based on the river pools into which stormwater subcatchments discharge, including Blands and Mile Pools.

4.9.1 Blands Pool

There are approximately 85 ha of residential precincts located east of Blands Pool, consisting of residential zoning density from R 25 to R 40. There exist significant potential for infill development within these subcatchments, with modelling indicating a 42% increase in total discharge from the catchment once development capacity is reached, when compared the current conditions (refer Table 14). Modelling also indicates that proposed infill development will result in a 66% increase in total suspended sediment and a 180% increase in TP discharge from urban subcatchments located east of Blands Pool (refer Table 14).

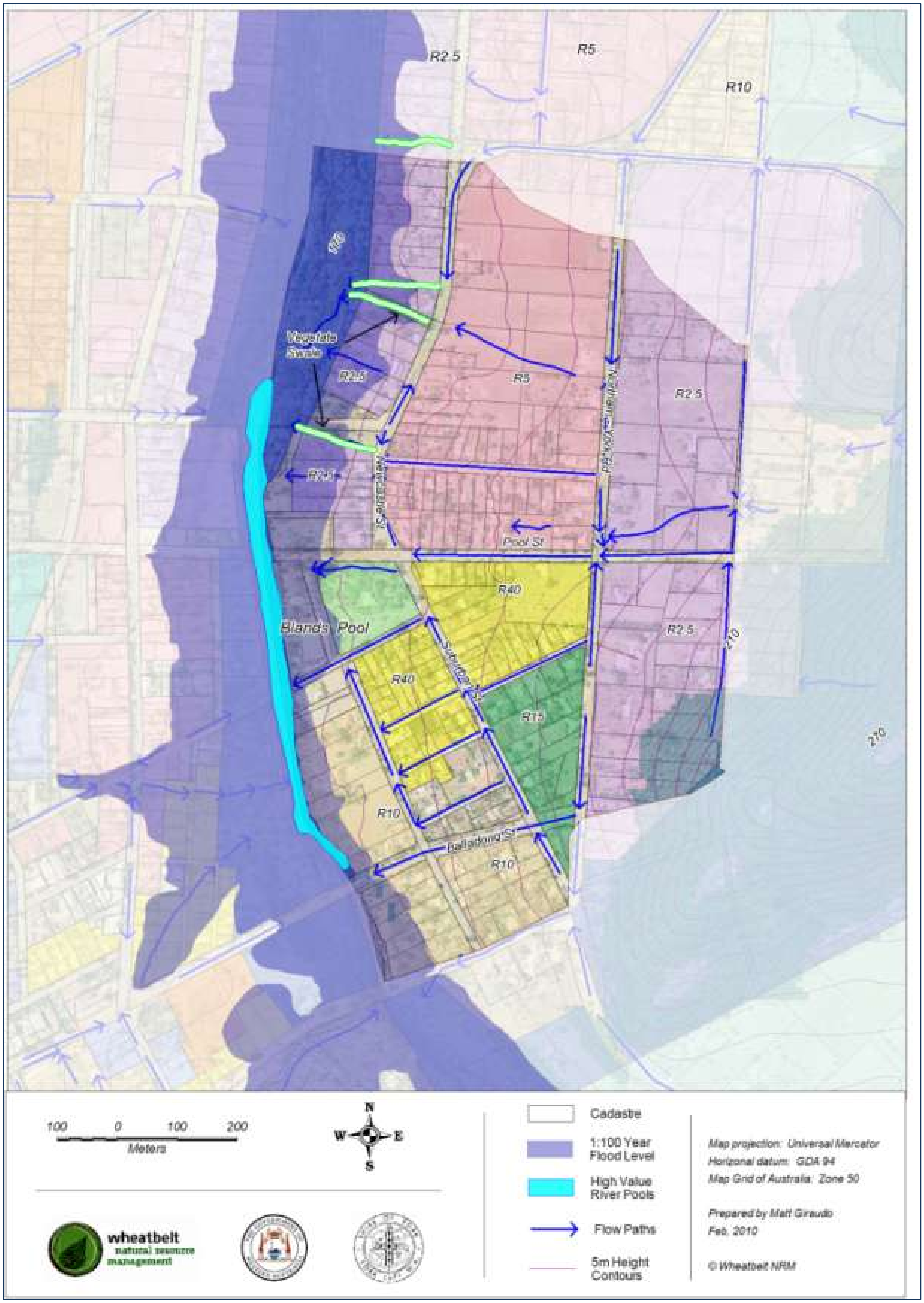
Table 14. Projected Increase in Flow and Nutrient Loads– East of Blands Pool

	Flow (ML)	TSS (kg)	TP (kg)	TN (kg)
Current Conditions	*79.2*	*60,290*	*15.9*	*152*
Proposed Infill Development	*112.6*	*100,170*	*28.9*	*252*
Projected Increase	*42%*	*66%*	*182%*	*166%*

The projected increase in suspended sediment and nutrients represents a considerable hazard to Blands Pool and the immediate downstream environment. The potential to construct infrastructure to improve stormwater quality is limited by the orientation of the urban catchment to the receiving body, however it is possible to vegetate swales located immediately upstream of the river pool to achieve partial improvement in water quality.

Modelling was undertaken to assess the effectiveness of the potential construction of three 100 – 130 m vegetated swales located to filter flows from the northern section of the catchment. Modelling indicates that implementation of the swales is likely to reduce total discharge of TSS by 50%, TP by 25% and TN by an estimated 8%.

Figure 9. Bland Pool East Sormwater Subcatchment



4.9.2 Mile Pool

There is approximately 78ha of residential catchment with zoning of mainly R5 and R10, with a small area of R2.5 located on the eastern side of the river that drains directly to Mile Pool. This residential area remains relatively undeveloped at the time of this study, and modelling indicates that infill development is likely to result in a 94% increase in flow and a 90% increase in TSS and TP within stormwater discharge. Outcomes of daily time step modeling undertaken from the subcatchments is presented in Table 15.

Table 15. Projected Increase in Flow and Nutrient Loads– East of Mile Pool

	Flow (ML)	TSS (kg)	TP (kg)	TN (kg)
Current Conditions	74	10,050	14.4	143
Proposed in fill development	144	19,200	27.2	226
Project Increase	94%	91%	89%	58%

The stormwater subcatchment is characterised by a series of unstable channel outlets to the Avon River, some of which display a high level of instability. The outfall at Cowan Street is particularly unstable, displaying severe erosion, and discharges directly to Mile Pool (refer Figure 10). Stabilisation of the outfall through the construction of an appropriate drop or centripetal structure is highly recommended.

4.9.3 Recommendations

- *Stablise and vegetated swales upstream on river pools to reduce erosion of river bank and reduce nutrient and suspended sediment load.*
- *Construct drop structures to alleviate severe bank erosion at swale entry points, particularly associated with the Cowan Street outfall.*

Figure 10. Cowan Street Outfall.

4.10 York Estates

York Estate is a relatively recent subdivision located on the east side of the Avon River, discharging downstream of Mile Pool. The 63 ha catchment is zoned R5/10 and discharges to a constructed dam prior to overflowing to the Avon River.

Modelling was undertaken to provide an indication of the flow and water quality likely to discharge from the subdivision. Outputs from the daily time step model for the York estate are presented in Table 16. The analysis undertaken indicates the development of the subdivision will result in a large proportional increase in TSS, TP and TN when compared to the pre-existing landuse. The most significant increase is likely to be that of TP, projected to increase from approximately 3 kg/yr to 22 kg/yr.

Table 16. Projected Increase in Flow and Nutrient Loads– York Estate

	Flow (ML)	TSS (kg)	TP (kg)	TN (kg)
Current Conditions	*58*	*7,290*	*3.0*	*101.0*
Estate Yield	*93*	*15,870*	*22.0*	*195.0*
Outflow *(Dam)*	*91*	*4,510*	*15*	*170*
Increase due to Estate *(Dam out flow)*	*57%*	*-38%*	*400%*	*52%*

Assumes dam is modified to release flow after temporary storage.

A retention dam has been constructed downstream of the subdivision, designed to intercept flow prior to discharge to the Avon River. The dam volume was estimated at approximately 3,500 cubic m (3.5 ML). Modelled discharge from the York Estate catchment is presented in Table 17. The analysis indicates that the dam has been design to contain approximately a 1:5 ARI, 1hr stromwater discharge. However the dam is designed as a retention structure, and daily timestep modelling for the period 1999 – 2009 indicates that the dam overflows to the Avon River after filling in the early part of the season. It is estimated that total annual discharge from the catchment in the order of 90 ML, significantly greater than the estimated dam capacity of 3.5 ML.

Table 17. Modelled Volume of Discharge (ML) from developed York Estate

	1hr Event	2hr Event	3 hr Event
1:1 ARI	*2.2*	*3.9*	*4.6*
1:5 ARI	*4.1*	*5.2*	*6.2*
1:10 ARI	*4.9*	*6.2*	*7.4*

Modelled results presented in Table 16 assumes that the dam is modified to behave as a detention structure, releasing flows through a 200 mm pipe allowing for a nominal detention time of approximately 12 hrs. This analysis indicates that the dam could result in a significant reduction in TSS, with sediment precipitating out within the dam. Modelling undertaken indicates that the retention dam would result in a reduction in TP discharging from the subdivision fro 22 kg/yr to approximately 14 kg/yr, assuming a relatively high proportion of TP discharging from the site is in particulate form.

The current construction of the dam is considered to have limited impact over nutrient discharge and therefore limited benefit to the immediate downstream environment. The reason is that the health of river pools is particularly sensitive to nutrient concentration entering the river during the latter part of the flow season. If the dam continues to operate as a retention structure (holding and not releasing inflow) it will be full during the latter part of the flow period. As a result late season discharge will simply flow in and then immediately out of the dam, resulting in virtually no late season nutrient abatement.

Reducing late season nutrient concentrations within stormwater is considered critically important in maintaining health of the downstream river environments. The water quality entering river pools during the late winter – spring period has particular significance to the health of river pools as there are limited opportunities for dilution of nutrients contained within inflow throughout the spring and summer period.

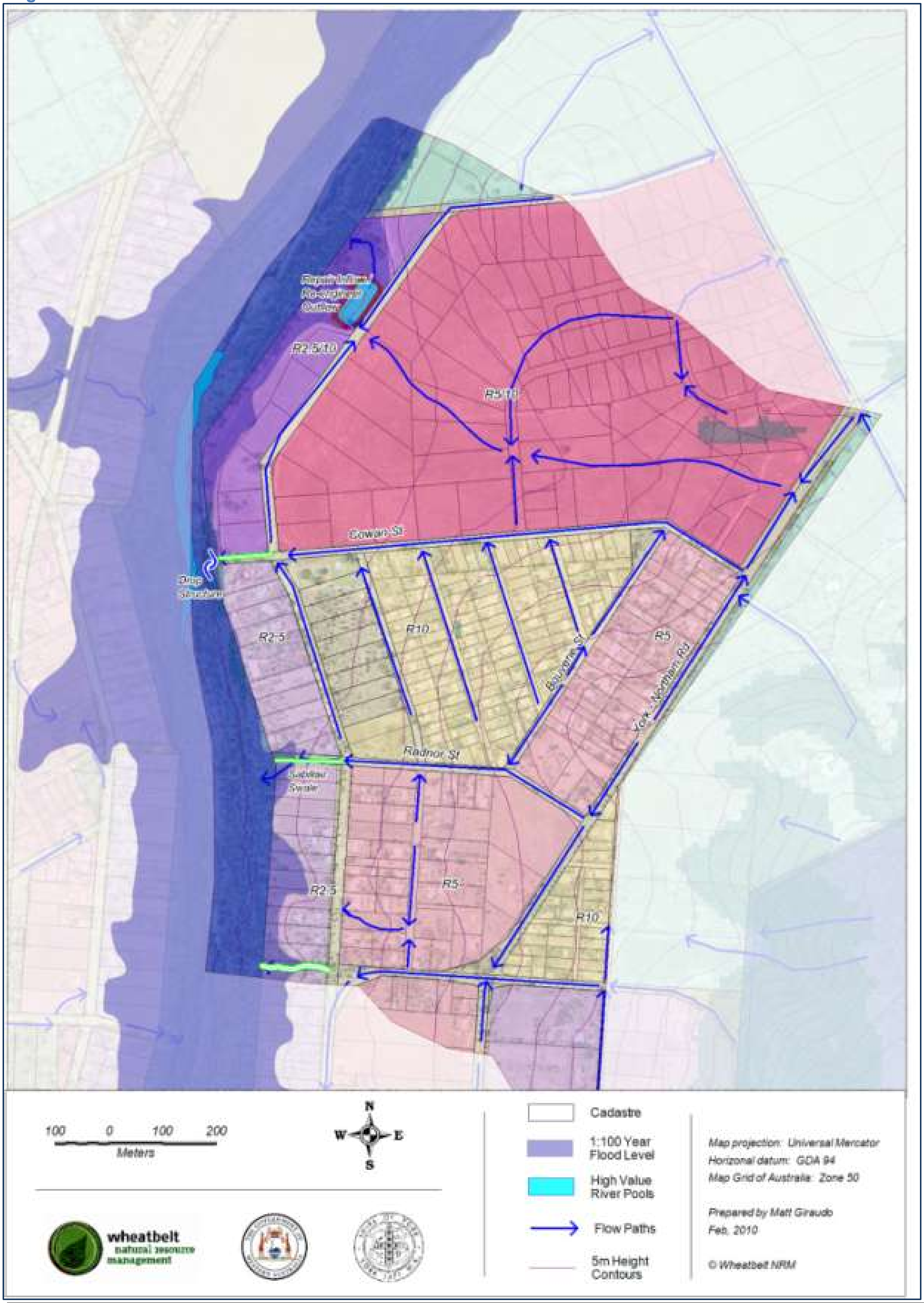
In addition, poor construction of the inlet channel to the dam has resulted in undermining of the rock lined inlet, due to the absence of a cut off wall at the end of the channel, at the outfall into the dam (refer Figure 11).

Figure 11 Undermining of Inlet Channel

4.10.1 Recommendations

- *Repair inlet structure to dam.*
- *Re-engineer outflow to allow dam to discharge after setting of sediment.*

Figure 12. Mile Pool East Sormwater Subcatchment



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Appendix A: River Pools of the Shire of York

Pool	*Status*	*Size*	*Significant Ecological Value **
Wilberforce	Minimal sediment – due to Church Pool upstream. Pool contains a strip of riparian vegetation with no understory.	820 m x 3m	Yes
Church	Also known as Mackie Pool. Pool contains approximately 400 m of sediment. Pool receives sediment directly from immediate catchment	750 m x 2m	No
Little	Filled with sediment by 1976.	1,000m long	No
Tipperary	Est. 85% filled with sediment. The pool has minimal fringing vegetation with some revegetation undertaken during the 1990s.	340 m x 1.5 m	Yes
Mears	Attractive with public access – est. pool 70% filled with sediment . Pool has minimal riparian vegetation. High nutrient levels lead to algal blooms.	350m x 1.25m	Yes
One Mile	Partially filled with sediment and at risk of further filling. Highly polluted due to nutrient load, however popular for picnic. Pool may be self scouring.	200m x 2.0m	Yes
Blands (Town)	Contains a sand slug in the centre of the pool. High nutrient content, water is eutrophic. Banks stable	710 m x 2.0m	Yes
Railway	Rapidly filling with sediment and banks eroding. Protects downstream Bland's Pool from receiving sediment.	170 m x 2.0 m	Yes
Cold Harbour	Completely filled with sediment, but banks stable.	Filled	No
Mt Hardy	Completely filled with sediment, but banks stable.	Filled	No
Gwambygine	One of the few remaining pools in good natural condition. Deepest pool upstream of York.	800m x 4 m	Yes
Oakover	Pool contains a heavy, yet stable sediment load.	Filled	No

Appendix B

HEC-RAS Modelling Output

Figure 13. HEC-RAS Output – 2 m^3/s – York Commercial Precinct

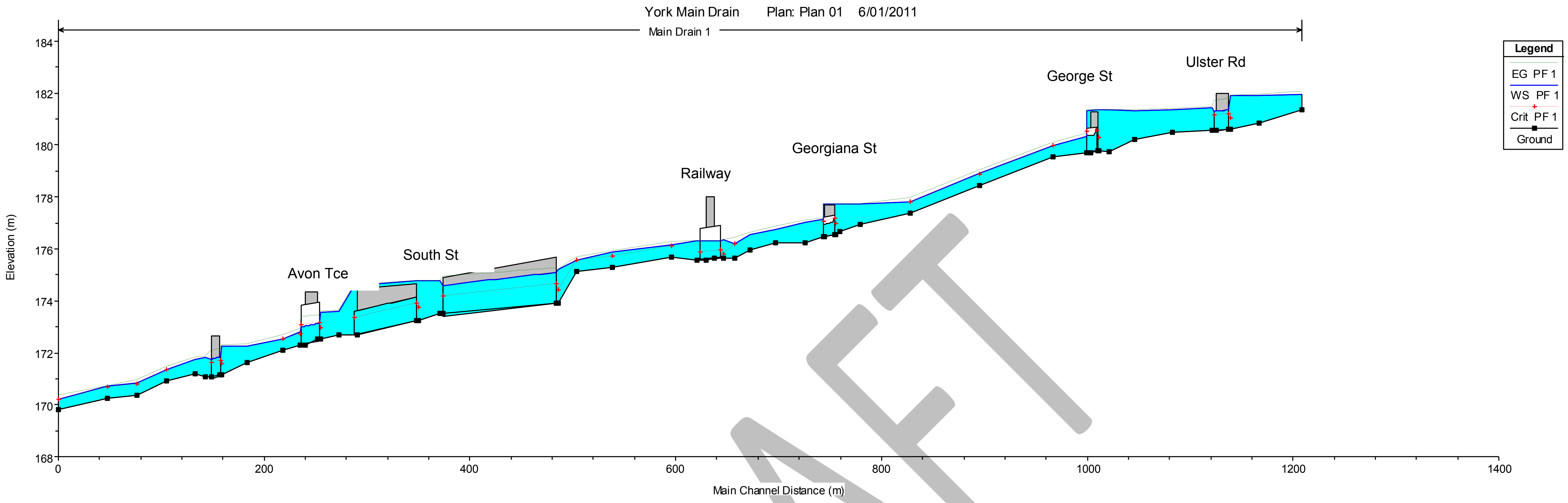

Figure 14 HEC-RAS Output – 4 m^3/s – York Commercial Precinct

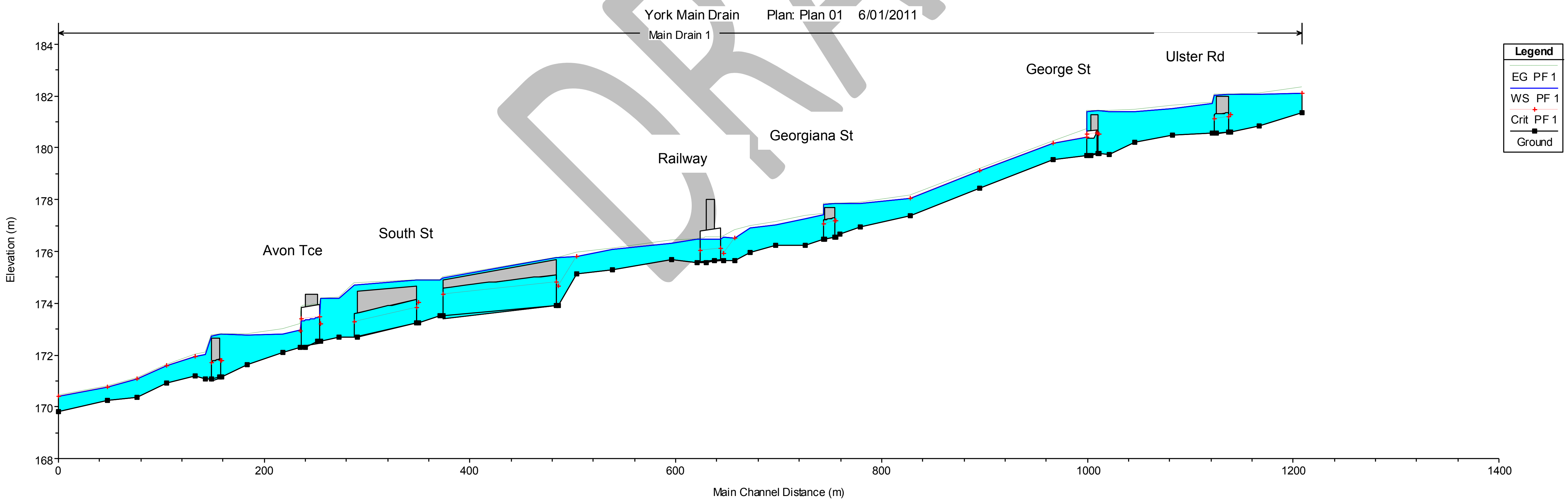

Figure 15 HEC-RAS Output – 8 m3/s – York Commercial Precinct