BEFORE THE PANEL
APPOINTED BY THE DUNEDIN CITY COUNCIL

Under	The Resource Management Act 1991 (the **Act** or **RMA**)
IN THE MATTER	of proposed Variation 2 (Additional Housing Capacity) to the Second Generation Dunedin District Plan (**2GP**)
BY	**GLADSTONE FAMILY TRUST** **Submitter (OS219.003, 219.004, 219.005, 219.008)**

STATEMENT OF EVIDENCE OF MELANIE KAY STEVENSON

GALLAWAY COOK ALLAN LAWYERS
Phil Page / Rebecca Crawford
phil.page@gallawaycookallan.co.nz
rebecca.crawford@gallawaycookallan.co.nz

P O Box 143
Dunedin 9054
Ph: (03) 477 7312
Fax: (03) 477 5564

STATEMENT OF EVIDENCE OF MELANIE KAY STEVENSON

1. My full name is Melanie Kay Stevenson. I am a Director of Fluent Solutions Limited and an Environmental Engineer with over 25 years experience in environmental, utilities and infrastructure engineering.

2. I hold BSc (Physics) and BE (Natural Resources) from Otago University and Canterbury University, respectively. I am a member of Engineering New Zealand and Water New Zealand.

3. Although not necessary in respect of council hearings, I can confirm I have read the Expert Witness Code of Conduct set out in the Environment Court's Practice Note dated 1 December 2014 and agree to comply with it. I have complied with the Code of Conduct in preparing this evidence, and I agree to comply with it while giving oral evidence before the hearing panel. Except where I state that I am relying on the evidence of another person, this written evidence is within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed in this evidence.

4. I have prepared the Potable Water and Wastewater sections and reviewed the Stormwater sections of the two 3 waters services feasibility assessments in relation to this matter which are attached at appendix 1 and appendix 2.

Date: 4 August 2022

Melanie Stevenson

Appendix 1: Gladstone Heights 8 Gladstone Heights 9 and Gladstone Grove

Gladstone Heights Ltd

Gladstone Heights 8, Gladstone Heights 9 and Gladstone Grove

3 Waters Services – Feasibility Assessment

August 2022

Fluent SOLUTIONS

www.fluentsolutions.co.nz

Fluent SOLUTIONS

Gladstone Heights Ltd

Gladstone Heights 8, Gladstone Heights 9 and Gladstone Grove

3 Waters Services – Feasibility Assessment

Task	Responsibility	Signature
Project Manager:	Melanie Stevenson	
Prepared By:	Hopcyn Matthews / Melanie Stevenson / Alexis Patrylak	
Reviewed By:	Melanie Stevenson	
Approved For Issue By:	Melanie Stevenson	

Issue Date	Revision No.	Author	Checked	Approved
4th August 2022	Rev A	HM	MS	MS

Prepared By:
Fluent Infrastructure Solutions Ltd
2nd Floor, Burns House
10 George Street
PO Box 5240
Dunedin 9054
Telephone: + 64 3 929 1263
Email: office@fluentsolutions.co.nz
Web: www.fluentsolutions.co.nz

Job No.: 000713
Date: 4 August 2022
Reference: RP 22-08-04 HM 000713 (Rev A).Docx

Gladstone Heights Ltd

Gladstone Heights 8, Gladstone Heights 9 and Gladstone Grove

3 Waters Services – Feasibility Assessment

1.0 Introduction

Fluent Solutions have been engaged by Gladstone Heights Ltd to prepare a feasibility report on the 3 water services for the proposed development at areas Gladstone Heights 8 (GH8), Gladstone Heights 9 (GH9) and Gladstone Grove (GG).

The purpose of this report is to provide a high level options assessment for the feasibility of water, wastewater and stormwater servicing for the proposed GH8, GH9 and GG subdivisions.

2.0 Background

2.1 Location

The proposed Chain Hills subdivision lies between Chain Hills Road, the Dunedin Southern Motorway and Gladstone Road North, Mosgiel, as shown in Figure 2.1. The land is relatively steep, undulating farmland with gullys draining to the southwest to the Owhiro Stream. The whole area rises from an elevation of 136m to 224m Otago Metric Datum (OMD). The land proposed for development is adjacent to the Gladstone Heights subdivision 1-7.

Figure 2.1: Proposed Location Gladstone Heights 8, 9 and Gladstone Grove Subdivision

2.2 Development

There are three areas proposed for development. These are:

- Gladstone Heights 8
- Gladstone Heights 9
- Gladstone Grove

The Structure Plan and Scheme Plan for the Gladstone Heights Development is shown in Figure 2.2 and Figure 2.3.

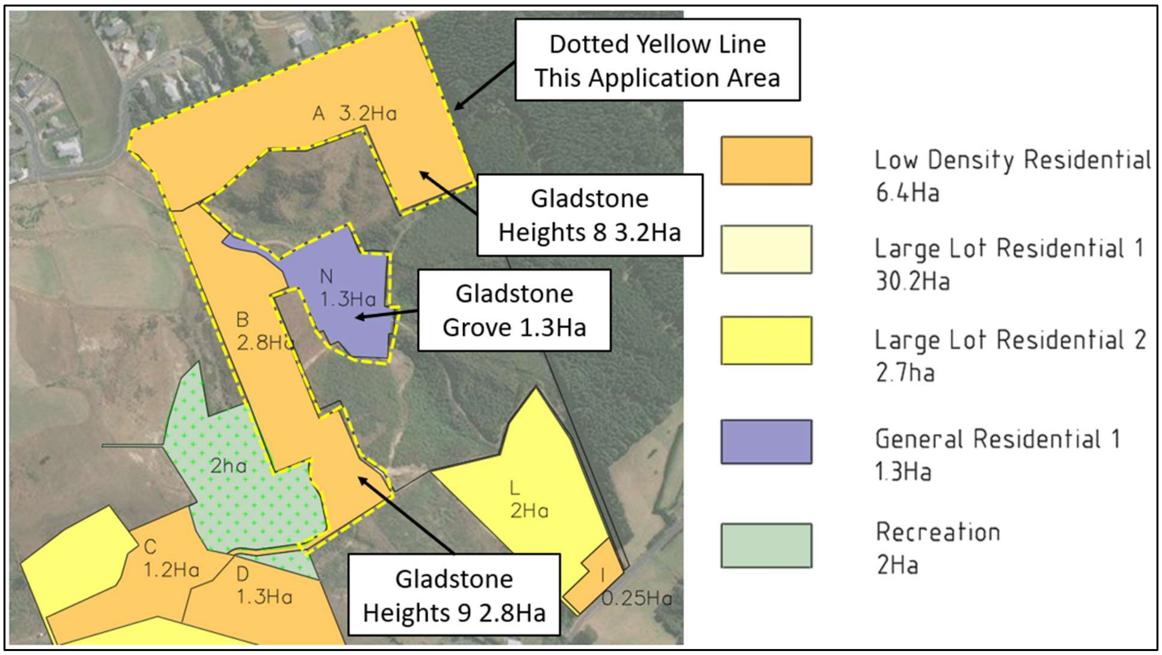

Figure 2.2: Proposed Structure Plan for Gladstone Heights Development

2.2.1 Gladstone Heights 8

The area identified as Gladstone Heights 8 (GH8) is 3.2 Ha of elevated land (139m to 194m OMD) on the northern boundary of the Gladstone Heights development area with access off the existing Pinfold Place. It is currently zoned as Hill Slopes Rural.

The Developer proposes to rezone this area Low Density residential and subdivide the land into 22 x 750m^2 minimum. It is intended that Lots are >1000m^2.

It is proposed that these Lots are fully serviced with water and wastewater.

2.2.2 Gladstone Heights 9

The area identified as Gladstone Heights 9 (GH9) is 2.8 Ha of elevated land (136m to 224m OMD) to the east of Rosella Place, eastern boundary of the Gladstone Heights development Stage 1-5. Access would be from the existing Pinfold Place. It is currently zoned as Hill Slopes Rural.

The Developer proposes to rezone this area Low Density Residential and subdivide the land into 16 x 750m^2 minimum. It is intended that Lots are >1000m^2.

It is proposed that these Lots are fully serviced with water and wastewater.

2.2.3 Gladstone Grove

The area identified as Gladstone Grove (GG) is 1.3 Ha of elevated land (144m to 160m OMD) to the southeast of the existing stormwater detention pond for Stages 1-5 of Gladstone Heights. Access would be from the existing Pinfold Place. It is currently zoned as Hill Slopes Rural.

The Developer proposes to rezone this area as General residential and subdivide the land into 14 x min 500m^2 Lots.

It is proposed that these Lots are fully serviced with water and wastewater.

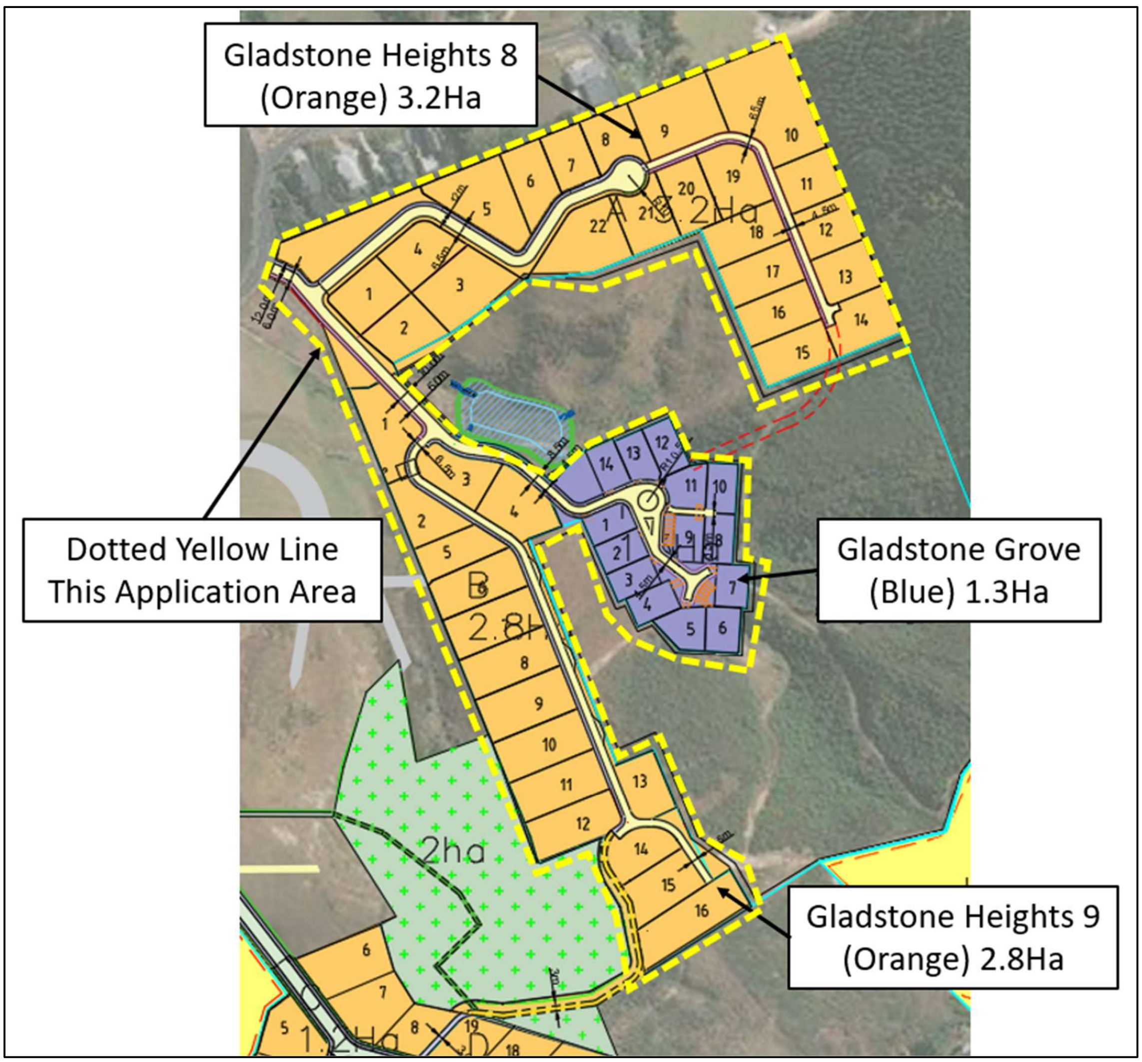

Figure 2.3: Proposed Scheme Plan for GH 8, GH 9 and GG Development

3.0 Water Supply

Stages GH8, GH9 and GG are proposed to have a water supply installed by the Developer and then vested to the Dunedin City Council. This is applicable to infrastructure previously proposed for the existing Gladstone Heights development.

3.1 Key Requirements for Water Supply System Vested to DCC

The design and construction of water supply systems to be vested to the Dunedin City Council must be undertaken in accordance with the requirements of NZS 4404:2004 except where amended and extended for the DCC requirements as specified in the Dunedin Code of Subdivision and Development 2010.

General requirements for a water supply system are to provide a secure and reliable supply of potable water for consumption and water for the purposes of fire-fighting.

More specifically the water supply system shall:

- Provide water of sufficient quantity and at the correct pressure to meet DCC service levels. The residual pressure in the water reticulation shall not be less than 300kPa (30m) when measured at ground level at the roadside boundary of lots. The static water pressure is not to exceed 900kPa.
- Provide fire fighting supply to meet the SNZ PAS 4509:2008.
- Be designed and constructed to optimise "whole of life" costs.
- Be positioned for ease of locating infrastructure, and access for maintenance and repair.

3.2 Water Demand

In accordance with the Dunedin City Council (DCC) Code of Subdivision and Development 2010 (COSD), the estimated water demand is to be based on the following criteria:

- Average daily flow = average daily flow per person (250L/p/d) x people per property x no. of properties
- Peak demand = average demand x peaking factor (PF), where PF = 5

For Gladstone Heights 8,9 and Gladstone Grove, the demands are calculated to be:

- Average Daily Demand = 250L/p/day x 3 people x 52[1] lots
  = 39m^3/day
- Peak Hourly Demand = 39m^3/day x PF5
  = 8.1m^3/hour

Peak demands of 8.1m^3/hour are considered appropriate, when assessing the overall impact of the subdivision on the water supply network.

[1] GH8 (22) plus GG (14) +GH9 (16) = 52

3.3 DCC Water Network and Pressure Available

Properties along Gladstone Road north, including the Gladstone Heights Development, are supplied by the Wingatui Reservoir, which has a floor level of RL237 and a top level of RL234m. The operating level is expected to be around RL 232m[2].

With minimal headlosses in the reticulated network, the water elevation at Gladstone Heights would be around RL230m.

However, hydraulic modelling and data logging completed by DCC in 2020 and July 2021, respectively, indicates that the DCC network experiences significant pressure fluctuations. The data logging indicates that these are around 10m but modelling suggested they could increase to 18m, with high demand.

Figure 3.1 below shows the water elevation from the Data logging that was performed in July 2021 in Jocelyn Way. The results indicate a water elevation fluctuating between RL224 and 234m.

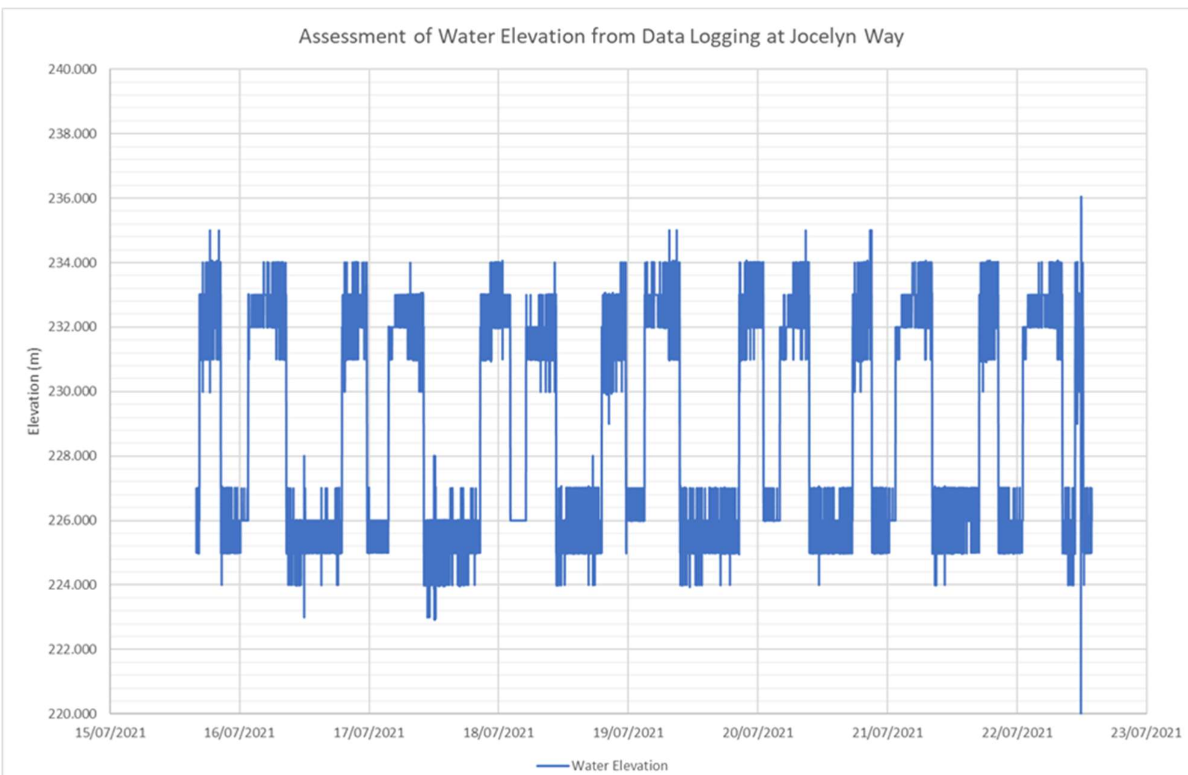

Figure 3.1: Water Elevation from Data Logging (WFH07111)

The pressure fluctuations appear to occur when Quarry Hill Reservoir is being filled. This has been occurring since the Mosgiel bores were decommissioned and the area was fed from Mt Grand.

[2] Please note all elevations are reported in Otago Metric Datum, which is 100m above MSL

For the purposes of this feasibility assessment, it is assumed that pressure compliant water can be supplied to property boundaries RL<186m. This is 30m below RL216m and is based on worse case modelling. It is considered conservative.

With upgrades to the DCC network, a water elevation of RL227 would be achievable. This means that houses above around RL197m could meet the DCC Code of subdivision (30m head at the boundary).

3.4 Proposed Water Supply Infrastructure

The existing Gladstone Heights Subdivision is supplied by the DCC Mt Grand water supply via the Wingatui Reservoir.

Stage 1-3 of Gladstone Heights is currently constructed with all Lots sold. Stages 4-7 are not yet constructed.

Stage 1-4 are proposed to be supplied by gravity with Stages 5 through to 7 being supplied by an elevated storage tank above the subdivision at an elevation RL 255-260m OMD. The storage tank is to be supplied by an inline booster pump.

3.4.1 Proposed GH8

Stage GH8 lot elevations range between 136m and 194m OMD, based on the existing hillside contours. Two lots, Lot 12 and Lot 13, have a boundary elevation of 188m OMD based on the existing natural hill contour. With earthworks, these Lot boundaries could be lowered to maintain the 30m pressure while being supplied under gravity from the Wingatui Water Reservoir level. Pressure levels at the boundary would be >30m.

GH8 will be supplied to the existing network with a DN150 pipeline at Pinfold Place.

3.4.2 Proposed GH9

The elevation of the Stage GH9 lots range between 136m and 224m based on the natural existing hillside contours. There are 6 lots (Lot 11-16) that have boundary elevations higher than 186m OMD.

All of the lots that have a boundary elevation lower in elevation than 186m OMD will be supplied by DN150 pipeline to from Rosella Place.

To supply the 6 lots of GH9, which are located above 186m OMD, it is proposed that water from the Gladstone Stage 7 is used. Pressure is supplied from a reservoir above located RL 255-260m OMD). A small diameter pipeline would convey domestic water supply from between Lots 8 and 19 in GH Stage 7 to the upper lots in GH9. There is a track proposed connecting the two stages which provide a suitable alignment for the pipe.

3.4.3 Gladstone Grove (GG)

The elevation of the Stage GG lots range between 146m and 158m OMD based on the natural existing hillside contours. The entirety of Stage GG will be supplied by a DN150 water connection that feeds into this area from Rosella Place.

Figure 3.1 and Figure 3.2 below provide an outline of the proposed infrastructure.

Figure 3.1: Layout of Water Services Infrastructure for Gladstone Heights GH8, GH9 and GG

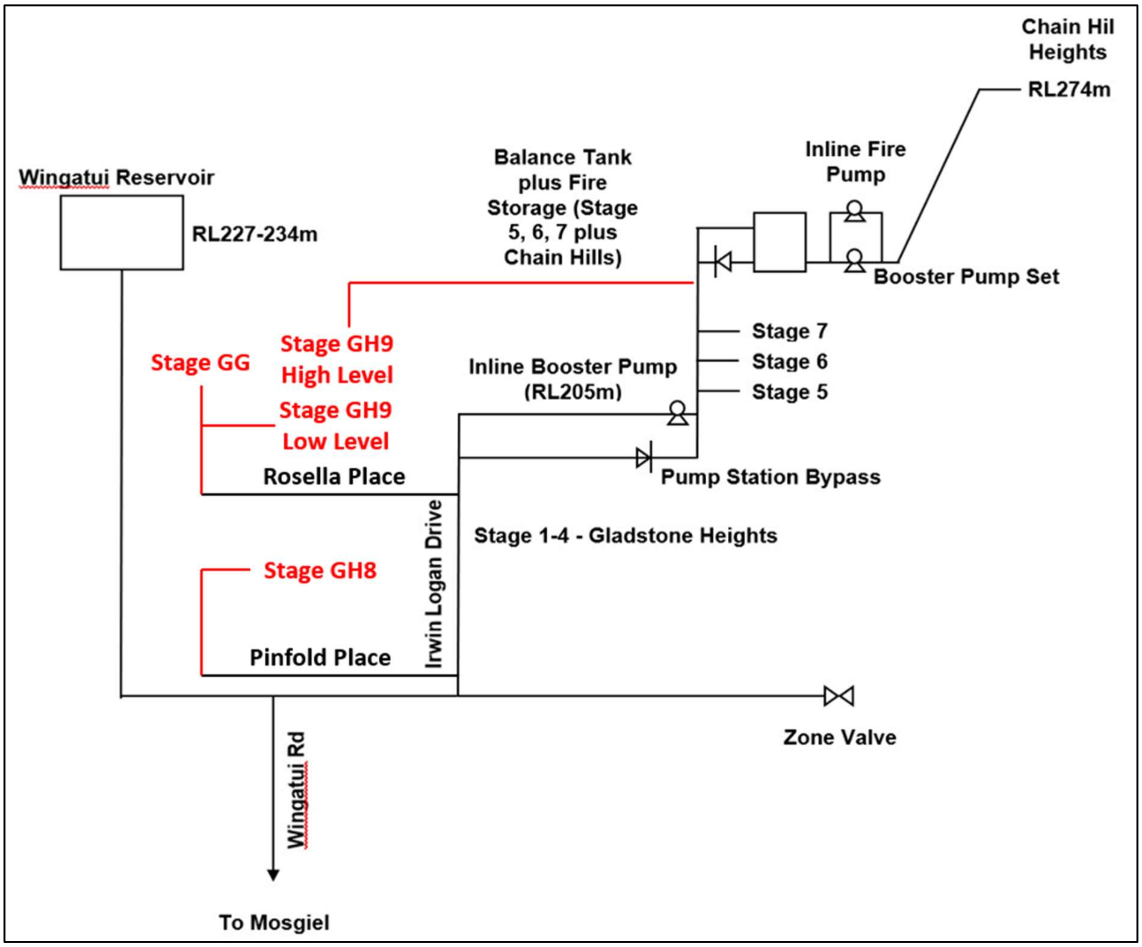

Figure 3.2: Schematic of Water Services Infrastructure for Gladstone Heights with the proposed GH8, GH9 and GG shown in Red

3.5 Fire Fighting

SNZ PAS 4509:2008 NZ Fire Service Fire Fighting Code requires the subdivision needs to supply firefighting water at a flow of 12.5 litres per second (L/s) from 2 hydrants (25L/sec) and maintain a residual pressure of 10m.

Fire flow modelling data provided by the DCC (December 2020) shows that a residual pressure of 1.44m is available during 25L/sec fire flows at an elevation of 195m OMD. This indicates that a fire flow residual pressure of 10m head would be achievable at elevations up to 186m OMD. Fire flow requirements as set out in SNZ PAS 4509-2008 for FW2 can therefore be met by extending the DCC water main and having fire hydrants elevated at RL186m or lower.

Alternative fire fighting solutions are also available in the absence of adequate reticulation services.

3.5.1 Stage GH8

The Lots in Stage GH8 are all below an elevation of RL186m and can be served by extending the DCC water main.

3.5.2 Stage GH9

It is proposed that Stage GH9 is served for fire fighting by extending the DCC water main up to RL195m (this is between Lots 12 and 13). This hydrant will be around 90m from Lot 16 (farthest away Lot) and based on modelling results, should be able to provide 25L/sec with 1.44m residual head. While this hydrant may not always retain a 10m residual pressure at peak times, a second hydrant within 135m at an elevation <RL186m will be available.

3.5.3 Stage GG

All of the proposed lots are below an elevation of 186m OMD and can be served by extending the DCC water main.

3.6 Reservoir Storage

Additional reservoir storage to meet the demands of Lots 11-16 for GH9 need to be allowed for in the reservoir above Stage 7.

3.6.1 Operating Storage Volume

The operating storage is the storage volume differential between the incoming water supply and the peak demand. For Lots 11 to 16 of GH9, it is assumed that during peak periods, no water is available from the Gladstone Heights Stages 1-4 reticulation and the new reservoir must supply the peak flows. Therefore, the operational storage volume is the equivalent of 5hrs peak demand.

Assuming peak hourly flows occur for a period of 5 consecutive hours (5pm until 9pm), and the reservoir supplies all of this demand, the volume of operational storage required is:

Operational storage = 5 hours x Peak
= 5 hours x (250L/p/day x 3 people x 6 lots x PF5)
= 5 hour x 0.94m^3/hour
= 4.7m^3

3.6.1.1 Emergency Storage Volume

Emergency storage volume allocation to cover reticulation outage or any other supply issues upstream of the reservoir is usually calculated as 8 hours storage at average daily flows to allow time for the rectification of the defect.

Using the average daily flow, the emergency storage volume equates to:

Average Daily Flow = 250L/day X 3 people x 6 dwellings
= 4.5m^3 per day

Emergency Storage = 4.5m^3/day x 8/24 =1.5m^3

3.6.1.2 Total Added Storage Volume

The total storage volume is therefore recommended to be:

Operational Storage	$4.7m^3$
Emergency Storage	$1.5m^3$
Total Storage	**$6.2m^3$**

4.0 Wastewater Servicing

Stage GH8, GH9 and GG proposed wastewater drainage system will be installed by the Developer and then vested to the Dunedin City Council. This is applicable to infrastructure previously proposed for Gladstone Heights 1-7.

4.1 Existing Infrastructure

Current Lots within the Gladstone Heights Subdivision 1-7 are serviced by a DN150 wastewater main that follows down Irwin Logan Drive and connects with Gladstone Road North. A DN150 pipeline then drains to the Wingatui No. 4 pump station. With Stage 7 of Gladstone Heights completed the pump station will service an area of approximately 87.5 Ha as shown in Figure 4.1. The pump station pumps into the downstream DCC network and ultimately to the Green Island Wastewater Plant.

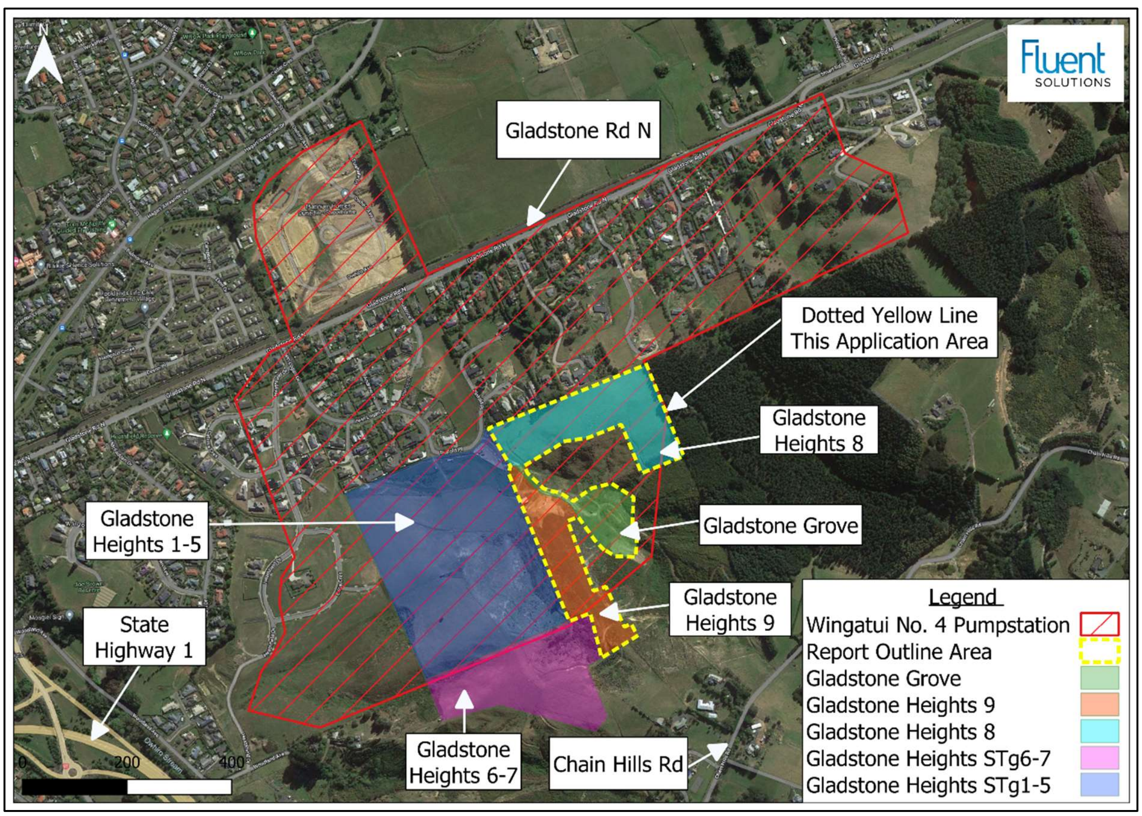

Figure 4.1: Wingatui No. 4 Pumpstation Approximate Current Catchment Area

4.2 Wastewater Production

The DCC Code of Subdivision outlines the following requirements for residential wastewater design flows:

- The Average Dry Weather Flow should be based on 270L/p/d
- A dry weather diurnal peaking factor of 2
- A wet weather peaking factor of 3
- The number of people per dwelling should be between 3.5

The estimated wastewater design flows for the proposed Gladstone Heights GH8, GH8 and GG subdivisions are presented in Table 4.1 below.

Table 4.1: GH8, GH9 and GG Wastewater Demand Estimate

Flow Type	# of Lots	# of Persons/House	Flow Rate (L/p/d)	Diurnal Peaking Factor	Wet Weather Peaking Factor	Total Estimated Wastewater Flow
Average Dry Weather Flow (ADWF)	52	3.5	270	-	-	49.1m^3/day
Peak Diurnal Dry Weather Flow (PDWF)	52	3.5	270	2	-	1.1L/sec
Peak Wet Weather Flow (PWWF)	52	3.5	270	2	3	3.4L/sec

The impact of the increased wastewater flow estimates from the development have not been assessed for the downstream reticulation, pumping stations or wastewater treatment plants. If the capacity of the downstream wastewater network were an issue, wastewater detention storage could be considered to manage flows until the DCC network was upgraded.

5.0 Stormwater Management

5.1 Existing Stormwater Infrastructure

The proposed development site is located immediately to the east of the existing Gladstone Heights subdivision, as shown in Figure 5.1. Stages 1-5 (dark blue) have been constructed and the main stormwater detention pond built to service this area. Stages 6-7 (pink) are in the process of being consented and would provide separate detention and drain to the west.

Please note that the detention pond systems for each Stages 1-5 and Stages 6-7 were not designed to accept additional stormwater flows from future development areas. Therefore, the proposed Gladstone Heights Stages 8 (light blue) and 9 (orange) and the Gladstone

Grove (green) developments included in this assessment would have stormwater servicing separate to the Gladstone Heights Stages 1-7.

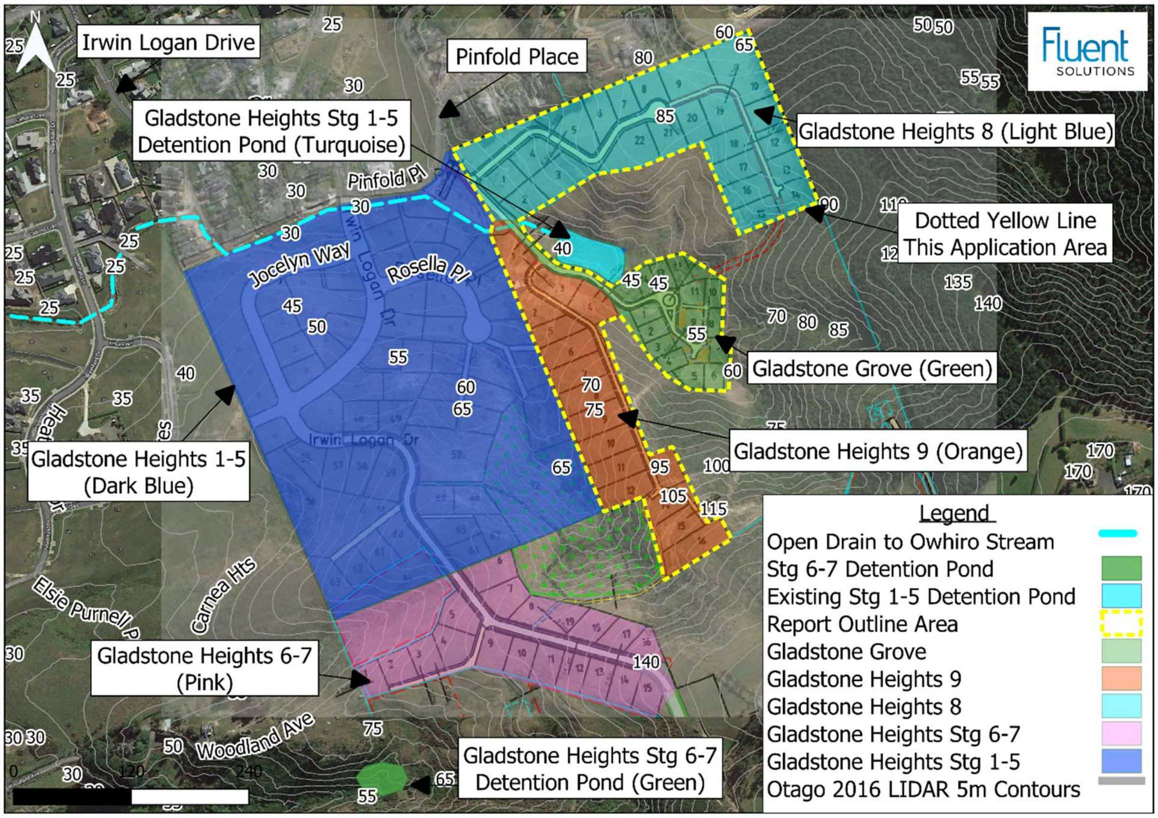

Figure 5.1: Existing Stormwater Infrastructure and Surrounding Catchment

5.2 Catchment Flow Paths

Figure 5.2 shows the pre-development natural overland flow paths for the proposed development area. The flow paths generally drain to the northwest corner of the development site into an existing open drain.

The site as shown by the contours in Figure 5.2 is relatively steep. Both GH8 and GH9 are located on small hillside ridgeline and have a noticeable change in elevation (39m to 94m RL GH8 and 36m to 124 m RL GH9). GG is located in the valley floor and has a lower change in elevation (60m to 40m RL).

It is considered that the post-development flow paths would be similar to that of the pre-development.

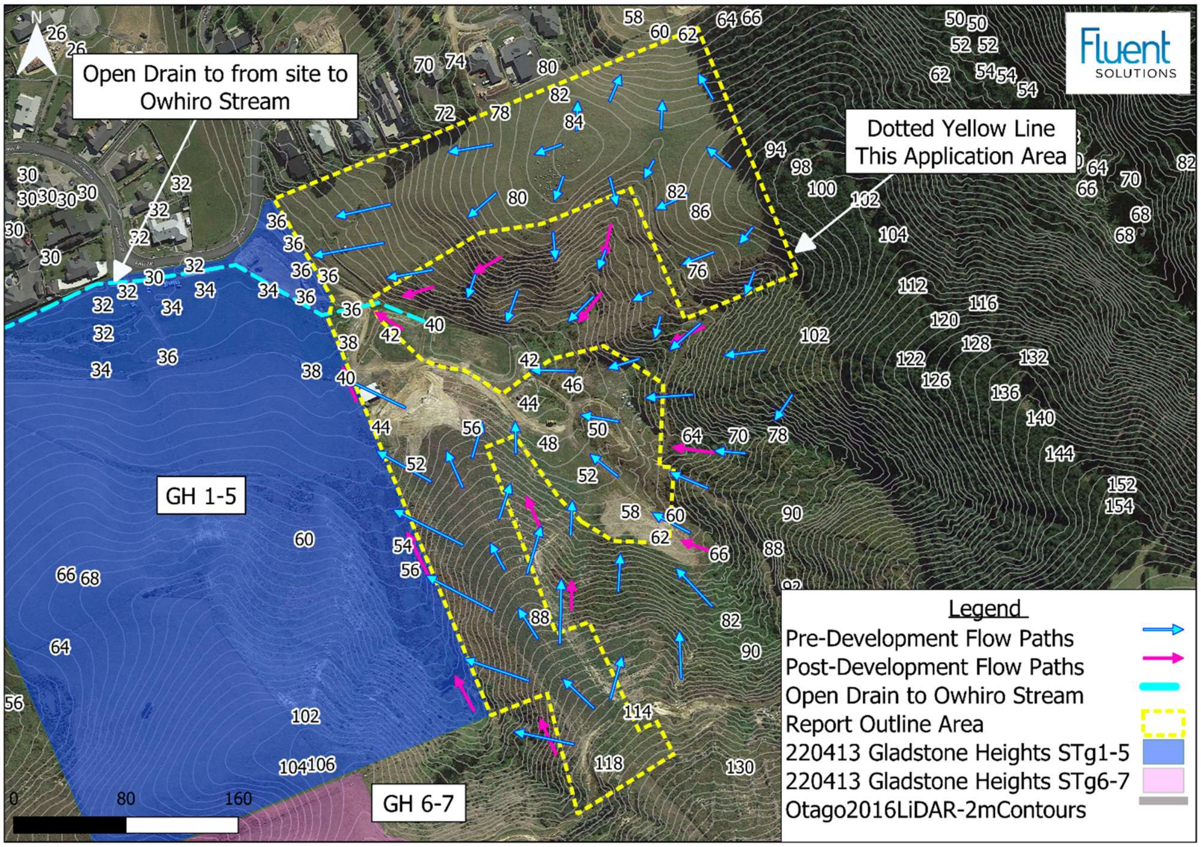

Figure 5.2: Catchment Flow Paths – Pre-development

5.3 Local Stormwater Features

Flows from the site generally drain to the north to an existing open drain system. The drain flows under Gladstone Road North before discharging into the Owhiro Stream upstream of Gordon Road and continues to flow in a westerly direction. This is the same discharging location as the existing detention pond for Stage 1-5 of Gladstone Heights. Please refer to Figure 5.3 below for the location of the stormwater features.

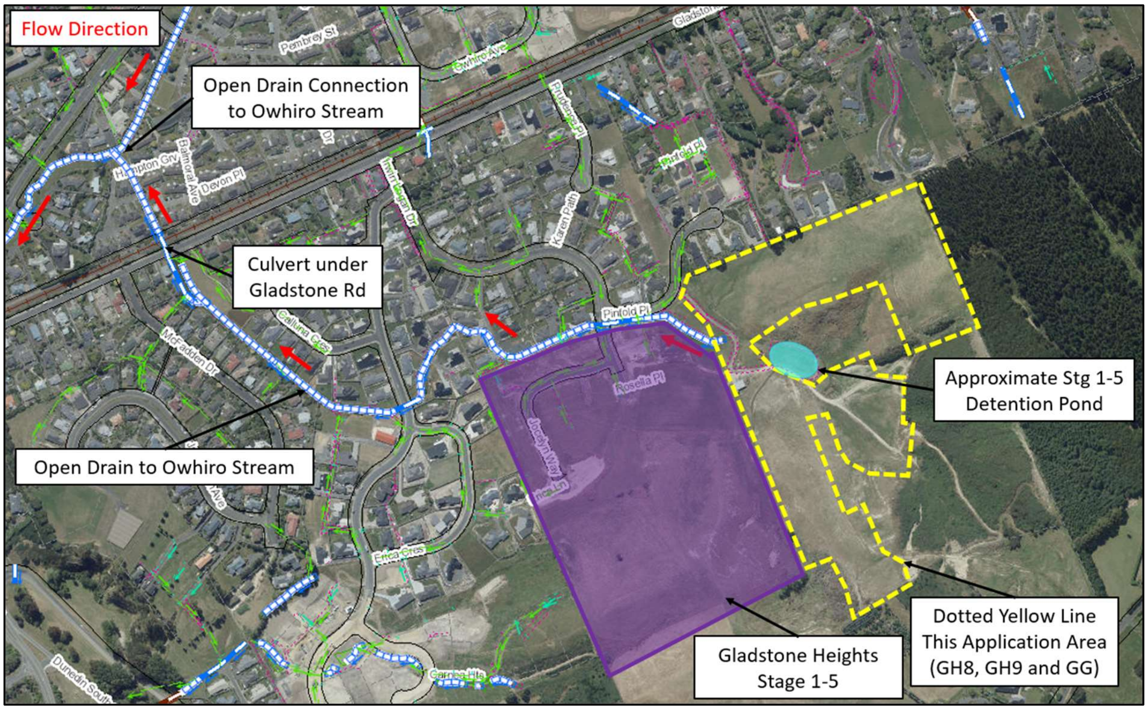

Figure 5.3: DCC Water Local Stormwater Features

It is understood that the Owhiro Stream catchment is sensitive to flood flow volumes as well as peak flows, particularly for the longer duration storm events in the area upstream of Gordon Road.

It is noted that there are potential capacity limitations in the open drain catchment, including existing culverts, which will need to be considered as part of the design.

5.4 Stormwater Management Requirements

An overview of the DCC requirements for stormwater management is set out below. Also included are the proposed measures to ensure management of stormwater runoff effects.

5.4.1 Design Storm Events

The DCC COSD requires that a primary stormwater or flood management system be designed to convey, as a minimum, a 10yr Average Recurrence Interval (ARI) taking into account climate change. Where a secondary flow path is available, the secondary flow path is required to convey the balance of a 100yr ARI flow without damage to property and with freeboard. If a secondary flow path is not available, the primary system is required to convey a 100yr ARI flow. Consideration should be given to both upstream and downstream effects.

For the proposed developments, the pipe network system would be located in the road and discharge to the detention area would be considered the primary network. The road would act as a secondary overland flow path in large events in combination with the other flow paths.

5.4.2 Climate Change

The current Dunedin City Council “Standards for Stormwater Management Plans” memo (13 June 2019) requires the design to take into account allowance for an assumed increase in average annual temperature following the RCP8.5 climate change projection scenario for the period 2081 – 2100 (published by NIWA in HIRDS Version 4). Typically, this RCP8.5 (2081-2100) scenario has been applied to the rainfall used to calculate both the pre- and post-development runoff flows.

Additionally, it is proposed that the calculation of the pre- and post-development flows from the site are considered based on the current rainfall (or historical rainfall published by HIRDS). The purpose of this is to ensure that the flow leaving site is not greater than the current flow conditions.

5.4.3 Impervious Area Assumptions

Impervious area allowances for the lots are to include an assessment based on an assumed house size, driveway, and pathway allowance (relative to the size of land) against the allowed impervious area percentage under the district planning requirements. The larger of the two values would be utilised in the design moving forward.

5.4.4 Peak Flow Mitigation and Downstream Effects

The stormwater management design shall include measures to:

- Avoid increases in peak runoff flow. Note that it is not intended that the stormwater management plan will avoid volume increases. However, this aspect can be considered further if required by Council.
- Avoid adverse impacts on the water quality of receiving waters.
- Minimise environmental impacts, which include management of erosion from discharges.
- Allow for emergency flow paths in the event of blockages.
- Provide provision for freeboard. It is proposed that the freeboard allowances are based on a functioning primary system. In the event of a blockage of the primary system or other critical infrastructure, the secondary system or alternative overland flow paths would function with reduced freeboard.
- Allow for consideration of a super design event and design of the system to enable safe operation during this event. It is proposed to utilise the 250yr ARI storm to account for the super-design event as this information is readily available from the HIRDS version 4 database.
- Ensure that adverse effects that are more than minor are not created downstream.

Separate to the stormwater management design, a site management and erosion and sedimentation management plan should be developed and approved prior to earthworks and site development.

Use of the current rainfall considerations coupled with consideration for flexibility within the stormwater management system design would ensure that the post-development flows in the future, when climate change has occurred, are no more than the existing case as of current. One example of this may be to implement a temporary orifice plate to control outflows from a detention pond based on lower current peak flows.

5.4.5 Operations and Maintenance

An operations and maintenance plan would be developed as part of the detailed design for the system. This would include determination of ownership and responsibilities for maintaining the system, recommended maintenance requirements, and frequency of inspections.

Additionally, the operations and maintenance plan, as a minimum, needs to consider:

- Public safety
- Risk of blockage
- Access
- Mowing, vegetation management
- Ease of removal of silt and debris
- Maintenance schedules, timing, and reporting.

5.4.6 Treatment

Stormwater treatment is to be considered as part of the design including at a minimum treating the 'first flush' volume (90th percentile daily rainfall depth) or flow rate (90^{th} percentile rainfall intensity) in accordance with best practice techniques for at least 75% Total Suspended Solids (TSS) removal on a long-term average basis.

5.5 Stormwater Management Options Assessment

The stormwater management options included as part of this high-level assessment are set out below. Note that the scope of the assessment was limited to focus on stormwater management on-site or discharge through existing downstream infrastructure only.

Volume and flow estimates would need confirmed through a more detailed design process.

A summary of the stormwater management options as identified as part of this assessment are presented in Table 5.1. An assessment of the benefits and drawbacks for each scenario is also presented along with comment on the feasibility of the solution to suit the sites.

It should be noted that the basic nature of development in a catchment increases the frequency of flows which likely exacerbates erosion. For each of the proposed options, consideration would need to be given to erosion protection.

Table 5.1: Summary of Stormwater Management Options

Option	Description	Benefits	Drawbacks	Preferred Option Commentary
1	Detention tanks on individual lots to manage flows from each individual lot for GH8, GH9 and GG	▪ Allows for the site to be built progressively as stormwater is managed as at a micro level. ▪ Does not impact on the developable area which could be otherwise used for lots. ▪ Allows for potential options to reuse rainwater.	▪ Surface tanks can only collect runoff from roof surfaces. Even with sub-surface tanks collection of runoff from other impervious surfaces such as driveways or pathways is difficult. ▪ Tanks (either surface or sub-surface) are often not maintained and would require involvement from individual lot owners. Maintenance checks would need to be managed either by Council or a body corporate. ▪ There is no allowance for mitigation of runoff from the communal areas such as roads, which means that lot owners have to provide further capacity to account for unmitigated runoff from these areas. ▪ Lot owners required to do further investigation as to tank sizing and front cost. ▪ Available space for building within the lots is compromised.	This is appropriate for Large Lot Residential areas but not for the General Residential (GG site) and Low Density Residential (GH8 and GH9 site) due to space requirements.
2	Single, communal detention facility to manage flows from the whole site (located at downstream boundary)	▪ Communal system means not onerous for individual owners. ▪ Able to collect flows from all development areas. ▪ Easily flexible design to allow for reduced discharge to accommodate current rainfall flow rates. ▪ Does not impact on developable land area.	▪ Maintenance would need to be completed by a body corporate or vested to Council. ▪ Potential hazard due to ponding at depth. ▪ Risk of complications due to the discharge flow paths running through multiple properties. ▪ No area larger enough downstream of the proposed GH8, GH9 an GG development area. ▪ Existing On Sie Detention Pond for Stages 1-5 encroaches the available area.	This option is not preferred as there is a lack of available space to build the detention pond at the downstream boundary extent. Additionally a large detention pond on a slope could have potential hazard considerations for overflows.
3	Multiple detention ponds, in the order of 4 ponds within the greater development to manage flows from the whole site	▪ Communal system means not onerous for individual owners. ▪ Able to collect flows from all development areas. ▪ Easily flexible design to allow for reduced discharge to accommodate current rainfall flow rate. ▪ Easier to manage downstream erosion as flow limited higher up the catchment.	▪ May result in a larger detention area than a single combined system. ▪ Maintenance would need to be completed by a body corporate or vested to Council. ▪ Potential hazard due to ponding at depth. ▪ Reduces the amount of developable land for lots.	This is the preferred option for managing stormwater from the proposed development for GH8, GH9 and GG. See Figure 5.4 for potential locations of detention ponds.
4	Discharge via ground soakage	▪ Reduces discharge flows from the site.	▪ Due to the steepness of the three catchments GH8, GH9 and GG the ground may be unsuitable to support discharge to ground and may cause migration through the hillside to seep out downstream. ▪ Soil types in the area are Claremont 11b (sourced from Landcare Research) which are characterised as poorly drained and high-water logging vulnerability which are not suitable for ground soakage.	This is not a possible option for stages GH8, GH9 and GG due to the topography of the site.

Based on the analysis presented in the Table 5.1 above, the preferred stormwater management servicing is utilising Option 3, multiple detention ponds. A preliminary stormwater management plan is shown in Figure 5.4 below. Note that the existing on-site stormwater detention pond which was constructed for Stages 1 – 5 will not be used for stormwater management for future stages pertaining to this report. The locations, sizes, and detailed design of the stormwater management infrastructure would be developed at a later stage.

Further comment on the proposed preliminary stormwater management layout as shown in Figure 5.4 below.

Gladstone Heights Stage 8 (GH8)

- The eastern perimeter of stage GH8 will have a cut off drain to intercept the flows from the natural surrounding area. These flows will not be mitigated as they are not part of the proposed development.
- The developed lots in stage GH8, approximately Lots 1 to 4 will be conveyed via swales and discharged into SW Detention Pond 1.
- The remaining developed lots, Lots 5 to 22, will be conveyed via swales and discharged into SW Detention Pond 4.

Gladstone Grove (GG)

- The entirety of the GG developed lots will discharge into SW Detention Pond 3 via swales.
- The perimeter of the GG development will have a cut off drain to intercept the flows from the natural surrounding area.

Gladstone Heights Stage 9 (GH9)

- The lower developed lots of GH9, approximately Lot 1, 2, 5, 6, 7, 8 and 9 will discharge into the SW Detention Pond 1.
- The upper developed lots of GH9, approximately Lots 10 to 16, are to be connected into SW Detention Pond 2.
- Developed lots, Lots 3 to 4, of GH9 will discharge into the same detention pond as area GG, SW Detention Pond 3.
- The southern boundary of Lot 12 and Lot 16 will have a cut off drain to intercept the flows from the natural surrounding area.

The road network withing the 3 development areas will provide an additional secondary overland flow path.

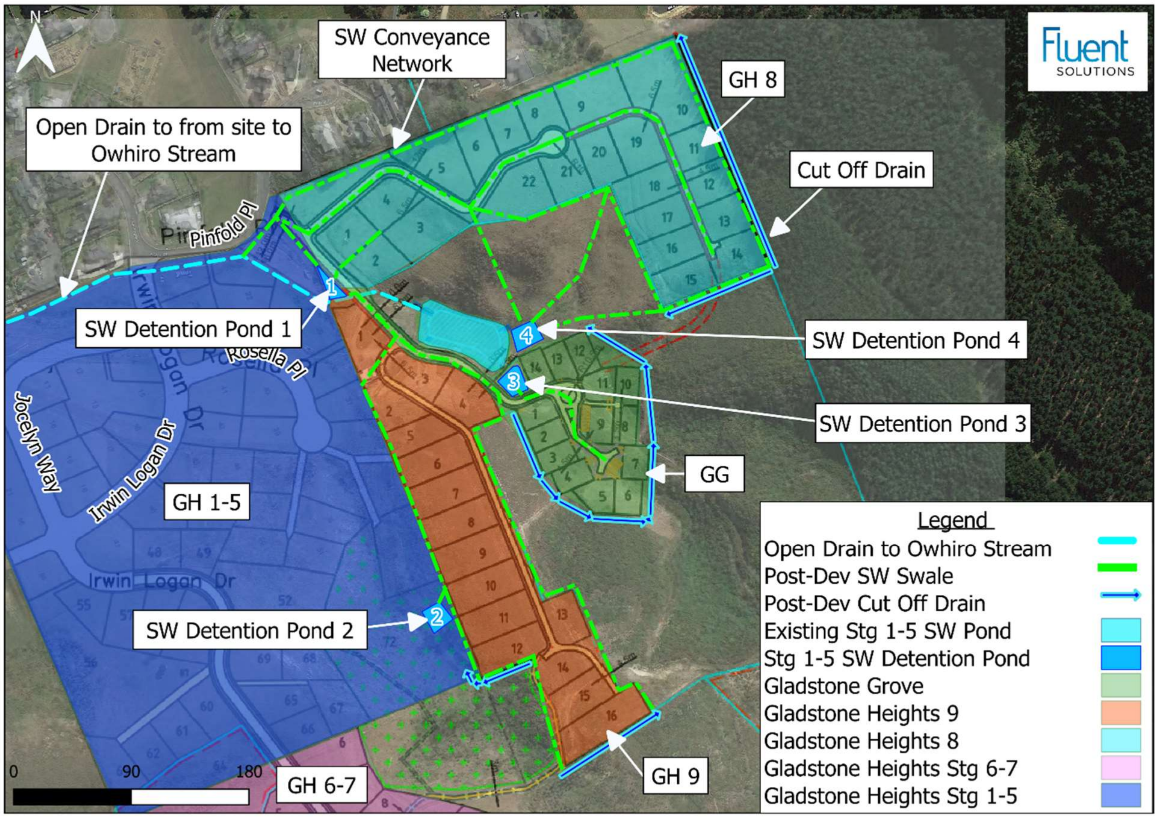

Figure 5.4: Preliminary Stormwater Management Infrastructure for GH8, GH9 and GG Development

6.0 Conclusion

The proposed Gladstone Heights GH8, GH9 and GG subdivisions can be serviced for 3 waters.

The average water demand on the DCC network is calculated to be 39m^3/day. Peak demands are calculated to be 8.1m^3/hour.

It is proposed that the water infrastructure for GH8, GH9 and GG is an extension of the Gladstone Heights reticulation. GH8 would be serviced by a connection from Pinfold Place and GH9 and GG, would be served from Rosella Place. 6 lots (Lots 11-16) that are elevated above RL186m in GH9 can be supplied by a small diameter rider main that connects GH 6 and GH7 to these lots. Fire fighting can still be provided by a DN150m in the road.

The average dry weather flow for wastewater (using the DCC COSD) is calculated to be 49m^3/day and a peak wet weather flow of 3.4L/sec. It is proposed that this be drained to the catchment feeding the Wingatui No. 4 Pumpstation. The impact of the increased wastewater flow estimates from the development have not been assessed however, if the capacity of the downstream wastewater network were an issue, wastewater detention storage could be considered to manage flows until the DCC network was upgraded.

The preferred option for stormwater management involves 4 stormwater detention ponds located around the proposed development catchment. The stormwater management plan recognises the need to manage peak flows as well as control erosion. The locations, sizes, and design of the stormwater management infrastructure would be developed at the time of consenting and design.

The details of the specific system will be confirmed during detailed design.

Gladstone Heights Ltd

Chain Hills Development

3 Water Services –
Feasibility Assessment

August 2022

Fluent SOLUTIONS

www.fluentsolutions.co.nz

Fluent SOLUTIONS

Gladstone Heights Ltd

Chain Hills Development
3 Water Services – Feasibility Assessment

Task	Responsibility	Signature
Project Manager:	Melanie Stevenson	
Prepared By:	Melanie Stevenson / Alexis Patrylak	
Reviewed By:	Melanie Stevenson	
Approved For Issue By:	Melanie Stevenson	

Issue Date	Revision No.	Author	Checked	Approved
3 August 2022	A	M. Stevenson	M. Stevenson	M. Stevenson
4th August 2022	B	M. Stevenson	M. Stevenson	M. Stevenson

Prepared By:
Fluent Infrastructure Solutions Ltd
2nd Floor, Burns House
10 George Street
PO Box 5240
Dunedin 9054
Telephone: + 64 3 929 1263
Email: office@fluentsolutions.co.nz
Web: www.fluentsolutions.co.nz

Job No.: 000713
Date: 4 August 2022
Reference: RP 22-08-04 000713 MKS Chain Hills Park (Rev B).Docx

Gladstone Heights Ltd

Chain Hills Development
3 Water Services – Feasibility Assessment

1.0 Introduction

Fluent Solutions have been engaged by Gladstone Heights Ltd to prepare a feasibility report on the 3 water services for the proposed development at Chain Hills.

The purpose of this report is to provide a high level options assessment for the feasibility of water, wastewater and stormwater servicing for the proposed Chain Hills subdivision.

2.0 Background

2.1 Location

The proposed Chain Hills subdivision lies between Chain Hills Road, the Dunedin Southern Motorway and Gladstone Road North, Mosgiel. The land is relatively steep, undulating farmland with gullys draining to the north west to the Owhiro Stream. The whole area rises from an elevation of RL36m to RL274m.

The land proposed for development is adjacent the Gladstone Heights subdivision.

Figure 2.1: Location Proposed Chain Hills Subdivision

2.2 Development

There are three areas proposed for development. These are:

- Chain Hills Heights
- Chain Hills Park
- Woodland Park

The Structure Plan and Scheme Plan for the Chain Hills Development is shown in Figure 2.2 and 2.3 below.

2.2.1 Chain Hills Heights (E)

The E area identified as Chain Hills Heights is 4.2 Ha of elevated land (~RL248 to 274m) adjacent Chain Hills Road. It is currently zoned as Rural Residential. The Developer proposes to rezone this area as General Residential 1 subdivide the land into 51 x 500m^2 Lots and 8 x 1000m^2 Lots.

It is proposed that all of these Lots are fully serviced with water and wastewater.

2.2.2 Chain Hills Park (G and F, K)

The G and F areas proposed for Chain Hills Park is a total of 31.9 Ha and is currently zoned Rural Residential and Hill Slopes Rural. It is proposed that this area is rezoned Large Lot Residential 1 and a total of 17 Lifestyle Lots are created.

The Developer proposes to rezone area K as Low Density Residential and subdivide the land into 2 x >1,000m^2 sections.

Lots 6-19 would be serviced with a restricted water supply with the remaining Lots collecting their own water from roof runoff. All sites would have their own on-site wastewater systems.

2.2.3 Woodland Park (H)

Woodland Park (area H) is a 2.7 Ha area currently zoned as Hill Slopes Rural. It is proposed that this area be rezoned to Large Lot Residential 2 and 6 Lifestyle lots be created (>3000m^2). These Lots would collect their own water from roof runoff and have on-site wastewater systems.

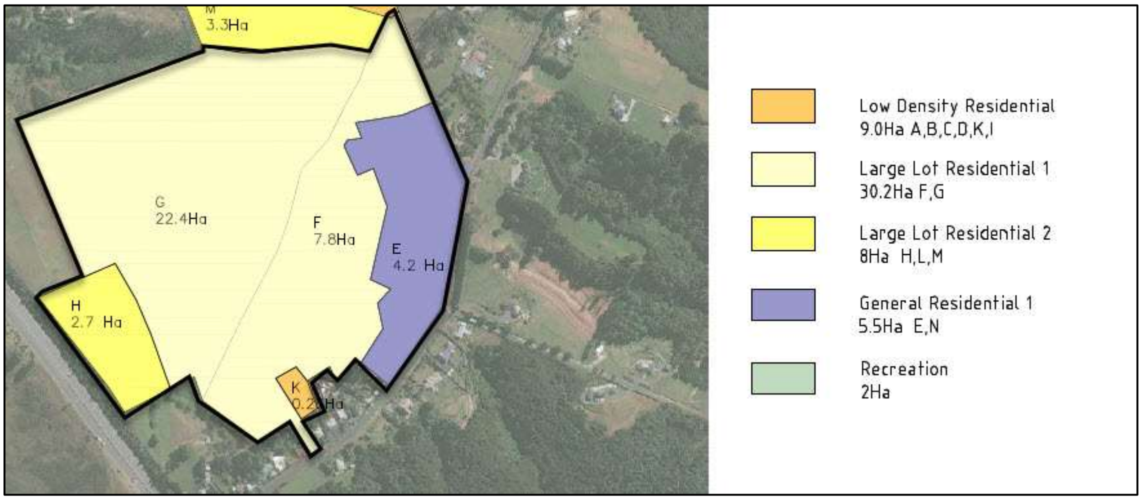

Figure 2.2: Proposed Structure Plan for Chain Hills Development

Figure 2.3: Proposed Scheme Plan for Chain Hills Development

3.0 Water Supply

For Lots identified as Large Lot residential 1 or 2 (F & G), it is proposed that water supply would be from a mixture of rain water tanks or a restricted water supply. The responsibility of supply and maintenance of tanks shall be that of the land owner.

Due to location, it is proposed that Area K – Low Density Residential – is also serviced with the use of rain water tanks.

For Lots identified as General Residential 1 (E) it is proposed that the water supply be installed by the Developer and then vested to the Dunedin City Council. This is applicable to infrastructure proposed for Chain Hills Heights. The following section focusses on Chain Hill Heights infrastructure.

3.1 Key Requirements for Water Supply System Vested to DCC

The design and construction of water supply systems to be vested to the Dunedin City Council must be undertaken in accordance with the requirements of NZS 4404:2004 except where amended and extended for the DCC requirements as specified in the Dunedin Code of Subdivision and Development 2010.

General requirements for a water supply system are to provide a secure and reliable supply of potable water for consumption and water for the purposes of fire-fighting.

More specifically the water supply system shall:

- Provide water of sufficient quantity and at the correct pressure to meet DCC service levels. The residual pressure in the water reticulation shall not be less than 300kPa (30m) when measured at ground level at the roadside boundary of lots. The static water pressure is not to exceed 900kPa.
- Provide fire fighting supply to meet the SNZ PAS 4509:2008.
- Be designed and constructed to optimise "whole of life" costs.
- Be positioned for ease of locating infrastructure, and access for maintenance and repair.

3.2 Water Demand

In accordance with the Dunedin City Council (DCC) Code of Subdivision and Development 2010 (COSD), the estimated water demand is to be based on the following criteria:

- Average daily flow = average daily flow per person (250L/p/d) x people per property x no. of properties
- Peak demand = average demand x peaking factor (PF), where PF = 5

For Chain Hills Heights, the demands are calculated to be:

- Average Daily Demand = 250L/p/day x 3 people x 59 lots
  = 44.25m^3/day
- Peak Hourly Demand = 44.25m^3/day x PF5
  = 9.2m^3/hour

For the restricted supply to Chain Hills Park, the calculated demand is:

- Average Daily Demand = 1m^3/day x 14 lots
  = 14m^3/day
- Peak Hourly Demand = 14 Lots x 1m^3/day
  = 0.6m^3/hour

Average daily demands of 58m^3/day and Peak demands of 9.8m^3/hour are considered appropriate, when assessing the overall impact of the subdivision on the water supply network. Peak flow is likely to be reduced with the installation of storage.

3.3 Fire Fighting

SNZ PAS 4509:2008 NZ Fire Service Fire Fighting Code requires firefighting water at a flow of 12.5 litres per second (L/s) from 2 hydrants (total 25L/sec) and maintain a residual pressure of 10m.

Alternative fire fighting solutions are also available in the absence of adequate reticulation services.

3.4 Proposed Water Supply Infrastructure

3.4.1 Description

The proposed subdivision would be supplied by connection to the water infrastructure installed at the Gladstone Heights Subdivision. Figure 3.1 and Figure 3.2 below provide an outline of the proposed infrastructure.

The Gladstone Heights Subdivision is supplied by the Dunedin City Council (DCC) Mt Grand water supply via the Wingatui Reservoir. The Wingatui Reservoir has an operating water level elevation range of 230-233m (OMD).

Stage 1-3 of Gladstone Heights is currently constructed with all Lots sold. Stage 4-7 is not yet constructed, but it is proposed that the water supply be pumped up to a storage tank located above the subdivision (elevation RL 255-260m).

To supply Chain Hills Heights, the water would need to be pumped from the reservoirs above Stage 7. The most feasible option to supply Chain Hills Heights is to pump water directly to the residential Lots using a booster pump set to provide pressure and flow on demand to residential Lots. These pump sets are controlled by maintaining a set pressure at the pump station and ramping up and down to maintain the set pressure. The pressure would be set to maintain a minimum of 300kPa at the upper most elevated site.

A pump set to provide domestic supply would need to have a capacity of around 6 L/sec and a duty head of 600kPa. To ensure water supply is maintained during power outages, a back-up generator would be included.

Consideration was given to installing a second reservoir at Chain Hills and gravity supplying from the tank to the subdivision. However, there is no suitably elevated (RL310m) land nearby and booster pumping would still be required to supply adequate pressures and flows to the residential lots. This option would add another plant asset for maintenance and has therefore been discounted.

3.4.2 Fire Fighting

Due to a lack of elevated land adjacent the Chain Hills Heights development, the installation of fire-fighting storage and fire pumps are considered the most reliable option to meet the SNZ PAS 4509:2008 Fire Fighting Code of Practice.

Fire pumps would provide for the required 25L/sec at the required pressure.

To ensure fire-fighting capabilities were available during a power outage, a back-up generator would be necessary.

The reticulated network would be DN150 pipework with fire hydrants.

Alternatively, fire storage tanks could be provided at strategic locations adjacent the subdivision to allow fire appliances to fill up during fire fighting events. These would be topped up with the water supply system but would not feed into the reticulated network due to inadequate pressure and potential contamination of the reticulation from stagnant water.

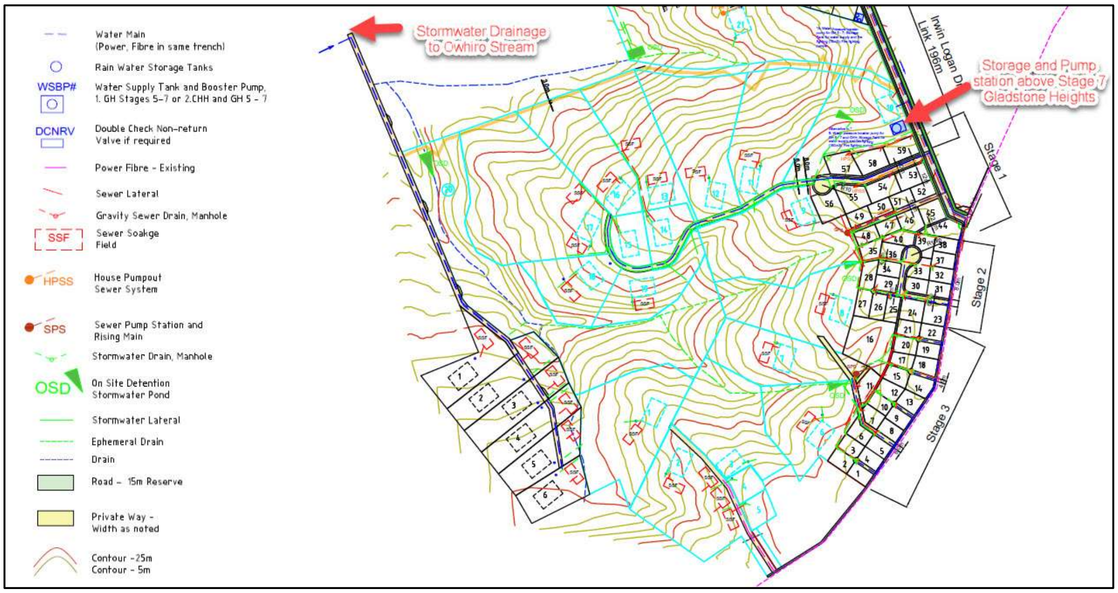

Figure 3.1: Layout of Water Services Infrastructure for Chain Hills Heights

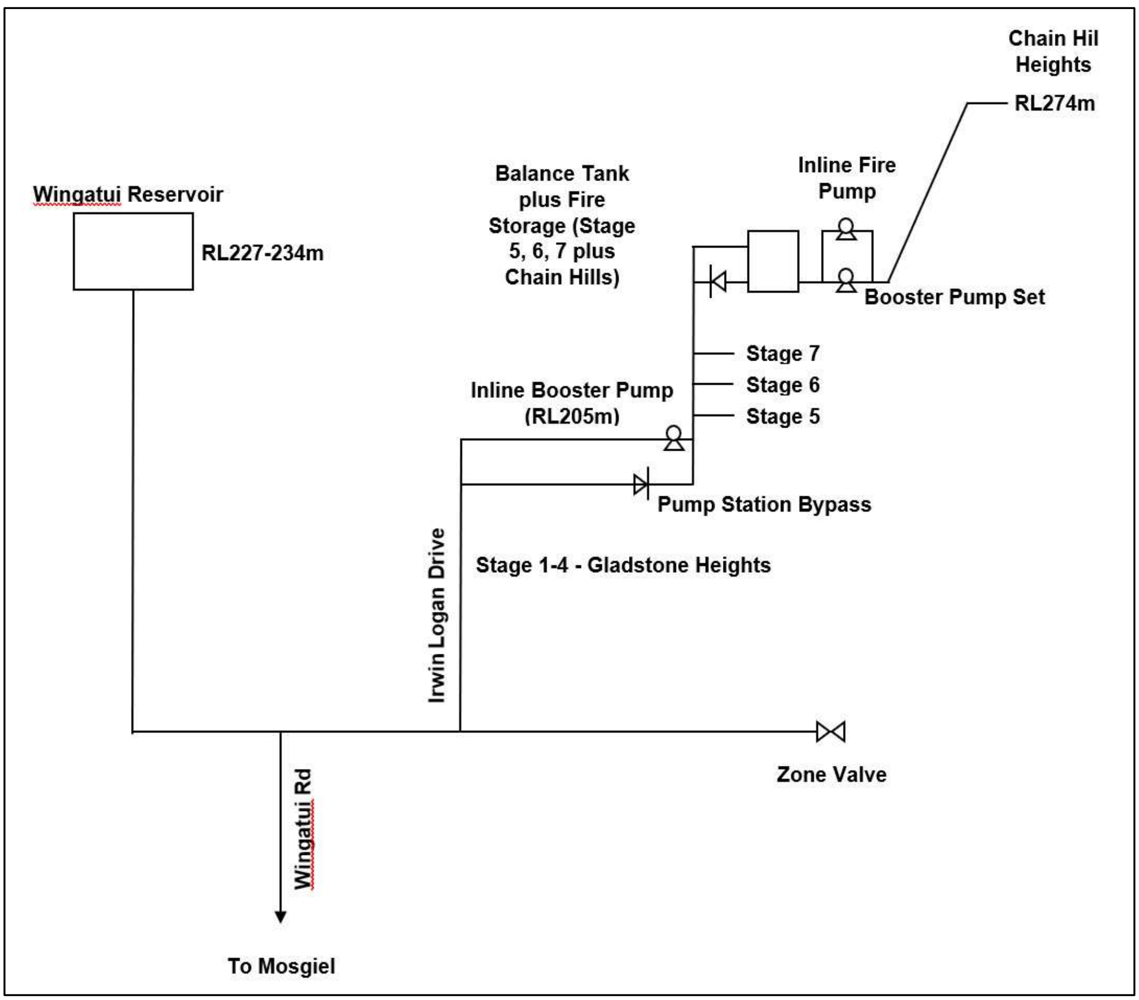

Figure 3.2: Schematic of Water Services Infrastructure for Chain Hills Heights

3.4.3 Storage Sizing

Sizing

The sizing of a reservoir needs to provide for the following:

- Capacity to supply water during periods of high demand in excess of what the reticulation can provide. This is called operating storage.
- Capacity to supply stored water in case of supply failure. This is called emergency storage.
- Fire fighting storage requirements.

Operating Storage Volume

The operating storage is the storage volume differential between the incoming water supply and the peak demand. For the Chain Hills development, it is assumed that during peak periods, no water is available from the Gladstone Heights reticulation and the new reservoir must supply the peak flows. Therefore, the operational storage volume is the equivalent of 5hrs peak demand.

Assuming peak hourly flows occur for a period of 5 consecutive hours (5pm until 9pm), and the reservoir supplies all of this demand, the volume of operational storage required is:

Operational storage = 5 hour x 9.8m^3/hour = 49m^3

Emergency Storage Volume

Emergency storage volume allocation to cover reticulation outage or any other supply issues upstream of the reservoir is usually calculated as 8 hours storage at average daily flows to allow time for the rectification of the defect.

Using the average daily flow, the emergency storage volume equates to:

Average Daily Flow = 58.25m^3 per day

Emergency Storage = 58.25m^3/day x 8/24 =19.4m^3

Fire Fighting Storage Volume

The New Zealand Fire Service Fire Fighting Water Supplies Code of Practice SNZ PAS 4509:2008 recommends that for a non-reticulated water supply the minimum water storage is 45m^3. This is based on a Fire Hazard Classification of FW2.

Total Storage Volume

The total storage volume is therefore recommended to be:

Operational Storage	49m^3
Emergency Storage	19.4m^3
Fire fighting Storage	45.0m^3
Total Storage	**113.4m^3** (68.4m^3 without firefighting storage)

If the development of Stages 5-7 of the Gladstone Heights subdivision is already constructed, and provision of fire fighting storage is provided, the additional storage required to service Chain Hills is 68.4m^3. This could be provided by an additional 3 x 25,000L plastic tanks, or if incorporated into the construction of Stages 5-7 of the Gladstone Heights subdivision, this could be a larger single steel tank (that provides storage for both developments).

If firefighting tanks are required to be installed adjacent the development, at least 45m^3 of storage would be installed in an accessible area for the fire appliances. The location and number of these tanks would need to be discussed with the Fire Service.

4.0 Wastewater Servicing

It is proposed that for Lots identified as Large Lot residential 1 or 2, wastewater will be managed on-site using a septic tank system and dispersal field. The responsibility of supply and maintenance shall be that of the land owner.

For Lots identified as General Residential 1 and Low Density Residential, it is proposed that the wastewater drainage system be installed by the Developer and then vested to the Dunedin City Council. The following section focusses on Chain Hill Heights infrastructure.

4.1 Existing Infrastructure

Current Lots within the Gladstone Heights Subdivision are serviced by a DN150 wastewater main that follows down Irwin Logan Drive and connects with Gladstone Road North. A DN150 pipeline then drains to the Wingatui No. 4 pump station. With Stage 7 of Gladstone Heights completed the pump station will service an area of approximately 87.5 Ha as shown in Figure 4.1 below. The pump station pumps into the downstream DCC network and ultimately to the Green Island Wastewater Plant.

Figure 4.1: Wingatui No. 4 Pumpstation Approximate Current Catchment Area

4.2 Wastewater Production

The DCC Code of Subdivision outlines the following requirements for residential wastewater design flows:

- The Average Dry Weather Flow should be based on 270L/p/d
- A dry weather diurnal peaking factor of 2
- A wet weather peaking factor of 3
- The number of people per dwelling should be between 3.5

The estimated wastewater design flows for the proposed Chain Hills Heights of the subdivision are presented in Table 4.1 below.

Table 4.1: Wastewater Demand Estimate

Flow Type	# of Lots	# of Persons/House	Flow Rate (L/p/d)	Diurnal Peaking Factor	Wet Weather Peaking Factor	Total Estimated Wastewater Flow
Average Dry Weather Flow (ADWF)	59	3.5	270	-	-	56m^3/day
Peak Diurnal Dry Weather Flow (PDWF)	59	3.5	270	2	-	1.3L/sec
Peak Wet Weather Flow (PWWF)	59	3.5	270	2	3	3.9L/sec

The impact of the increased wastewater flow estimates from the development have not been assessed for the downstream reticulation, pumping stations or wastewater treatment plants. If the capacity of the downstream wastewater network were an issue, wastewater detention storage could be considered to manage flows until the DCC network was upgraded.

An alternative option may be to pump into the wastewater catchment in Fairfield (see Figure 4.2 below). This could also collect wastewater from other properties along Chain Hills Road if advantageous to the Dunedin City Council. The distance is approximately 1.8km and would require new pipelines, pump stations and an assessment of the downstream network.

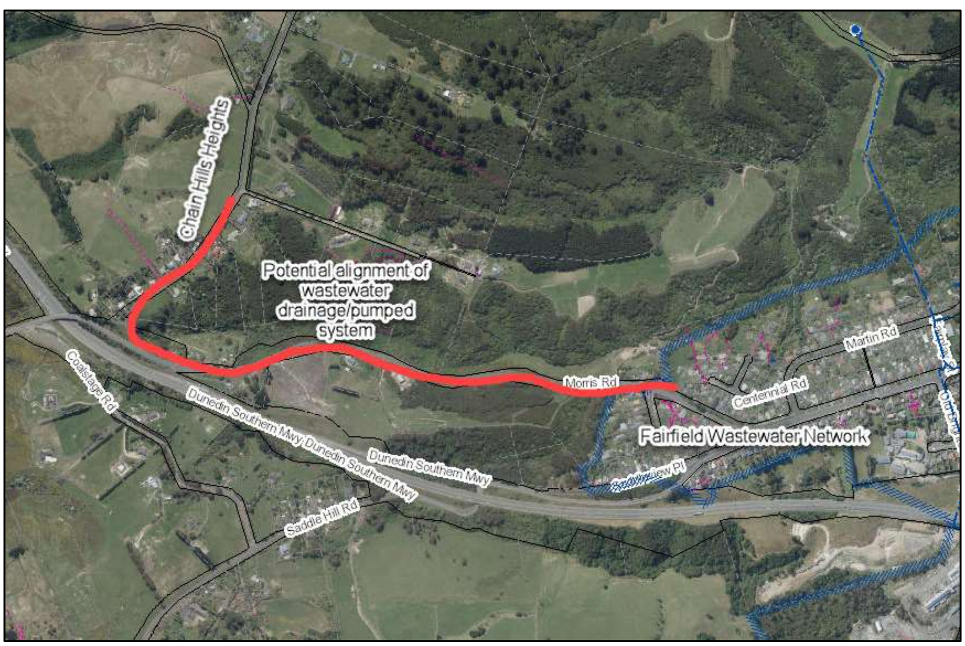

Figure 4.2: Potential Alignment of Gravity/Pumped Sewer to Fairfield Network

5.0 Stormwater Management

5.1 Existing Stormwater Infrastructure

The proposed development site is located upstream of the existing Gladstone Heights subdivision – refer to Figure 5.1. Stages 1-5 has been consented and the main stormwater detention pond built to service this area. The later Stages 6 and 7 provide separate detention and drain to the west. Stage 6 and 7 have not yet been consented or constructed.

The proposed Chain Hills Heights, Chain Hills Park, and Woodland Park developments included in this assessment would be able to have stormwater servicing separate to the Gladstone Heights development.

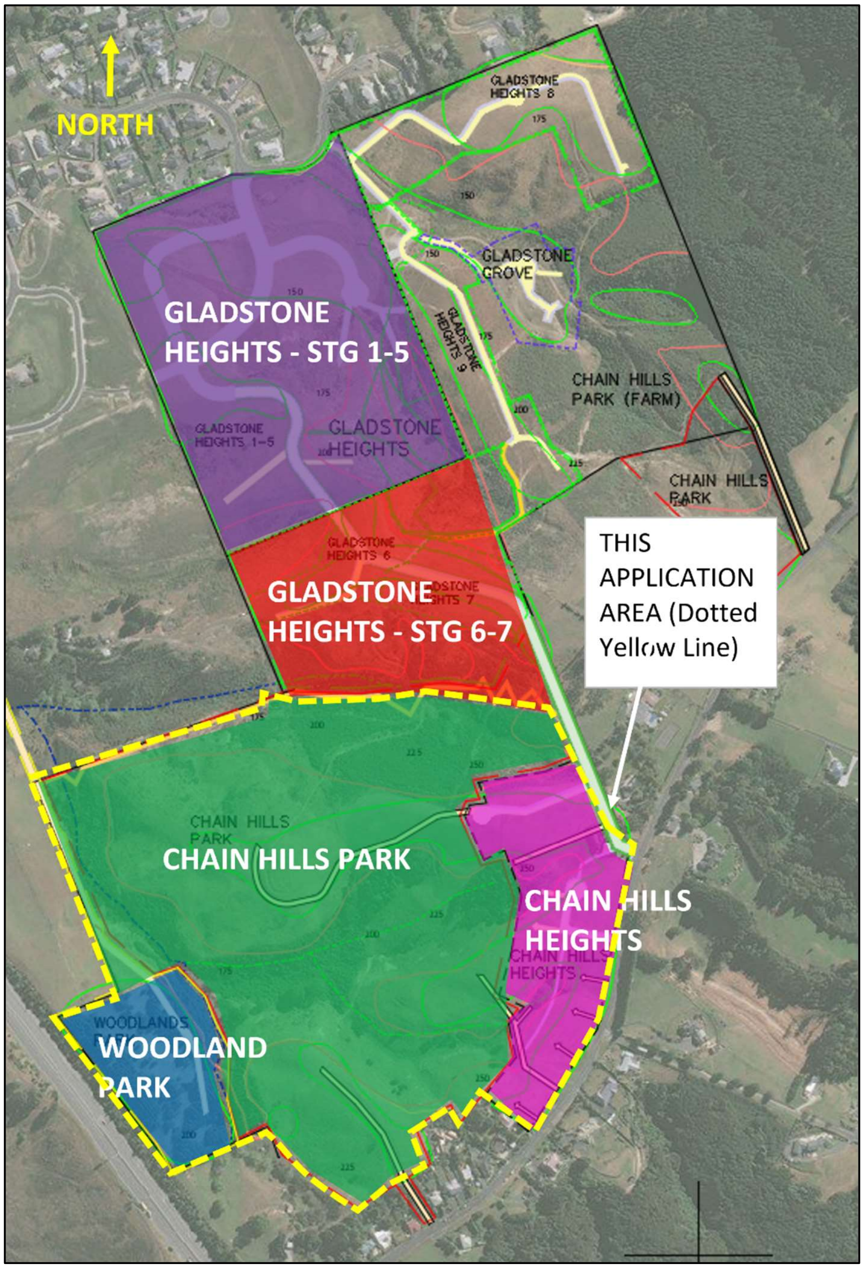

Figure 5.1: Existing Stormwater Infrastructure and Surrounding Catchment

5.2 Local Stormwater Features

The stormwater from the Chain Hills Heights, Chain Hills Park, and Woodland Park site discharges to the west into Quarry Creek before entering the Owhiro Stream downstream of Mosgiel. This is presented in Figure 5.2 below.

Figure 5.2: Local Stormwater Features

It is understood that the Owhiro Stream catchment is sensitive to flood flow volumes as well as peak flows, particularly for the longer duration storm events in the area upstream of Gordon Road. The discharge of Quarry Creek into the Owhiro Stream is located downstream of Gordon Road.

It is noted that there are potential capacity limitations in the Quarry Creek catchment, including existing culverts, which will need to be considered as part of the design. It is also noted that Quarry Creek discharges into/becomes Scheduled Drain O5, which is part of the Otago Regional Council (ORC) drainage scheme network. A Resource Consent from the ORC for discharge of stormwater may be required and will be considered as part of the design process.

5.3 Catchment Flow Paths

Figure 5.3 shows the pre-development natural overland flow paths. It is considered that the post-development flow paths would be similar to that of the pre-development.

Note that all drainage paths for the Chain Hills Heights, Chain Hills Park, and Woodland Park site discharge to Quarry Creek via two main gully channels.

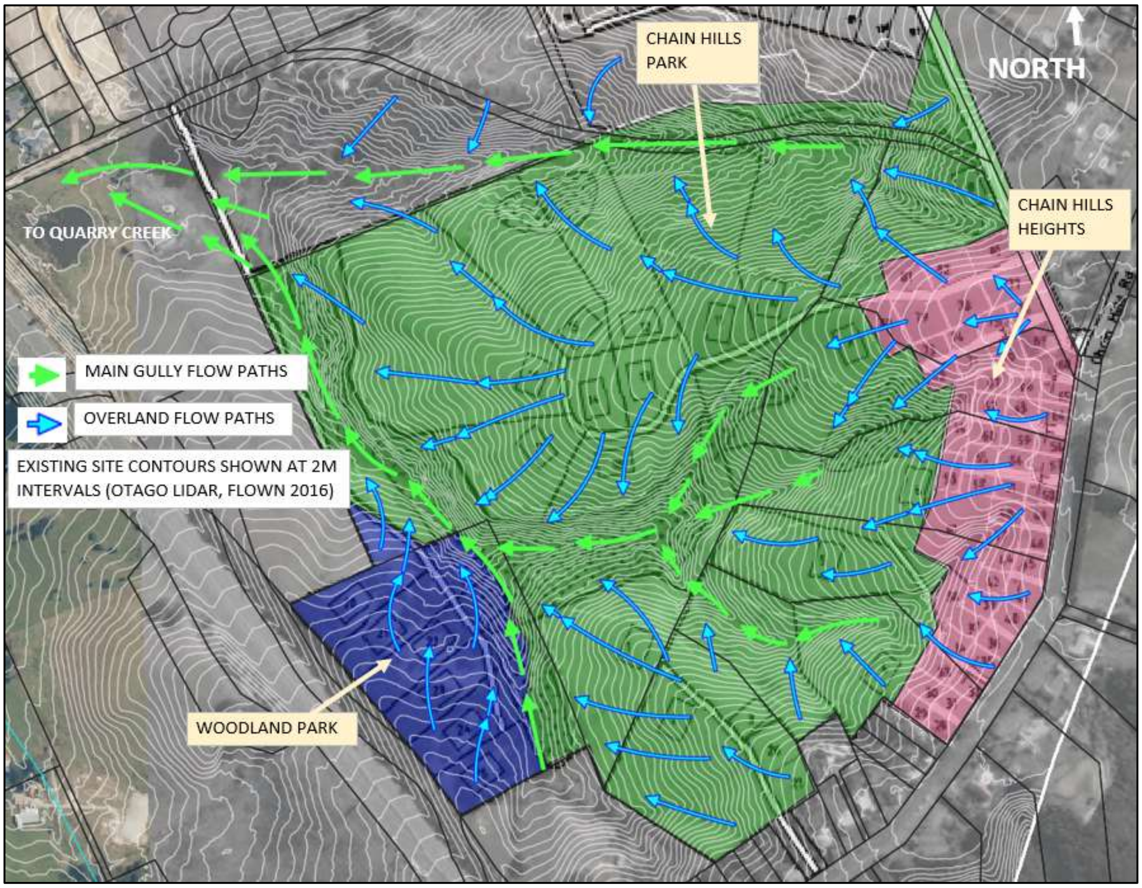

Figure 5.3: Catchment Flow Paths – Pre-development

5.4 Stormwater Management Requirements

An overview of the Dunedin City Council (DCC) requirements for stormwater management is set out below. Also included are the proposed measures to ensure management of stormwater runoff effects.

5.4.1 Design Storm Events

The DCC Code of Subdivision and Development (COSD) requires that a primary stormwater or flood management system be designed to convey, as a minimum, a 10yr Average Recurrence Interval (ARI) taking into account climate change. Where a secondary flow path is available, the secondary flow path is required to convey the balance of a 100yr ARI flow without damage to property and with freeboard. If a secondary flow path is not available, the primary system is required to convey a 100yr ARI flow. Consideration should be given to both upstream and downstream effects.

For the proposed development, the pipe network system would be located in the road and discharge to the detention area would be considered the primary network. The road would act as a secondary overland flow path in large events in combination with the other flow paths shown.

5.4.2 Climate Change

The current Dunedin City Council “Standards for Stormwater Management Plans” memo (13 June 2019) requires the design to take into account allowance for an assumed increase in average annual temperature following the RCP8.5 climate change projection scenario for the period 2081 – 2100 (published by NIWA in HIRDS Version 4). Typically, this RCP8.5 (2081-2100) scenario has been applied to the rainfall used to calculate both the pre- and post-development runoff flows.

Additionally, it is proposed that the calculation of the pre- and post-development flows from the site are considered based on the current rainfall (or historical rainfall published by HIRDS). The purpose of this is to ensure that the flow leaving site is not greater than the current flow conditions.

5.4.3 Impervious Area Assumptions

Impervious area allowances for the lots are to include an assessment based on an assumed house size, driveway, and pathway allowance (relative to the size of land) against the allowed impervious area percentage under the district planning requirements. The larger of the two values would be utilised in the design moving forward.

5.4.4 Peak Flow Mitigation and Downstream Effects

The stormwater management design shall include measures to:

- Avoid increases in peak runoff flow. Note that it is not intended that the stormwater management plan will avoid volume increases.
- Avoid adverse impacts on the water quality of receiving waters.
- Minimise environmental impacts, which include management of erosion from discharges.
- Allow for emergency flow paths in the event of blockages.
- Provide provision for freeboard. It is proposed that the freeboard allowances are based on a functioning primary system. In the event of a blockage of the primary system or other critical infrastructure, the secondary system or alternative overland flow paths would function with reduced freeboard.
- Allow for consideration of a super design event and design of the system to enable safe operation during this event. It is proposed to utilise the 250yr ARI storm to account for the super-design event as this information is readily available from the HIRDS version 4 database.
- Ensure that adverse effects that are more than minor are not created downstream.

Separate to the stormwater management design, a site management and erosion and sedimentation management plan should be developed and approved prior to earthworks and site development.

The discharge from the development is proposed to flow through to Quarry Creek and into the Owhiro Stream downstream of Gordon Road.

Use of the current rainfall considerations coupled with consideration for flexibility within the stormwater management system design would ensure that the post-development flows in the future, when climate change has occurred, are no more than the existing case as of current. One example of this may be to implement a temporary orifice plate to control outflows from a detention pond based on lower current peak flows.

5.4.5 Operations and Maintenance

An operations and maintenance plan would be developed as part of the detailed design for the system. This would include determination of ownership and responsibilities for maintaining the system, recommended maintenance requirements, and frequency of inspections.

Additionally, the operations and maintenance plan, as a minimum, needs to consider:

- Public safety
- Risk of blockage
- Access
- Mowing, vegetation management
- Ease of removal of silt and debris
- Maintenance schedules, timing, and reporting.

5.4.6 Treatment

Stormwater treatment is to be considered as part of the design including at a minimum treating the 'first flush' volume (90th percentile daily rainfall depth) or flow rate (90th percentile rainfall intensity) in accordance with best practice techniques for at least 75% Total Suspended Solids (TSS) removal on a long-term average basis.

5.5 Stormwater Management Options Assessment

The stormwater management options included as part of this high-level assessment are set out below. Note that the scope of the assessment was limited to focus on stormwater management on-site or discharge through existing downstream infrastructure only.

Volume and flow estimates would need confirmed through a more detailed design process.

A summary of the stormwater management options as identified as part of this assessment are presented in Table 5.1. An assessment of the benefits and drawbacks for each scenario is also presented along with comment on the feasibility of the solution to suit the sites.

It should be noted that the basic nature of development in a catchment increases the frequency of flows which likely exacerbates erosion. For each of the proposed options, erosion protection to the gully flow paths will be needed.

Table 5.1: Summary of Stormwater Management Options

Option	Description	Benefits	Drawbacks	Preferred Option Commentary
1	Detention tanks on individual lots to manage flows from each individual lot	▪ Allows for the site to be built progressively as stormwater is managed as at a micro level. ▪ Does not impact on the developable area which could be otherwise used for lots. ▪ Allows for potential options to reuse rainwater.	▪ Surface tanks can only collect runoff from roof surfaces. Even with sub-surface tanks collection of runoff from other impervious surfaces such as driveways or pathways is difficult. ▪ Tanks (either surface or sub-surface) are often not maintained and would require involvement from individual lot owners. Maintenance checks would need to be managed either by Council or a body corporate. ▪ There is no allowance for mitigation of runoff from the communal areas such as roads, which means that lot owners have to provide further capacity to account for unmitigated runoff from these areas. ▪ Lot owners required to do further investigation as to tank sizing and front cost. ▪ Available space for building within the lots is compromised.	This is appropriate for Large Lot Residential and Lifestyle Lots (Chain Hills Park and Woodland Park).
2	Single, communal detention facility to manage flows from the whole site (located at downstream boundary)	▪ Communal system means not onerous for individual owners. ▪ Able to collect flows from all development areas. ▪ Easily flexible design to allow for reduced discharge to accommodate current rainfall flow rates. ▪ Does not impact on developable land area.	▪ Maintenance would need to be completed by a body corporate or vested to Council. ▪ Potential hazard due to ponding at depth. ▪ The flows in the upper catchment would be unmitigated requiring added erosion protection in the gullies. There would also be a risk of complications due to the discharge flow paths running through multiple properties. ▪ Installation of erosion protection measures in the gully may be difficult to construct given the steep nature and access for equipment.	This option is not preferred due to the need for extensive erosion protection works through the downstream gullies.
3	Multiple detention ponds within the greater development to manage flows from the whole site	▪ Communal system means not onerous for individual owners. ▪ Able to collect flows from all development areas. ▪ Easily flexible design to allow for reduced discharge to accommodate current rainfall flow rate. ▪ Easier to manage downstream erosion as flow limited higher up the catchment.	▪ May result in a larger detention area than a single combined system. ▪ Maintenance would need to be completed by a body corporate or vested to Council. ▪ Potential hazard due to ponding at depth. ▪ Reduces the amount of developable land for lots.	This is the preferred option for managing stormwater from the smaller Residential Lots (Chain Hills Heights). See Figure 5.4 for potential locations of detention ponds.
4	Discharge via ground soakage	▪ Reduces discharge flows from the site.	▪ Due to the steepness of the catchment, the ground may be unsuitable to support discharge to ground and may cause migration through the hillside to seep out downstream.	This is a possible option for Large Lot Residential and Lifestyle Lots (Chain Hills Park and Woodland Park).

Based on the analysis presented in the Table 5.1 above, the preferred stormwater management servicing option is shown in Figure 5.4 below. Note that different stormwater management solutions for the Chain Hills Park / Woodland Park and Chain Hills Heights areas are proposed. The locations, sizes, and design of the stormwater management infrastructure would be developed at the time of consenting and design.

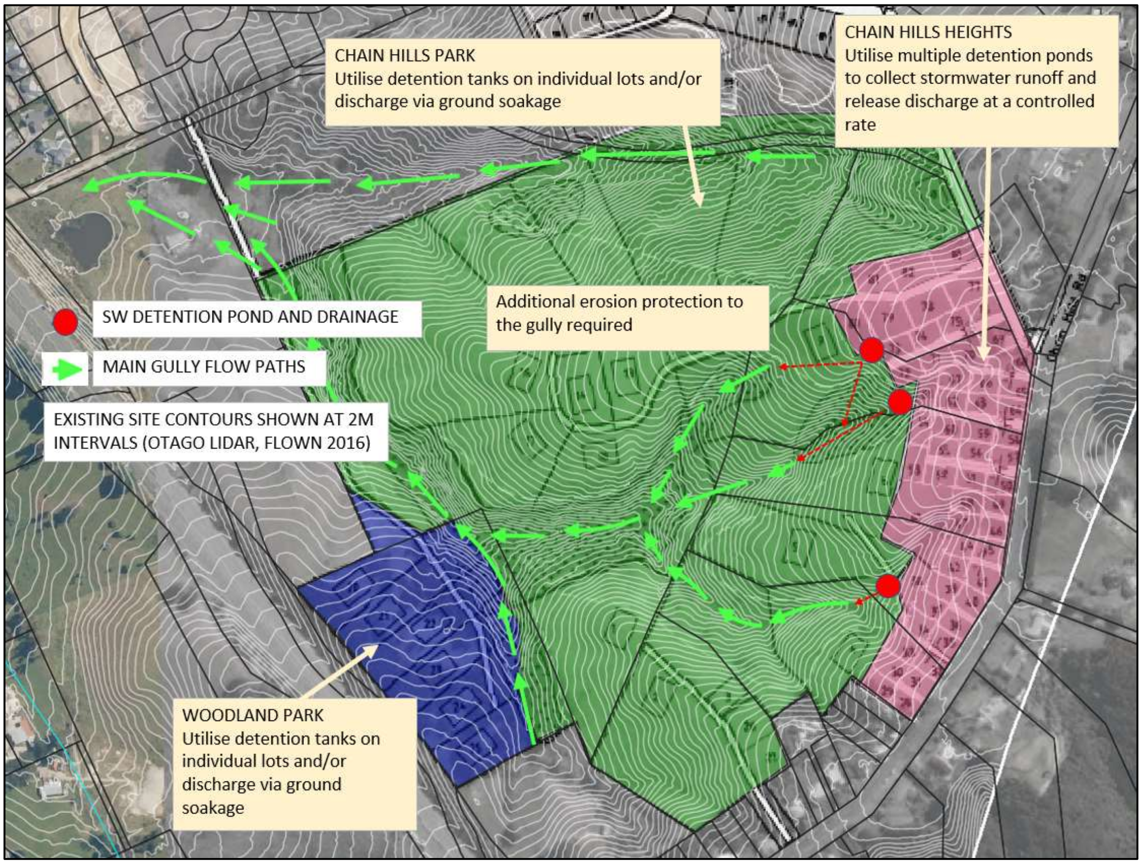

Figure 5.4: Preliminary Stormwater Management Infrastructure for Chain Hills Development

6.0 Conclusion

The proposed Chain Hills subdivision can be serviced for 3 waters.

The average water demand on the DCC network is calculated to be $58m^3$/day. Peak demands are calculated to be $9.8m^3$/hour but the demands on the DCC system would be minimised through the use of water storage.

It is proposed that the water infrastructure for Chain Hills is an extension of the Gladstone Heights reticulation, some additional storage, a set of booster and inline fire pumps, and a generator for security of supply during power outages. Other than the reticulation, all of this infrastructure would be located at the storage tank site provided for Stage 6-7 of Gladstone

Heights. This limits the issues associated with operating infrastructure spread over several sites.

The average dry weather flow for wastewater (using the DCC COSD) is calculated to be 56m^3/day and a peak wet weather flow of 3.9L/sec. It is proposed that this be drained to the catchment feeding the Wingatui No. 4 Pumpstation. The impact of the increased wastewater flow estimates from the development have not been assessed however, if the capacity of the downstream wastewater network were an issue, wastewater detention storage could be considered to manage flows until the DCC network was upgraded.

The preferred option for stormwater management involves various servicing options based on the lot sizes and location of the lots within the catchment. The stormwater management combines a recognises the need to manage peak flows as well as control erosion. The locations, sizes, and design of the stormwater management infrastructure would be developed at the time of consenting and design.

The details of the specific system will be confirmed during detailed design.