

**INFRASTRUCTURE FEASIBILITY REPORT**

**Arrowtown South Private Plan Change**

12 AUGUST 2009

This document has been prepared in support of the Arrowtown South Private Plan Change. No liability is accepted by this company or any employee or sub-consultant of this company with respect to its use by any other person.

This disclaimer shall apply notwithstanding that the report may be made available to other persons for an application for permission or approval to fulfil a legal requirement.

## QUALITY ASSURANCE STATEMENT

<b>PROJECT MANAGER</b> Peter White	<b>REVIEWED BY</b> Peter White and Lee Paterson
<b>PREPARED BY</b> Alec Mitchell	<b>APPROVED FOR ISSUE BY</b> Peter White

### DUNEDIN

Level 3, John Wickliffe House, 265 Princes Street, PO Box 4, Dunedin 9054, New Zealand  
P + 64-3-477 0885, F + 64-3-477 0616

## REVISION SCHEDULE

Rev No	Date	Description	Prepared By	Reviewed By	Approved By
1	5/6/09		Alec Mitchell	Peter White	
2	16/7/09	Revised	Alec Mitchell	Peter White	
3	12/8/09	200 sections	Alec Mitchell	Peter White	

# Arrowtown South Private Plan Change

## CONTENTS

1	Introduction .....	1
1.1	Purpose of report .....	1
1.2	Background .....	1
2	Water Supply .....	2
2.1	Existing Arrowtown Water Supply Network .....	2
2.2	Future Growth .....	2
2.3	Water Demand .....	2
2.4	Water Storage Capacity .....	3
2.5	Reticulation Network Capacity .....	3
2.6	Conclusion .....	4
3	Wastewater .....	5
3.1	Existing Arrowtown Wastewater System .....	5
3.2	Wastewater Collection .....	5
3.3	Wastewater Generation .....	5
3.4	Wastewater Network Analysis .....	6
3.4.1	Current Model .....	6
3.4.2	Model in Development .....	8
3.5	Conclusion .....	8
4	Ground Conditions .....	9
4.1	Site Description .....	9
4.2	Site Investigation .....	9
5	Stormwater Disposal .....	10
5.1	Current Drainage Overview .....	10
5.2	Potential Increase in Peak Runoff .....	10
5.3	Flood Risk .....	11
5.4	Stormwater Quality .....	11
Appendix A:	Concept Site Layout .....	12

Appendix B:	Arrowtown Services .....	13
Appendix C:	Reports .....	14
Appendix D:	Soil Logs .....	15
Appendix E:	Site Survey .....	16

## **LIST OF TABLES**

Table 2-1 : Availability of Peak Hour Pressure .....	4
Table 3-1 : Arrowtown Wastewater Network .....	6

# 1 Introduction

## 1.1 Purpose of report

This engineering assessment has been prepared to support the application for a Private Plan Change to allow residential development of the land at the eastern end of Arrowtown. This is referred to as the Arrowtown South Private Plan Change.

The report addresses the feasibility of servicing residential development in this area. This has been based on a notional concept for the development comprising of up to 200 residential units.

The assessment addresses all engineering issues including water supply for the properties, wastewater collection, surface water runoff and flood risk. This assessment includes the need for new services as required to service the developments in compliance with the Queenstown Lakes District Councils Proposed District Plan and Subdivision Standards.

## 1.2 Background

The area of the proposed Arrowtown South Private Plan Change lies between McDonnell Road and Centennial Avenue. The main area to be rezoned is approximately 30.8 hectares, comprising of the Mt Soho block, the Adamson Block and several smaller adjacent blocks.

A development concept has been prepared (see Appendix A) for this area. This concept allows for approximately 200 residential units with limited small commercial area, and has been used as the basis of the assessment. However, the assessment is equally applicable to alternative developments of a similar scale.

The area of the proposed plan change is currently zoned as Rural General and is un-serviced by reticulated infrastructure. The existing houses in this area are serviced by bore water and on-site sewage treatment and disposal.

Development of this land will require that new infrastructure be established.

Servicing of the development is proposed as follows:

- Water supply to be connected to the existing Arrowtown reticulated supply.
- Wastewater pumped or gravity fed to existing pump stations in Arrowtown's wastewater network
- Surface water drainage to an unnamed tributary of the Arrow River

These means of servicing are further detailed in the relevant sections of this report.

This report acknowledges and takes into account the findings of the assessment provided by Market Economics Ltd.

This report does not cover power, roading or telecommunications.

## 2 Water Supply

### 2.1 Existing Arrowtown Water Supply Network

The area of the Arrowtown South Private Plan Change is adjacent to the Arrowtown Water Supply. The Arrowtown potable water reticulation network is supplied from two bores outside of town that pump to a storage tank; water is then fed to the town reticulation via a booster pump.

The nearest suitable connection points to the existing Arrowtown reticulation network adjacent to the area of the proposed plan change are a looped 150 mm watermain in Centennial Avenue and a looped 200mm watermain in McDonnell Road.

These connection points are shown in Appendix B.

### 2.2 Future Growth

The Arrowtown water model currently administered for the QLDC by Tonkin and Taylor, does not have an allowance for future growth within the network.

Tonkin and Taylor advised that QLDC water modelling practice is based upon current population numbers and no allowance has been made for future population increase or the resulting change in demand. Using the information from the Market Economics report, we identified the sections nearby the Arrowtown South development that could be readily be built upon, and asked T&T to incorporate the demand from these into the model for the purposes of assessing the potential impact of Arrowtown South Private Plan Change. These additional 42 lots in the Advance Terrace area would have the most significant impact upon the available pressure within Plan Change area. These 42 lots are a sizeable proportion of the total of the approximately 138 lots available to be built upon within the existing Residential Arrowtown Historic Zone and Low Density Residential Zone.

### 2.3 Water Demand

The Queenstown Lakes District Council (QLDC) uses NZS 4404:2004 with amendments as its standard for new developments and engineering work. This allows for the following water demands:

- Average Daily Flow 700 litres/head/day
- Hourly Peaking Factor 6.6 (outside Queenstown)
- 3 Persons per dwelling

Daily demand is therefore assessed at 420 m<sup>3</sup> for the concept of 200 residential units.

## 2.4 Water Storage Capacity

Arrowtown Water Supply currently has a 1,450 cubic metre storage reservoir supplying the town's 1,254 dwellings. This is used to provide reserve storage for normal demand and storage for fire fighting.

The New Zealand Fire Service Firefighting Water Supplies Code of Practice SNZ PAS 4509:2008 requires that 180m<sup>3</sup> of water is stored and available for fire fighting to meet a FW 3 water supply classification. This is based upon a Fire Hazard Category (FHC) 2, with a maximum firecell size of 399 m<sup>2</sup>. This classification is appropriate for the existing Arrowtown Township and the proposed area to be rezoned, as there are commercial and community facilities of a moderate size in the existing township. There is no increase in the water storage required for fire fighting due to the proposed rezoning.

Requirement for reserve storage within Queenstown Lakes District are normally 8 hrs at average demand. The proposed 200 lots of the Arrowtown South Private Plan Change and an additional 42 dwellings on Advance Terrace would place an additional demand of 140 m<sup>3</sup> and 29 m<sup>3</sup> respectively over the 8 hours on the backup storage capacity. This brings the required storage volume to meet 8 hours average daily flow to 1,047 m<sup>3</sup>, along with the 180 m<sup>3</sup> for fire fighting, giving a net total storage requirement of 1,227 m<sup>3</sup>.

The 1,450 m<sup>3</sup> tank has sufficient capacity to provide more than 8 hours storage for the combined Arrowtown and rezoned area total dwelling number of 1,496 and the 180 m<sup>3</sup> of storage required for fire fighting in the FW3 classification.

No upgrade of the existing Arrowtown water storage is therefore required to service Arrowtown South Private Plan Change.

## 2.5 Reticulation Network Capacity

Tonkin and Taylor Ltd administer the water supply network model for Arrowtown Water Supply Scheme on behalf of the QLDC. They were commissioned by MWH to analyse the potential impact upon the existing network by the concept design of the Arrowtown South Proposed Private Plan Change.

The report from Tonkin and Taylor is included in Appendix C, along with the concept layout of reticulation mains.

The model used is a WaterGEMS steady state model, last updated in 2007.

The demand criteria for the Arrowtown reticulation used for the modelling were:

- Peak Hour Flow = 6.6 x ADF to meet the 300 kPa minimum residual pressure at the household connection.
- Peak Day Flow = 3.3 x ADF
- Fire flows of 12.5 l/s and 100 kPa minimum residual pressures at hydrants within the new development.

The fire flows used are those required for an FW2 classification under the NZFS Fire Fighting Water Supplies Code of Practice. This is appropriate for residential areas. The FW2 classification requirements from SNZ PAS 4509:2008 was considered appropriate for the proposed development as the rezoning is for residential. No significant commercial property has been considered that would require a greater fire classification.

Tonkin and Taylor were asked to consider any minimum requirements for the reticulation network in the new development and any upgrades required to the township's existing network. They were provided with

a proposed site layout and topographic survey, to consider the impact of elevation upon available pressure.

Key results reported by Tonkin and Taylor are summarised in Table 2.1

**Table 2-1 : Availability of Peak Hour Pressure**

	<b>Minimum Residual Pressure (kPa)</b>	<b>Fire Flow available (l/s)</b>
<b>Adamson Block – 43 lots</b>	<b>680 &gt; 300 OK</b>	<b>25</b>
<b>Mt Soho – 157 lots</b>	<b>330 &gt; 300 OK</b>	<b>25</b>

The model showed that Peak Hour Demand could be met within the development with a residual pressure of at least 330 kPa. Hence the QLDC requirement for a minimum service pressure of 300 kPa is met. The model also demonstrated that the minimum service pressure for Arrowtown, including the 42 lots in Advance Terrace, can also be met with the Arrowtown South Private Plan Change area connected.

It should be noted that these levels of service can be met while still having spare capacity with the VSD booster pumps.

Modelling also showed that Class FW2 fire flows can be achieved on all mains within the development. This equates to 12.5 l/s being available from hydrants within 135m of any lot and a further 12.5 l/s being available within 270 m during Peak Day Demand.

## 2.6 Conclusion

The area of the proposed Arrowtown South Private Plan Change can be supplied with potable water and fire fighting water supply, meeting QLDC standards, from the Arrowtown Water Supply Scheme.

No upgrade of the existing Arrowtown water reticulation network is required to supply the Arrowtown South Private Plan Change while maintaining the required level of service in Arrowtown.

## **3 Wastewater**

### **3.1 Existing Arrowtown Wastewater System**

The Arrowtown Wastewater reticulation network is adjacent to the area of the Arrowtown South Private Plan Change.

The current wastewater system in the vicinity of the proposed development comprises a gravity sewer pipe network as well as two pump stations located in McDonnell Road and in Norfolk Street. McDonnell Road Pump Station lifts to the gravity network at Cotter Avenue and from there, gravitates to Norfolk Street Pump Station. Norfolk Street Pump Station then pumps in turn to Bendemeer (Lake Hayes PS 2) Pump Station. This then pumps the wastewater to the Shotover oxidization ponds. The Norfolk Street Pump Station also receives flow from surrounding area, including Centennial Avenue.

A schematic of the pump stations layout is included in Appendix B along with a GIS layout of the foul sewer network.

### **3.2 Wastewater Collection**

Using the concept layout for the new development and the topographic site survey, a conceptual gravity pipe network was determined.

Wastewater can be collected from the development by a network of gravity pipes. Some pumping may be required within the development area to lift wastewater to discharge to the Arrowtown reticulation.

Allowing for the topography of the site, two connection points to the Arrowtown reticulation are likely to be required; one at McDonnell Road for the western part of the new development and one at Centennial Avenue for the eastern part.

The western portion of the site comprises of approximately 130 lots that would connect to the McDonnell Road Pump Station. Wastewater would then be pumped into the gravity network at Cotter Avenue and flows on to the Norfolk Street Pump Station.

The eastern portion of the site comprising approximately 70 lots can connect to the gravity reticulation at Centennial Avenue then gravitate to the Norfolk Street Pump Station.

### **3.3 Wastewater Generation**

Estimates of wastewater quantities are based upon NZS 4404:2004 Code of subdivision and the QLDC amendments.

The following design parameters are specified by the QLDC for residential development within the district:

- Average Dry Weather Flow: 300 l/s
- Dry Weather Diurnal PF: 2.5
- Dilution/ Infiltration factor: 2
- Number of people per dwelling: 3.5

These were used to consider the additional flows likely to occur following the areas rezoning and subsequent development.

The additional flows into the Arrowtown wastewater network were calculated by using the above figures in conjunction with an additional 130 lots feeding to the McDonnell Road Pump Station, and flow from all 200 lots contributing to the peak flow to the Norfolk Street Pump Station. This equated to 7.9 l/s of additional peak inflow to McDonnell Road Pump Station and 12.1 l/s of additional peak inflow to Norfolk Street Pump Station.

### 3.4 Wastewater Network Analysis

#### 3.4.1 Current Model

##### 3.4.1.1 Pumped Network

QLDC uses Rationale Ltd to administer their wastewater network model. Rationale were commissioned to report on the impact of an earlier concept of developing 90 residential lots on the Mt Soho Trust block in September 2007. This concept would have seen an additional 56 lots flowing to McDonnell Road Pump Station and 34 joining the gravity network at Centennial Avenue.

Rationale have advised that there have been not upgrades within the Arrowtown wastewater network since the September 2007 report (refer to Appendix C) was written. Data contained in that report has therefore been used to assess the potential impact of the proposed Plan Change on the Arrowtown wastewater network.

The network model used by Rationale for Arrowtown includes population growth projections to 2026 that were agreed to be used by QLDC as part of their 2006 Strategic Review Verification of Wastewater Infrastructure. These were the population growth projections that were used in the Council's LTCCP. These may not necessarily agree with those growth projections described in the Market Economics report. However the Rationale model using these QLDC growth projections provide the best assessment currently available of the impact of the future growth on the wastewater network.

The 2026 peak wastewater flows have been used to demonstrate the ability of the current wastewater network to accommodate current and future flows, and identify any potential upgrades that may be required.

This is summarised in table 3-1

**Table 3-1 : Arrowtown Wastewater Network**

Item	Description (from QLDC GIS)	Current Capacity (l/s)	Estimated Peak Design Flows			Adequate for flows from the proposed plan change
			2026 <sup>1</sup> Peak Flow (l/s)	Peak Flow from Plan Change Area (l/s)	Potential future Peak flows with plan change (l/s)	
McDonnell Rd Pump Station	ASB 30HD	14.5 <sup>2</sup>	7.7	7.9	15.6	No
McDonnell Rd Rising Main	150mm uPVC	35 <sup>3</sup>	7.7	7.9	15.6	Yes
Norfolk St Pump Station	Flygt 3300	92 <sup>4</sup> (Duty/Assist)	70.2	12.1	82.3	Yes
Norfolk St Pump Station Rising Main	300mm uPVC	142 <sup>5</sup>	70.2	12.1	82.3	Yes
Bendemeer Pump Station	Flygt 3220	89.2 <sup>4</sup>	102.3	12.1	114.4	No

<sup>1</sup> From Rationale Report, September 2007

<sup>2</sup> From MWH Queenstown

<sup>3</sup> From QLDC GIS

<sup>4</sup> From QLDC SCADA data

<sup>5</sup> From Rationale Report, September 2007

New Bendemeer Pump Station, due to be installed June 09	Flygt 3301	80 <sup>6</sup> (Duty/Assist available)	102.3	12.1	114.4	Yes
Bendemeer Pump Station Rising main	375 mm uPVC	227 <sup>7</sup>	102.3	12.1	114.4	Yes

Pump capacity is the pump duty point

### McDonnell Street Pump Station

The total estimated flow into the pump station at McDonnell Road from the existing residential area and the Arrowtown South Private Plan Change area is greater than the duty point for the existing pumps installed.

This pump station is currently in the process of being upgraded with larger capacity pumps but these may not have sufficient capacity for the additional inflow from the Arrowtown South Private Plan Change area. The duty point of these new pumps should be confirmed during the detailed design stage.

The 150mm rising main has sufficient capacity to accommodate the estimated future flows.

### Norfolk Street Pump Station

Rationale have advised us that this pump station is run in a duty/assist pump arrangement. The duty point for a single pump is 66 l/s. The combined flow rate with two pumps in parallel is 92 l/s; this was taken from SCADA flow meter data from the rising main at this location. This is sufficient to accommodate the estimated 2026 inflows and the additional flow from the Private Plan Change area.

The pump station also has a significant amount of storage of approximately 115 m<sup>3</sup>.

The 300mm rising main has sufficient capacity to accommodate the estimated future flows.

### Bendemeer Pump Station (Lake Hayes PS 2)

We have been advised by GHD that the Bendemeer Pump Station is currently in the process of being upgraded.

The current pump station has a flow rate of 89.2 l/s and head of 40 m at the duty point.

The new pumps will be set up in a duty/assist arrangement. The single pump will have a duty point of 63.4 l/s at 56.3 m. GHD have advised us that the combined flow from these pumps will be limited to 80 l/s. It is noted that pump rate is less than the estimated 2006 Peak Wet Weather Flow of 85 l/s and the 2026 Peak Wet Weather Flow value of 102.3 l/s, as stated by Rationale in their report from September 2007. GHD believe that when combined with the large storage capacity at the pump station, of approximately 230 m<sup>3</sup>, that no inundation of the pumps will occur.

It should be noted that in accordance with current best practice, pumps should normally be sized to match the Peak Wet Weather Flow (PWWF), to prevent the pumps from being overwhelmed. The QLDC agreed to have the new pumps at Bendemeer (Lake Hayes PS2) sized to less than the PWWF to limit the number of starts of the pump.

As the existing PWWF to Lake Hayes PS2 exceeds the proposed pumps duty point, it is likely that the additional flows from the proposed development will increase the margin by which inflow potentially

<sup>6</sup> From GHD

<sup>7</sup> From Rationale Report, September 2007

exceeds the outflow. This will increase the number of starts required by the pumps, and decrease the emergency storage available at the pump station.

GHD have remarked that the pumps have a VSD drive with a manual override on the pumps to allow them to exceed the capped limit of 80 l/s, to ensure that no inundation of the pump station occurs during wet weather flow.

This control philosophy will need to be confirmed with the QLDC during the detailed design stage of the development.

The rising main from Lake Hayes PS2 is adequately sized to accommodate the estimated future flows.

#### *3.4.1.2 Gravity Network*

Rationale also carried out an analysis of the adjacent Arrowtown gravity foul sewers that would be affected by the development of the land within the area of the proposed plan change. For the 2007 proposal of 90 lots, it was found that there was sufficient capacity in the existing network.

They also considered the 2026 flows in the network and found that there was only one short section that would be beyond its design capacity, based upon a guide that depth of flow should not exceed 80%. This criteria is recommended for the design of new pipelines but when considering the capacity of existing pipelines, is unnecessary on top of the already included peaking factors. The peak design flow is still within the hydraulic capacity of the pipeline. There was no surcharging of the manhole and due to the short length; they considered this flow to be acceptable in the pipe.

No upgrades of the existing gravity sewer network are therefore required.

### **3.4.2 Model in Development**

Rationale has advised us they are in the process of developing a new dynamic model for the QLDC and are currently calibrating it against SCADA data. The new model must be peer reviewed prior to being available for use; this process typically takes two months. They have indicated that the new model will show additional capacity in the wastewater network over the old static model.

The new model will be population based instead of average occupancy per dwelling, as previously used.

## **3.5 Conclusion**

Some minor upgrades of the existing Arrowtown wastewater network will be required to accommodate the peak flows from the full development of the Arrowtown South Private Plan Change area, based upon current QLDC guidelines.

These minor upgrades should be discussed with QLDC to verify that they fit with the Councils LTCCP upgrades programme.

All this information should be confirmed prior to detailed design.

## **4 Ground Conditions**

### **4.1 Site Description**

The site is located at the eastern end of Arrowtown and lies between Centennial Avenue and McDonnell Road.

There are three distinct areas to the site.

A gently sloping higher terrace on the eastern part of the site runs parallel to Centennial Avenue. The western part of the site consists of valley floor, either side of a small tributary of the Arrowtown River. This area is bounded by McDonnell Road to its west. Between these two areas there is a ridge with an escarpment to its western flank. The escarpment is approximately a 1 in 2 slope at its steepest. This ridge does not run the entire length of the site, and a gentle slope to its southern flank allows easier access between the high and low lying land, at the southern end of the site.

The site survey is contained in Appendix E

### **4.2 Site Investigation**

Test pits have been dug at nine locations across the site. These have indicated that there are a range of conditions across the site. The logs are included in Appendix D

Sands and gravels, with some cobbles and boulders were encountered on the terrace.

Silts and sands were encountered by the creek. The pits close to the creek were quite waterlogged and the pits collapsed when the water drained out of the soil.

The area on the terraces, away from the creek, is suitable for building platforms, subject to normal inspection and foundation design. No issues were indicated for the trenching of services, other than that care may be required for trench support.

The areas closer to the creek will need a more detailed investigation prior to design being carried out for either roading or building platforms. Specific design may be required for the building foundations in this area. The stability of the soil would also be improved by draining the area.

## 5 Stormwater Disposal

### 5.1 Current Drainage Overview

An unnamed tributary of the Arrow River runs north to south through the area to be rezoned. Based upon the concept layout for the new development, it should be possible to drain the entire site to the creek.

The area of the new development is comprised of approximately 30.8 hectares of farmland, including the Adamson block.

The site is primarily gentle or moderately sloping, the notable exception to this being the spur that runs almost the full length of the site, north to south.

Approximately a third of the site lies on gently sloping valley floor either side of the creek and drains to the creek. The other parts comprises of a terrace that lies adjacent to Centennial Avenue and a ridge that splits the site roughly down the middle. This will require a more detailed design of road corridors to ensure that there is a route for stormwater to drain to the creek.

It is possible to provide a pipe and surface channel system to collect and drain water from the development that generally follows the existing overland drainage flow patterns. The drainage flow can be overland as far as possible. This approach makes the best use of the natural features of the site, as well as providing means to limit peak runoff and to treat potential containments in the stormwater runoff.

A detailed design of the stormwater management design is not necessary for this feasibility report and has not been carried out. A stormwater management system for this site is expected to comprise of the following features:

- Drainage of roads to surface swales or channels. These swales will be drained by sumps and pipe connections to surface water channels, or directly to those surface water channels if possible. In the immediate vicinity of the watercourse, the sumps will discharge directly.
- Courtyard areas adjacent to houses will be drained to sumps, with pipe connections to surface water channels.
- Building platforms will be provided with a connection to a piped collection system. Pipelines will discharge to surface water channels.
- Landscaping and stormwater ponds.
- Landscaped channels.

Given the proposals for drainage patterns and stormwater management, discharges of stormwater are expected to comply with the requirements for a Permitted Activity under the Regional Plan – Water and therefore consents from Otago Regional Council for stormwater discharges are not likely to be required. However, the stormwater design should be discussed with Otago Regional Council to confirm what consents are needed.

### 5.2 Potential Increase in Peak Runoff

The building of roads and other impervious areas associated with residential developments will cause an increase in the peak stormwater runoff from the site.

The peak runoff from the site has been calculated using the rational method as described in section E1 of the *New Zealand Building Code*. A return period of 5 years has been used in accordance with NZS 4404:2004 for a development of this type. The catchment has been assessed as currently mainly comprising of medium soakage soils with pasture and scrub cover. An area of the current catchment has also been assessed as including an urban catchment along McDonnell Road.

The current peak flow from the catchment was calculated to be approximately 1.1 m<sup>3</sup>/s, based upon a runoff coefficient of 0.3 for the undeveloped land and a time of concentration of 45 minutes.

The peak flow from the catchment including the new development was calculated using a runoff coefficient of 0.65 for the area of the Proposed Private Plan Change and a time of concentration of 10 minutes. The estimated peak runoff flow was calculated as 1.6 m<sup>3</sup>/s.

The proposed development has a land area of approximately 30.8 hectares, which is a significant proportion of the existing catchment of 75 hectares. This, combined with the higher impermeability and shorter time of concentration, hence more intense storm, leads to a greater peak runoff flow.

The increase in the flow from the new development is still relatively low, and the existing water course can be shaped to pass this increased flow.

This increase in peak runoff could be further mitigated during detailed design by use of surface drainage swales, landscaping and stormwater ponds, and in channel controls.

### **5.3 Flood Risk**

Within the area to be rezoned the only properties that may be at risk of flooding are those near the stream. This will require further assessment subject to a final design. This risk can be mitigated by elevating building platform above the predicated flood level, allowing for freeboard to comply with the New Zealand Building Code. It may also be necessary to have some areas set aside for public reserve and not allow building further development, if the flood risk is deemed to be too severe at these particular locations alongside the creek.

### **5.4 Stormwater Quality**

The stormwater system can incorporate provisions to trap potential contaminants prior to discharge to the unnamed creek. This will be based on:

- Swale drains and overland flowpaths as the primary means of stormwater collection and conveyance
- Small local wetlands and ponding areas as part of the landscaping along the main overland flow paths
- Landscaping ponds in the golf course and selected locations in residential areas
- Sumps in courtyard areas at entrances to garages and residences.
- Proprietary separators

The actual systems to be employed will be subject to a detailed design.

There are no areas of high risk as a source of major contamination within the proposed development of the area to be rezoned.