Avondale Strategic Development Civil and Infrastructure Assessment

Beca

Reference: 510633

Revision: 1

2020-12-01

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Document control record

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Document control						
Report title	Avondale Strategic Development Civil and Infrastructure Assessment					
Document code	510633-0000-RPT-CC-001		**Project number**		510633	
File path	s 9(2)(a) [redacted]					
Client	Beca					
Client contact	Alex Fullerton		**Client reference**			
Rev	**Date**	**Revision details/status**	**Author**	**Reviewer**	**Verifier** (if required)	**Approver**
0	2020-11-27	Issue for client review	SN / AM	SN / AM	NB	KD
1	2020-12-01	Updated with Beca comments	SN / AM	SN / AM	NB	KD
Current revision	**1**					

Approval			
Author signature	s 9(2)(a) [redacted]	Approver signature	s 9(2)(a) [redacted]
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1 Introduction

1.1 General

Aurecon New Zealand Ltd (Aurecon) has been engaged to work in partnership with Beca, to assist Kāinga Ora – Homes and Communities (hereby referred to a Kāinga Ora) in understanding the development potential of various sites located within the Avondale Strategic Development Study Area, in Auckland. The study area includes Avondale Racecourse and 37 additional sites across the Avondale suburb. The development has the potential to provide an estimated 4,413 dwellings to the area, a net uplift of 4,032 dwellings from the pre-development state. The dwellings will range between two and eight stories, with the higher eight story apartment complexes located primarily towards Great North Road, in close proximity to Avondale Railway Station. The properties are shown on Kāinga Ora plan *State Ownership Site Areas* as presented within Appendix A.

As part of the wider feasibility assessment, Aurecon has been engaged to provide advice on the existing infrastructure within the area and to identify existing and future infrastructure constraints. The assessment includes desktop review of available information on the existing infrastructure and initial consultation with relevant Council Controlled Organisations (CCO's) and Network Utility Operators (NUO's) to discuss network constraints.

It is noted that the scope of this assessment does not include any design associated with network upgrades or the proposed development. Aurecon previously undertook a concept design report for the Avondale Racecourse, refer *HNZC Avondale Racecourse – Engineering, Geotechnical and Contaminated Land – Concept Report* dated November 2018. It is intended that this Civil and Infrastructure Assessment be supplementary to this earlier assessment.

1.2 Precinct Description

The proposed Avondale Strategic Development Study Area is located within Avondale, Auckland west of the city centre. The study area is bounded by Riverside Road and Victor Street to the north, Blockhouse Bay Road to the east, Great North Road to the south and the Whau River to the west. The Whau River flows north into the Waitemata Harbour. Refer to Figure 1 below showing the locality plan. The study area primarily comprises residential housing, the existing Avondale Racecourse and commercial areas located along Great North Road to the east of the Racecourse.

The largest development area within the study area is the Avondale Racecourse. The Avondale Racecourse, which is currently owned and operated by the Avondale Jockey Club, in an approximately 37-hectare site. The site comprises of a horse racing track and parade ring on a relatively flat platform which falls between RL16m and RL12.5m to the north-west corner. There are existing carparking areas and grandstands to the north of the site, which are also relatively flat. In addition to horse racing, the racecourse is currently used for the Avondale Market and the infield area used as a public sports ground. Existing vehicle and pedestrian access is available from Ash Street to the north, Elm Street and Racecourse Parade to the east and Wingate Street to the south.

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Figure 1: Avondale Precinct Development Study Area and Master Planned Areas (Source: Kāinga Ora)

The additional 37 sites identified by Kāinga Ora are in close proximity to the racecourse. These sites include:

- **Kāinga Ora Sites 1-21** - located to the north of the racecourse and are concentrated around Ash Street, Canal Road and Riversdale Road.
- **Kāinga Ora Sites 25-28** – Located to the west of the racecourse on Ash Street near to the Whau River.
- **Kāinga Ora Sites 22-24, 29-32, 34 and 36** – Located to the east of the racecourse in close proximity to the Great North Road shops.
- **Kāinga Ora Site 37** – Located on the opposite side of the railway to the remainder to the development sites, off Blockhouse Bay Road.
- **Kāinga Ora Sites 33 and 35** – Located south of the racecourse along Wingate Street and Great north Road.
- **Avondale Panuku** – Two additional sites have been identified that are intended to be unlocked as part of the Avondale Panuku development programme. These two sites are located on the corner of Rosebank Road and Great North Road, and the corner of Racecourse Road and Great North Road.

The majority of the identified sites (with the exception of the racecourse) contain existing dwellings which will need to be demolished prior to construction of the proposed development properties.

1.3 Development Yields

Development yield information has been provided by Beca for each of the identified potential development sites. The proposed dwelling yield numbers are estimated using National Policy Statement (NPS) density uplift method. Table 1 below summarises the existing and proposed development numbers for each of the Kāinga Ora study area sites.

Table 1: Summary of proposed development yields

Kāinga Ora Site	Site Address	Site Area (m^2)	Existing Dwellings	Proposed Dwellings	Number of Stories
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Kāinga Ora Site	Site Address	Site Area (m^2)	Existing Dwellings	Proposed Dwellings	Number of Stories
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Avondale Racecourse	Avondale Racecourse A	371,374	0	2,532	5-8
Unlock Avondale Panuku	Avondale Central	7,446	0	139	8
Unlock Avondale Panuku	Existing Community Facilities	7,566	0	0	0
TOTAL		**528,078**	**381**	**4,413**	**NA**

Within the development study area, further infill housing is also anticipated within non-Kāinga Ora sites. This infill housing has been estimated by Beca, based on Auckland i11 projections. The total dwelling number projections through to 2068 are provided below in Figure 2.

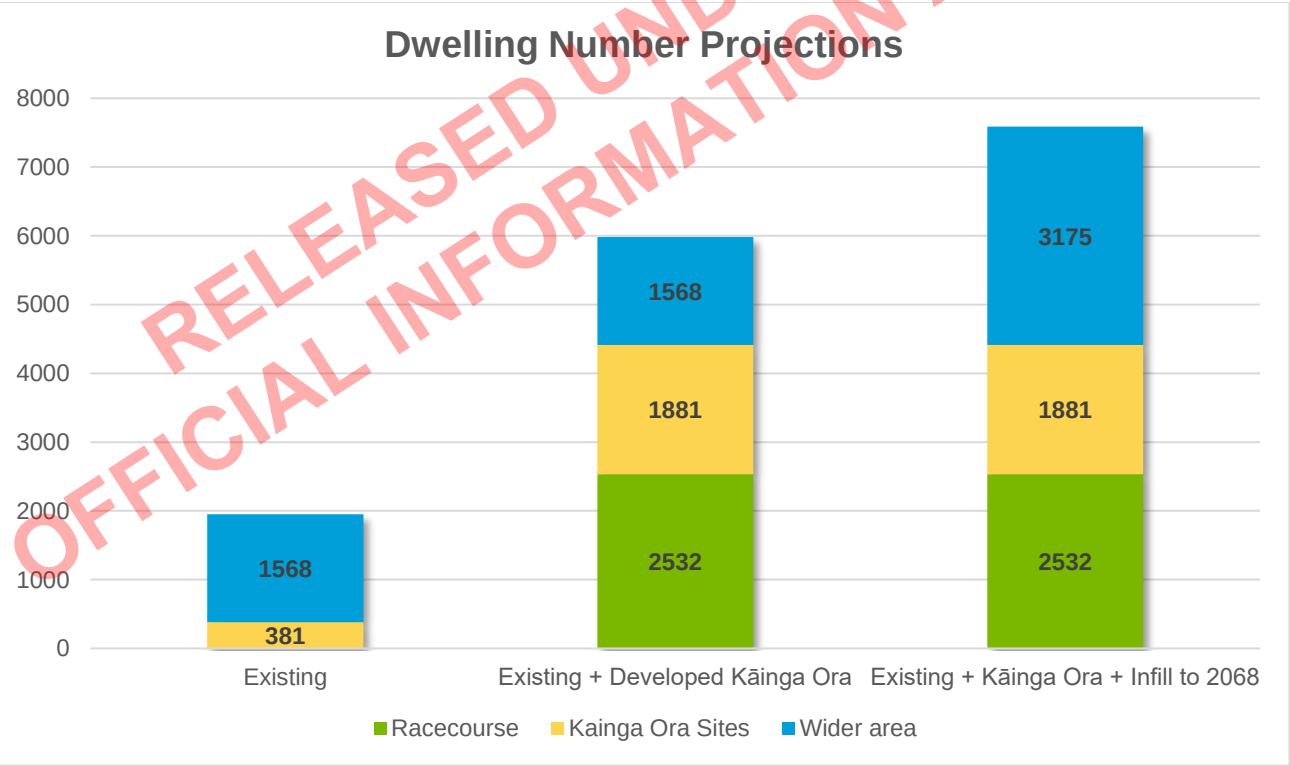

Figure 2: Dwelling Number Projections to 2068

1.4 Scope of Works

The scope of works Aurecon has been appointed to provide is covered in this report and includes the following:

- Update the infrastructure advice previously provided based on the updated project boundaries and proposed future development scenario.

- Provide advice on the known constraints within the wastewater, water supply, stormwater, power, communications and gas networks based on review of existing information.
- Engagement with CCO's and NUO including Watercare, Healthy Waters, Vector and Chorus to gain an understanding of planned projects, potential effects on an uplift in yield and to gain an understanding of their expectations on the way forward.

In addition, Aurecon has been commissioned to update the previous geotechnical and ground contamination site assessments (previously undertaken by Aurecon as part of the *Engineering, Geotechnical and Contaminated Land – Concept Report* for the Avondale Racecourse, dated November 2018). These are included as standalone reports. The associated references are outlined below:

- 510633-REP-GG-001 – Preliminary Geotechnical Desktop Report
- 510633-004-KF-MEM-0001 – Avondale Precinct IMP – Contaminated Land Review – Rev 01

2 Wastewater

2.1 Existing Wastewater Network

2.1.1 Existing Network Overview

The Watercare GIS demonstrates that the majority of the study area drains through gravity branches towards a 450-525mm diameter trunk main, refer Figure 3 below. The 450mm diameter main travels along the eastern boundary of the Avondale Racecourse site, north along Highbury Street, before increasing in diameter to 525mm near the intersection of Holly Street and Victor Street. Ultimately, this wastewater is conveyed to the Mangere Treatment plant located to the south-west of the site.

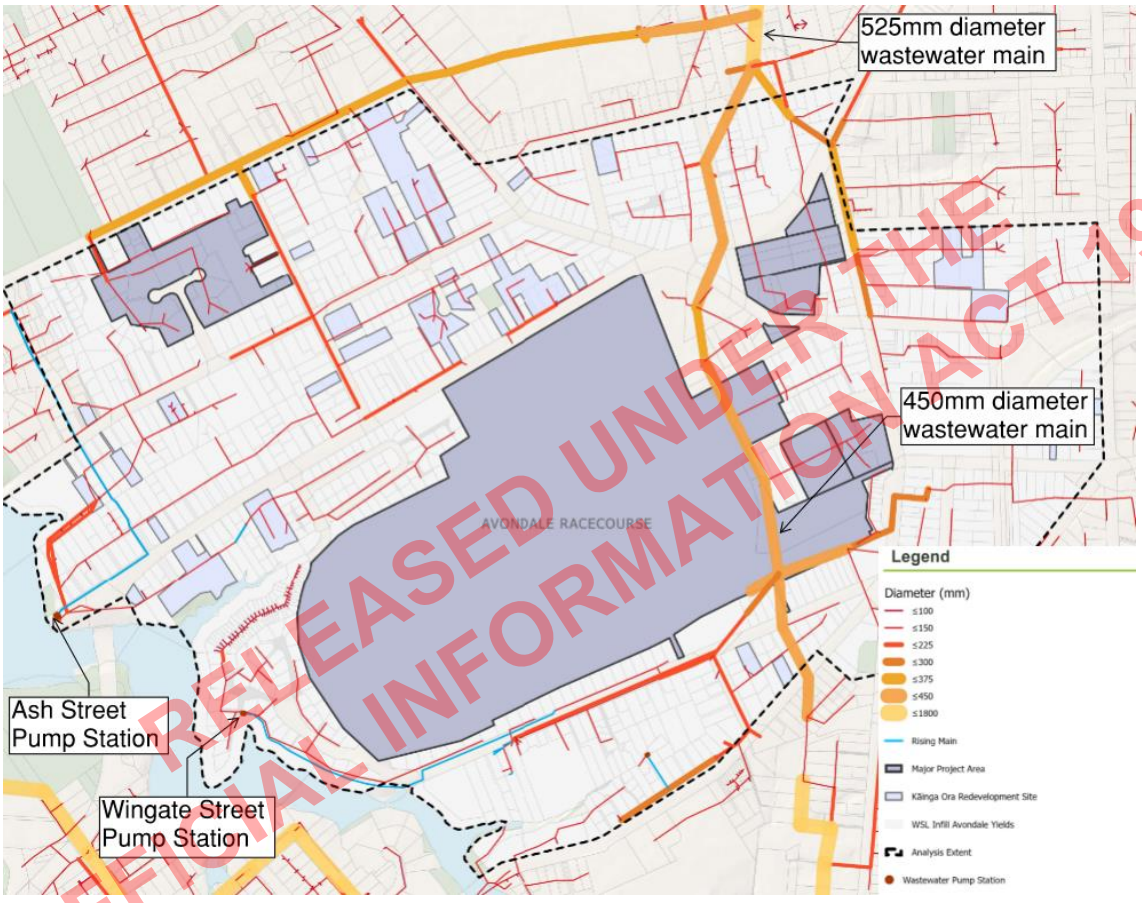

Figure 3: Wastewater network within study area (Pipe network source: Watercare GIS, November 2020)

Two wastewater pump stations are located within the study area downstream of the Kāinga Ora sites. The Wingate Street pump station is located behind 6 Wingate Street adjacent to the Whau River. The contributing catchment for this pump station includes properties from Tamora Lane and the western Portion of Wingate Street. From this pump station, the associated rising main discharges to the gravity network on Wingate Street (a tributary to the 450mm diameter trunk main).

A second pump station is located at the western end of Ash Street. The catchment for this pump station includes Ash Street west of Rosebank Road, Sandy Lane, Nacton Lane and Canal Road west of Wairau Avenue (excluding Bellgrove Place). The Watercare GIS indicates that this pump station pumps via a rising main to the gravity network located within s 9(2)(a)

Refer to FIGURE KK-0012 within Appendix B showing wastewater catchments within the study area.

Within the study area, the wastewater drainage network comprises 21.6km of gravity drains and 1.2km of pressurised rising mains. There are approximately 440 manhole structures within the study area. The diameter of the gravity mains is predominately 150mm diameter (72%) and 225mm diameter (11%), with the remainder of the network within the area ranging between 100mm to 450mm diameter.

Based on the Watercare GIS database, it is understood that the wastewater network within the study area was primarily constructed within the 1960s (76%). Over this period, it appears that the wastewater network was mainly constructed of vitrified clay (VC) or asbestos cement (AC). Trunk mains were primarily constructed of concrete (CONC). Newer sections of wastewater drains have subsequently been installed in the last three decades with predominately from polyethylene (PE), polyvinyl chloride (PVC-U) or vitrified clay materials. Refer to Figure 4 below for a breakdown of pipe age and material of the wastewater network in the precinct area.

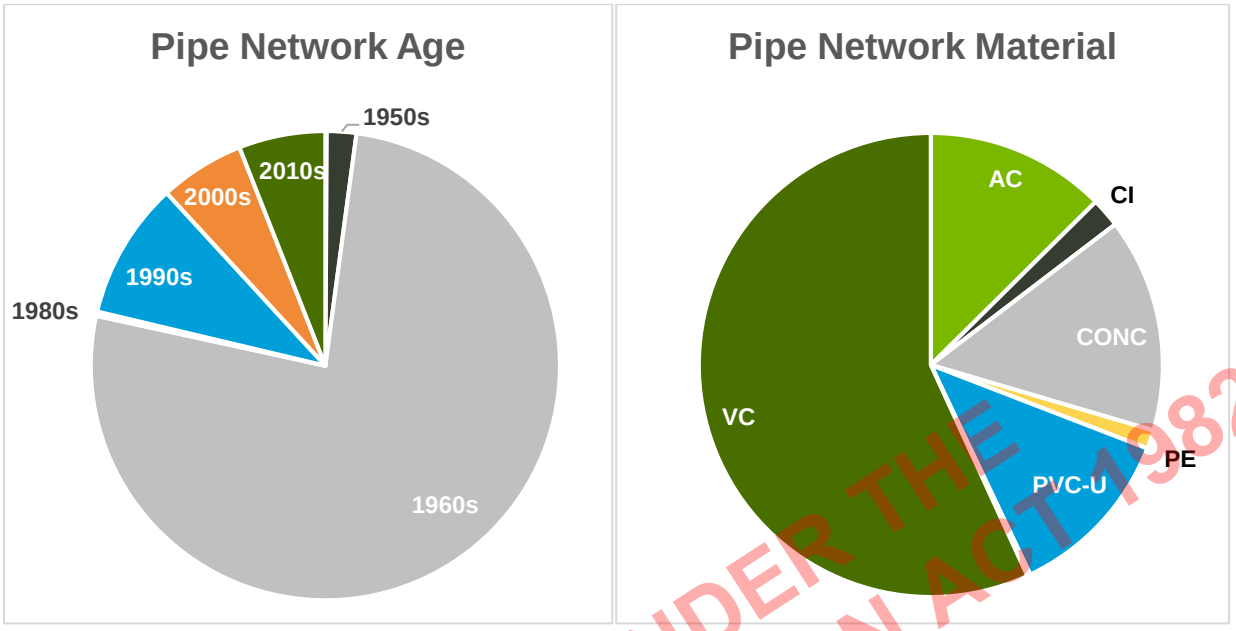

Figure 4: Wastewater Network Installation Decade and Pipe Materials

2.2 Network Condition

Condition data for relevant wastewater drains downstream of the Kāinga Ora study sites were requested from Watercare, but no information was made available at the time of this report. However, based on the materials and age of the existing pipes, some assumptions can be made regarding the likely remaining design life. The oldest pipes in the network are approximately 60 years old and, based on the construction material, some are reaching the end of their expected lives. Sufficient remaining life of the network was determined based on the requirement that pipes have 40% remaining in their design life 10 years after the completion of the project (year 2040 based on an assumed 10 years of design and construction). This is a parameter previously developed with Kāinga Ora to determine the outer enveloped of renewals for which the NUO may request a financial contribution. The table below lists the design life assumptions applicable to the wastewater network.

Table 2: Expected Pipe Life

Pipe Material	Design Life
Asbestos Cement	80 years
Cast Iron	125 years
PE	95 years
PVC	90 years
Steel	85 years
Concrete	90 years
Vitrified Clay	80 years

Based on the above assumptions and the pipe age and material data available within the Watercare GIS, Figure 5 below demonstrates the lengths of pipes within the study area are assessed to have either sufficient or insufficient useful remaining life. It is noted that for the purpose of this assessment, trunk mains are assumed to be those greater than 300mm diameter. The figure shows that none of the trunk mains within the study area are of an age and material to have sufficient useful remaining life. Within the local network (less than 300mm diameter), 24% of the pipe network within the area has sufficient remaining life and 76% has insufficient. This is also demonstrated within FIGURE KK-0011 located within Appendix B.

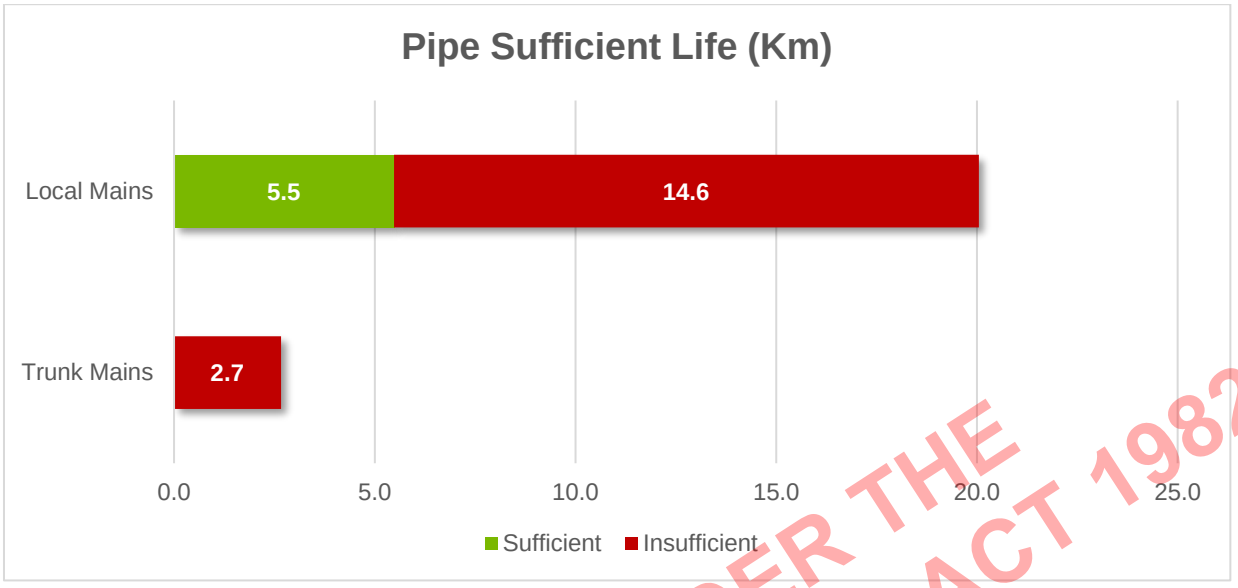

Figure 5: Wastewater Pipe Sufficient Life

2.2.1 Network Location

As previously mentioned, within the project area there are 22.8km of wastewater pipework within the precinct. Based on Watercare's GIS, a large proportion of pipes within the area are located within private property. Within the Kāinga Ora project sites, there are 3.4km of wastewater pipes (15% of the total). It is anticipated that these wastewater mains would need to be protected or relocated during construction works. Work over permits may also be required. Refer to Figure 6 below which shows where these pipe lengths are located within the project areas.

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Figure 6: Wastewater network location

There is a 450mm diameter pipeline that traverses the Avondale Racecourse to the east of the site, as shown below. The Watercare GIS indicates this pipe is 4.5m deep and is constructed of concrete. It is anticipated that a Works Over Approval will be required from Watercare for any works within 10m of the asset. If building over the main, the foundations of the housing will need to be designed to ensure the pipeline is protected, and there aren't unnecessary building foundation restrictions in its future replacement.

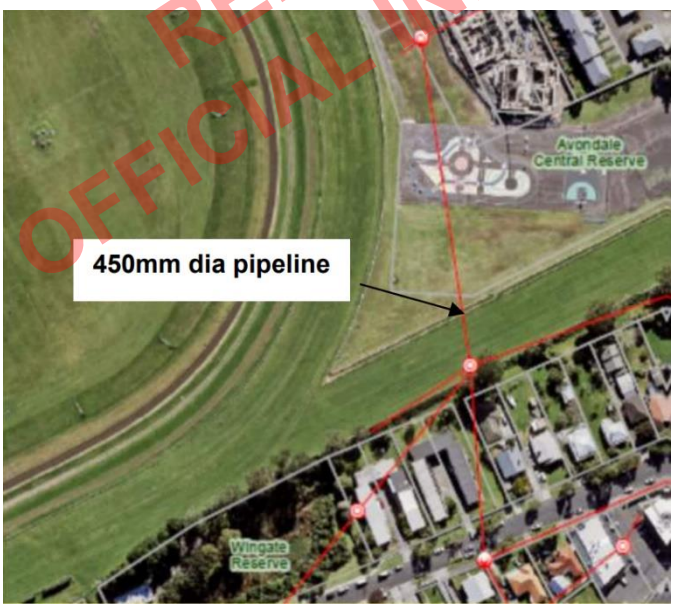


Figure 7: Existing 450mm diameter main through the racecourse site

2.2.2 Consultation with Watercare

Consultation between Watercare, Aurecon and Beca and Kāinga Ora was undertaken on the 29th of October 2020. Key outcomes of this meeting are as follows:

- Watercare require a Level 1 assessment in accordance with Section 5.3.5.1.2(C) of their code of practice to assess the existing network infrastructure capacity. This involved a spreadsheet analysis comparing the pipe full capacity (based on Manning's equation) to the peak wet weather wastewater flows. Typically, this is completed for wastewater pipes less than 300mm in diameter but given the scale of the development Watercare has requested that this assessment be undertaken for pipes up to 450mm diameter.
- Watercare holds a wastewater network model for the area which has been calibrated. This model has assessed system performance for six-month design storm event. It is noted that the results from this model were requested from Watercare but not made available at the time of this assessment.
- Watercare has confirmed that the capacity of the Ash Street pump station is 12.2L/s and the Wingate Street pump station is 7.1L/s.
- Any works undertaken above the 450mm diameter wastewater main located within the racecourse site will need to be discussed with the Watercare Worksover team during design stages.
- No works or upgrades are currently planned for the local wastewater network within the area.
- The Auckland Central Interceptor project is currently under construction and is due to be completed in 2025. This will run below ground from Grey Lynn, under the Manukau Harbour to the Māngere plant. It is understood that a collector main (CC6 shown in blue in the figure below) to service the Avondale area is intended to be constructed at a later date.

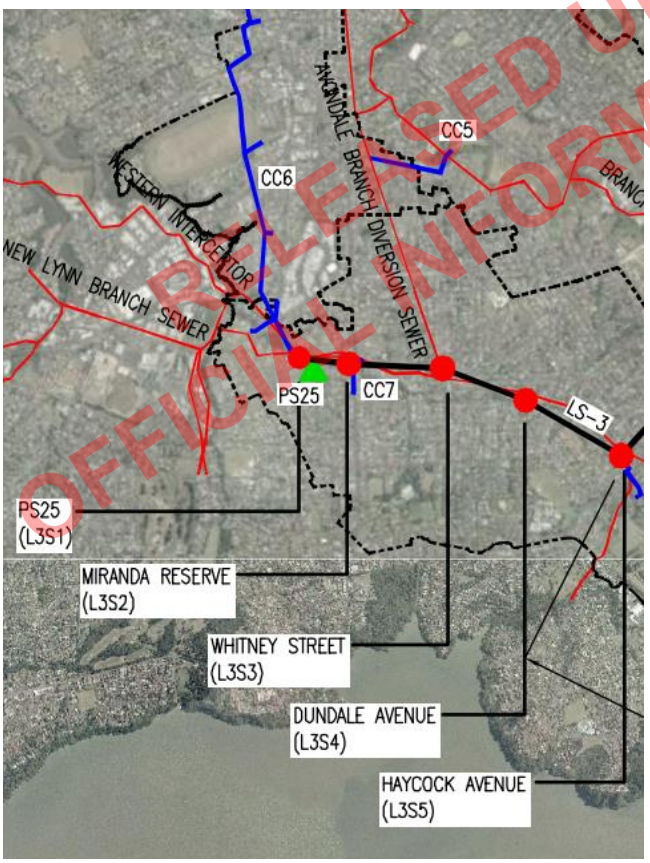


Figure 8: Proposed central interceptor collector main (CC6) to the Avondale area (Source: Watercare website, November 2020)

2.3 Development Wastewater Flows

Residential Wastewater flows from the development study area have been developed in accordance with the requirements of Watercare Auckland Code of Practice for Land Development and Subdivision (hereby referred to as the Watercare CoP). In accordance with the Watercare CoP, a population of 3 persons per unit has been assumed for all existing dwellings, future wider infill and for proposed Kāinga Ora sites where the number of storeys is less than four and the assumed bedroom numbers are between two and four. For future Kāinga Ora sites with buildings four storeys or over, a population of 5 is assumed. A peak dry weather flow (PDWF) peaking factor of 3.0 has been used. Peak wet weather flow (PWWF) peaking factors of 6.7 for less than four storey buildings and 5.0 for four storeys and above have been used. The existing flows from the Racecourse (Avondale Jockey club) have been calculated in accordance with the requirements for wet retail within the Watercare CoP. A summary of the calculated flows is presented below in Table 3.

Table 3: Wastewater Development Residential Flows

Development Area	Existing Population			Existing + Developed Kāinga Ora			Existing + Kāinga Ora + Infill to 2068		
	ADWF (L/s)	PDWF (L/s)	PWWF (L/s)	ADWF (L/s)	PDWF (L/s)	PWWF (L/s)	ADWF (L/s)	PDWF (L/s)	PWWF (L/s)
Racecourse	1	2	6	26	79	132	26	79	132
Kāinga Ora Sites (including Major Project Areas)	2	7	16	18	55	95	18	55	95
Wider infill to 2068	10	29	66	10	29	66	20	60	133
Total	**13**	**38**	**87**	**54**	**163**	**292**	**65**	**194**	**360**

Existing peak commercial flows within the study area have also been estimated for the purpose of network calculations, refer Section 2.4 below. These flows have been calculated based on the land use description for each lot within the GIS data provided by Beca. Where the land use classification has been described as depots, yards, engineering or metal work, these areas have been assumed to be as per the dry industrial medium water use as described within the Watercare CoP. Areas identified as entertainment, halls, medical centres, retail, taverns and wholesale has been taken as wet retail as described within the Watercare CoP. Flows have been calculated based on the lot area with a building footprint of 80% of the lot assumed. Based on these assumptions a PWWF from commercial outlets within the study area has been taken as 44L/s.

Peak flows from existing schools (including Avondale College, Avondale Primary and Rosebank School) have also been calculated in accordance with the Watercare CoP. Student numbers have been estimated based on the information available on the Education Counts website. Staff numbers are assumed based on one staff member per 15 students. The existing total PWWF from the schools within the study area is hence estimated as 12L/s.

2.4 Network Capacity

2.4.1 Network Capacity

As required under the Watercare Code of Practice and based on Watercare consultation (refer Section 2.2.2), a Level 1 pipe-full capacity check has been undertaken against the peak design flow. Manning's equation has been used to assess the capacity based on the pipe diameter and gradient and compared against the design flows presented within Section 2.3 above. The following assumptions have been made:

- The capacity of pipes downstream of Kāinga Ora sites have been calculated only. As per the Watercare CoP, the network assessment extents shall be to the nearest wastewater main which is 300mm diameter

or larger. However, given the scale of the development and upon request of Watercare, assessment of the Wastewater network up to 450mm diameter has been undertaken.

- Where multiple wastewater network branches are located within or close to each of the Kāinga Ora sites, for simplicity the Kāinga Ora sites are assumed to feed to one wastewater network only. This excludes the Racecourse site that has been assumed to be split between three networks based on connection points indicated in the Aurecon *Engineering, Geotechnical and Contaminated Land – Concept Report* (November 2018). Additional upgrades may be required should additional connections to those assumed be established.
- All pipe information including diameter, levels and gradient has been taken from the Watercare GIS database. Where the downstream or upstream invert levels are not available or if the downstream invert level is higher than the upstream inverts level, the minimum grades outlined within Table 5.4 of the Watercare CoP have been used.
- Pipe capacity has been calculated based on Manning's equation. Conservatively, the capacity of each pipe is assumed to be when the pipe is flowing at a depth of 80% of the diameter.
- Wastewater sub-catchments have been assumed to apply to the top of each pipe network section rather than applied to each individual pipe in order to simply the analysis. This is considered conservative.
- It is noted that wastewater calculations do not allow for downstream tail water levels. It is recommended that network modelling be undertaken during future design stages to understand the impact on the network.
- Calculation of existing wastewater rising main capacity has not been included under the scope of this assessment.

Based on the above assumptions and methodology, a total of 8.57Km of wastewater pipes downstream of Kāinga Ora study area sites have been checked for capacity. In the existing state, 95% of these pipes have been identified as having sufficient capacity. This percentage reduces to 67% when adding in additional flows from the proposed Kāinga Ora development. This further reduces to 58% when including additional non-Kāinga Ora infill which is projected to 2068. Refer to the summary table below and FIGURE KK-0012 included in Appendix B.

Table 4: Length of downstream wastewater pipe with sufficient capacity (km)

	Existing	Existing + Kāinga Ora	Existing + Kāinga Ora + Infill
Trunk Mains			
Sufficient Capacity	2.6	2.0	1.9
Under Capacity	0.2	0.8	0.9
Local Network			
Sufficient Capacity	5.5	3.7	3.1
Under Capacity	0.3	2.1	2.7

2.4.2 Pump Station Capacity

As noted within Section 2.1.1, there are two existing pump stations within the study area with contributing flows from the Kāinga Ora sites. Watercare have advised through consultation that the capacity of these pumping stations is 12.2L/s and 7.1L/s for the Ash Street and Wingate Street pump stations respectively. Based on the proposed PWWFs from the Kāinga Ora development and future infill to 2068, it is anticipated that these pump stations will be under capacity and hence upgrades will likely be required. The existing Ash Street pump station has been identified to be under capacity in the existing state. Confirmation will hence be required from Watercare as to whether there is any existing storage associated with this pump station. It is noted that the rising mains associated with these pump stations has not been included under the scope of this assessment but based on the increase in future flow rates it is anticipated that upgrades may be required.

Table 5: Wastewater pump station capacity and PWWF demands (L/s)

	Capacity	Existing PWWF	Existing + Developed Kāinga Ora PWWF	Existing + Kāinga Ora + Infill to 2068 PWWF
Ash Street Pump Station	12.2	25.8	78.3	93.8
Wingate Street Pump Station	7.1	4.3	48.2	54.4

2.5 Network Constraints

The key wastewater network constraints identified through this assessment are summarised below:

- Based on the material and age information available within the Watercare GIS, it is estimated that a high portion of wastewater network within the study area (76%) do not have sufficient useful remaining life. It is therefore anticipated that renewals of affected pipes may be required to service the development, the extent of which to be agreed with Watercare.
- It is estimated that should the Kāinga Ora development be progressed, 33% of the downstream network will have insufficient capacity to accommodate the associated flows. This will further worsen with additional infill development that is projected to 2068. Upgrades of the downstream existing network are hence likely to be required in order to facilitate the development.
- It is estimated that 3.4km of existing wastewater pipes are located within Kāinga Ora sites. These wastewater mains will need to be protected or diverted during construction. Works over permits may be required and if building over, specific foundation design to ensure the pipe is protected.
- The Ash Street and Wingate Street pump stations have been identified to have insufficient capacity to accommodate the development. Pump station upgrades are therefore likely to be required. Although not assessed, it is also anticipated that the associated rising mains may also require upgrading to meet the peak flow requirements.
- It is noted that the capacity of the downstream 525mm diameter trunk main has not be included as part of the assessment. Any constraints downstream of this point will require confirmation from Watercare.

4 Water Supply

4.1 Existing Water Supply Network

4.1.1 Network Overview

As shown within the Watercare GIS, the study area is serviced through a series of pressurised local water supply mains ranging between 15mm and 250mm. These networks are fed off a 250mm diameter water supply main that is located along Great North Road east of the racecourse site and north of the site along Ash Street and Rosebank Road. A 700mm diameter mild steel transmission main is also located along Great North Road. The nearest water supply reservoir to the site is the Mt Albert Reservoir located approximately 2km from Great North Road and the Avondale Racecourse site.

Information about the nearest bulk supply points have been requested from Watercare but were not provided at the time of this assessment.

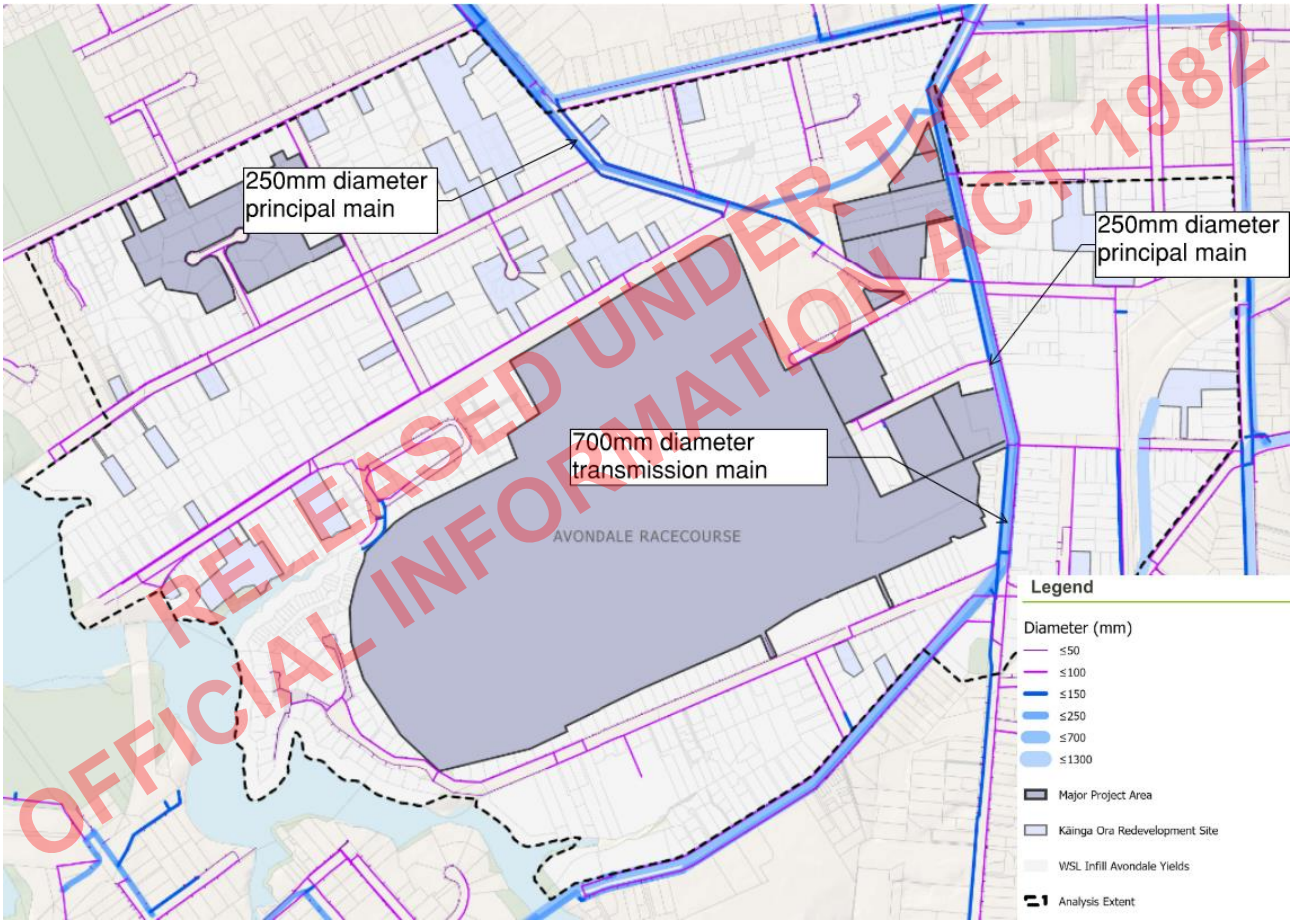


Figure 9: Water supply network within the study area (Pipe network source: Watercare GIS, November 2020)

The Watercare GIS identifies the distribution of principal mains and rider mains within the study area. The water supply network comprises 21km of principal mains and 4.4km of rider mains. Within the study area there is a total of 28.7km of water supply mains that includes property connections and transmission mains. The diameter of the principal mains is predominately 100mm diameter (66%), with the remainder of the principal mains within the area ranging between 40mm to 250mm diameter. The diameters of the rider mains ranges between 15mm to 100mm diameter, with the majority either 50mm diameter (56%) or 100mm diameter (37%).

Based on the Watercare GIS, it has been identified that a large portion of the water supply network within the study area was constructed within the 1960s (43%). Refer to Figure 10 below. Over this time, the water supply mains were primarily constructed of cast iron (CI) and asbestos cement (AC). Another 41% of the

network was installed within the 1990s and 2000s. These mains have primarily been constructed out of cast iron, polyethylene (PE) and polyvinyl chloride (PVC-U).

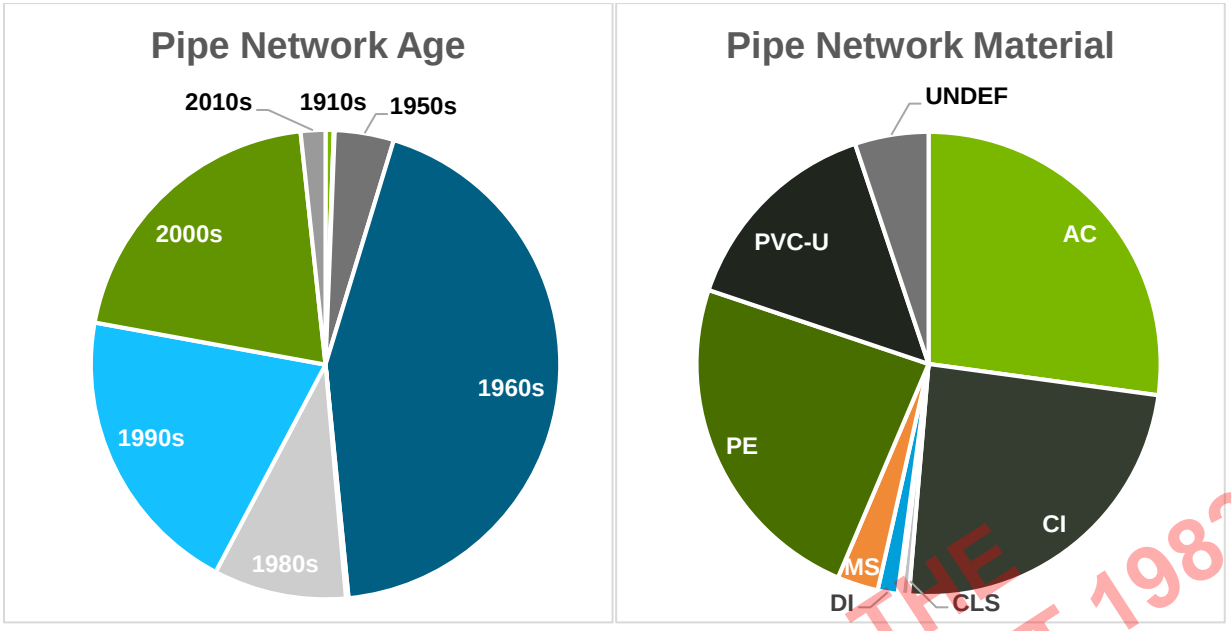


Figure 10: Water supply network installation decade and pipe materials

4.1.2 Network Condition

Given the extent of the development, no condition testing was made available from Watercare at the time of the assessment. Condition data for specific network pipes can be requested from the Watercare operations team should design progress. However, based on the materials and age of the existing pipes within the study area, some assumptions can be made regarding the likely remaining life. The oldest pipes in the network are approximately 120 years old and, based on the construction material, some are reaching the end of their expected lives. Sufficient remaining life of the network was hence determined based on the requirement that pipes have 40% remaining in their design life 10 years after the completion of the project (year 2040 based on an assumed 10 years of design and construction). This is a parameter previously developed with Kāinga Ora to determine the outer enveloped of renewals for which the NUO may request a financial contribution. The table below lists the design life assumptions applicable to the water supply network.

Pipe Material	Design Life
Asbestos Cement	80 years
Cast Iron	125 years
PE	95 years
PVC-U	90 years
Mild steel	85 years
Copper	90 years
Concrete lined steel	85 years
Ductile Iron	125 years

In accordance with the assumptions above, and the pipe age and material data available within the Watercare GIS, the lengths of pipe that have been identified within the study area to have either sufficient or

insufficient useful remaining life is presented within Figure 11 below. The figure demonstrates that 17.5km of water mains within the study area do not have sufficient remaining life. This equates to 61% of the network. This is also demonstrated within FIGURE KK-0021 within Appendix B. It is noted that where the pipe material is undefined within the Watercare GIS, it has been assumed if the pipe was installed in the 2000's is has sufficient life and the pipes installed in the 1960's to have insufficient life.

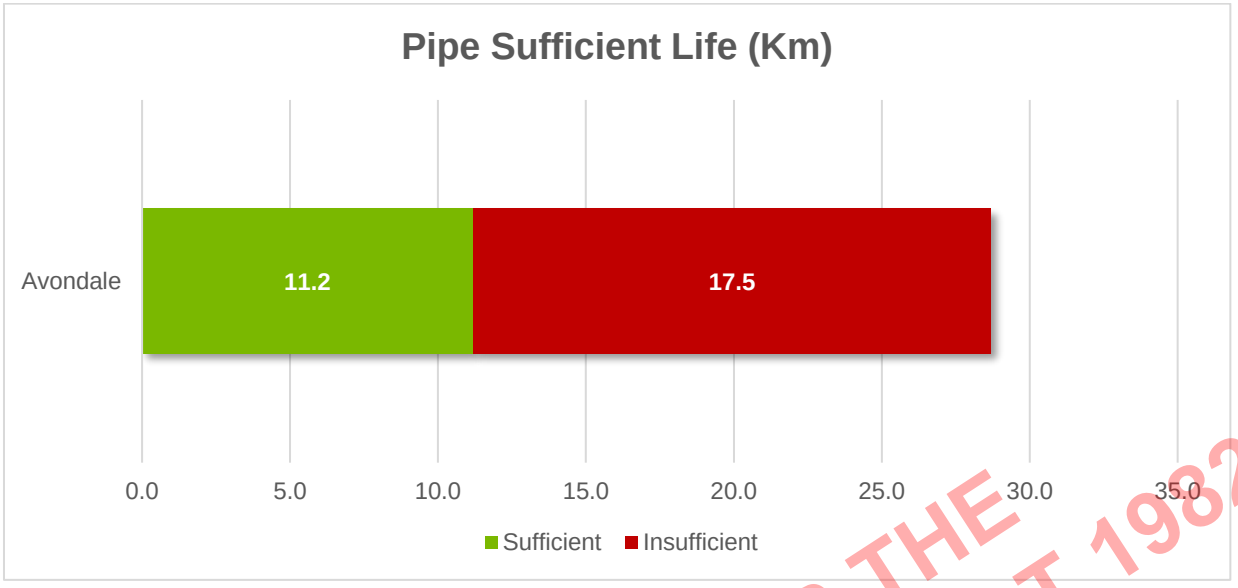


Figure 11: Water supply pipe sufficient life

4.1.3 Network Location

Based on the Watercare GIS, the majority of water supply pipes within the area are located within public roadways. Within the Kāinga Ora project sites, there are only 0.1km of water supply mains which is approximately 0.4% of the total network in the area. Refer to Figure 12 below which shows where these pipe lengths are located within the project areas.

Figure 12: Water supply network location

4.1.4 Network Pressure

Existing pressure within the water supply network was requested from Watercare but no information was made available at the time of this assessment. It is understood from consultation with Watercare that this area is an integral part to their pressure management and reduction in non-revenue water strategy. This strategy will work to reduce water losses and resultantly it is anticipated that water supply pressures within the area may increase.

As more than ten dwellings are proposed as part of the development, it is a requirement of Watercare that hydrant flow tests be completed to better understand capacity of the current network. This should be undertaken during later project stages based on both the development residential demands and fire flow requirements. Should there not be sufficient pressure within the network, pipe upgrades or installation of booster pumps may be required.

4.1.5 Consultation with Watercare

Consultation between Watercare, Aurecon and Beca and Kāinga Ora was undertaken on the 29th of October 2020. Key outcomes of this meeting are as follows:

- Watercare holds a water supply network model for the area which was calibrated in 2016. It is noted that the results from this model were requested from Watercare but not made available at the time of this assessment.
- This area is part of the Watercare Pressure Management / non-revenue water reduction strategy and hence current pressures within the network are likely to change.
- No works or upgrades are currently planned for the local wastewater network within the area.

To date, little information has been received from Watercare on their water supply network. It is understood they are currently working through their assessment internally based on the high-level yields provided.

4.2 Development Water Supply Demands

Residential water supply demands for the Avondale Precinct have been developed in accordance with the requirements of the Watercare CoP. As per the Watercare CoP, a population of 3 persons per unit has been used for all dwellings, assuming each has 2-4 bedrooms or high-rise apartments (four storeys or greater). A daily consumption of 200L/p/day has been taken for Kāinga Ora sites where the number of stories has been indicated to be four or over. All other areas (including existing) are assumed to have a daily consumption of 220L/p/day. Peaking factors for the peak day demand have been scaled between 1.5-2 dependent on the total population, based on Watercare CoP requirements. A peak hourly demand peaking factor or 2.5 has been applied. The existing demands from the Racecourse (Avondale Jockey club) have been calculated in accordance with the requirements for wet retail within the Watercare CoP. A summary of the calculated demands is presented below in Table 6.

Table 6: Water supply development peak demands

Development Area	Existing Population		Existing + Kāinga Ora		Existing + Kāinga Ora + Infill to 2068	
	Peak day demand (m3/d)	Peak Hourly Demand (L/s)	Peak day demand (m3/d)	Peak Hourly Demand (L/s)	Peak day demand (m3/d)	Peak Hourly Demand (L/s)
Racecourse	10	0.3	2,279	66	2,279	66
Kāinga Ora Sites (including Major Project Areas)	411	12	1,721	50	1,721	50
Wider infill to 2068	1,692	49	1,552	45	3,143	91
Total	**2,113**	**61**	**5,552**	**161**	**7,143**	**207**

It is noted that additional water supply demands will be required to service the existing commercial property within the study area and are not included in the above calculations.

Furthermore, additional water supply demands will be required from the network to meet fire flow requirements. It is assumed that the proposed apartment buildings will require fire flow water connections to provide sprinkler flow. Fire flow demands will need to be developed in accordance with SNZ PAS 4509:2008 *New Zealand Fire Service Firefighting Water Supplies Code of Practice*. Sprinkler flow will need supplemented by additional flow from adjacent hydrants. Total fire flows will be dependent on building classification which should be confirmed during later project stages in consultation with a fire engineer.

4.3 Network Capacity

It is understood from consultation with Watercare that a calibrated water supply model has been developed for this area. Information from this model, including the capacity of existing pipe network, has been requested but no information was provided at the time of this assessment. Similarly, confirmation of existing water pump station locations and capacity has been requested but not received.

From review of the existing network, it has been identified that a large portion of the principal main network serving the development has been constructed from 100mm diameter pipes. Given the net increase in water supply demands from the development, it is likely that these 100mm diameter mains will be insufficient to meet future water supply needs, especially where buildings are intended to be fitted with sprinklers as part of the fire protection design. In lieu of specific modelling data, it is hence considered that the mains identified within the below figure will likely be under capacity. These mains have been identified as those 100mm diameter or less supplying the Kāinga Ora sites, with extents taken to the nearest pipe which is 150mm diameter or larger. It is assumed that one main 150mm diameter or larger will be required down either side of the street adjacent to each Kāinga Ora site. On this basis, it can be assumed that 5.9km of water main

upgrades will be required to existing 100mm or less diameter mains. Refer to Figure 13 below and larger map within Appendix B.

Further input from Watercare will be required to identify any additional constraints to the water pipe network capacity, which will be provided as an update once available.

Figure 13: Potential upgrades required to 100mm diameter mains supplying Kāinga Ora sites

4.4 Network Constraints

The key water supply network constraints identified through this assessment include:

- Based on the material and age information available within the Watercare GIS, it is estimated that a high portion (61%) of water supply network located within the study area do not have sufficient useful remaining life. It is therefore anticipated that renewals of affected pipes may be required to service the development, the extent of which to be agreed with Watercare.
- Although no model information was provided by Watercare at the time of assessment, it is estimated that many of the existing 100mm diameter mains servicing the area will be undersized. Hence upgrades of the existing water supply network are hence likely to be required in order to facilitate the development, especially where buildings require fire water sprinkler connections.
- No information was made available from Watercare on the pressure within the existing network at the time of this assessment. Watercare has commented that they are undertaking works in the area to manage existing pressure and reduce non-revenue water. It is therefore anticipated that network pressures will increase. Hydrant pressure and flow testing will likely be required to inform any development design in accordance with Watercare requirements. Network upgrades including the installation of booster pumps may be required should the pressure within the network be deemed inadequate.
- Further consultation with Watercare will be required to assess any additional constraints within the Water Supply network.
- Confirmation of the water supply network transmission lines and bulk supply will require confirmation from Watercare.

5 Stormwater

5.1 Site Context

The site area is located within the surface water catchment draining to the Whau River. A small number of individual properties drain North towards the portion of Waitemata Harbour bounded by the North Western Motorway. The area has a number of discrete stormwater catchments that discharge to the Whau River along the length. Key catchments within the site are shown in FIGURE KK-0023 within Appendix B.

The area under consideration is currently occupied with a number of land uses, including a large sport facility, town centre and residential areas. The areas are zoned a combination of:

- Town Centre
- Mixed Use
- Terraced Housing and Apartment Buildings
- Mixed Housing Urban
- Special Use (Race-course area)

Specific sites of interest are currently developed to an average of 22% impervious. The large area of the racecourse skews this data, with the residential lots currently developed to 42% impervious.

5.2 Existing Stormwater Network

5.2.1 Network Overview

The Avondale area drains by gravity through a number of discrete networks towards the Whau River at the south west of the site. The area to the North of Rosebank Rd flows to the North towards the harbour. Generally, there are limited open channels within the site area, with the exception of the small tributary alongside the recent subdivision off Sandy Lane and Ash St, as well as between Wingate St and Great North Rd. These remaining open channels are reported to be at capacity, and experience issues with erosion due to high velocity and adjacent development. The Whau River itself discharges into the Waitemata Harbour within the Motu Manawa-Pollen Island Marine Reserve.

In the existing arrangement, the study area drains to 15 discrete stormwater networks, 12 are considered internal networks where the majority of the catchment area is within the study area and 3 are wider catchments that a small number of Kāinga Ora catchments are connected. Internal catchments range in size from 0.2ha to 25ha.

Figure 14 below shows the layout of stormwater infrastructure in the project area along with the sizes of some of the larger key networks.

s 9(2)(a)

Figure 14: Stormwater network within study area (Pipe network source: Auckland Council geomaps, Nov 2020)

Within the study area, the stormwater network collection system comprises 17.7km of pipeline, 450 manhole structures and 330 recorded sumps. Sizes of the network range from 100mm to 1800mm and are made of a range of materials.

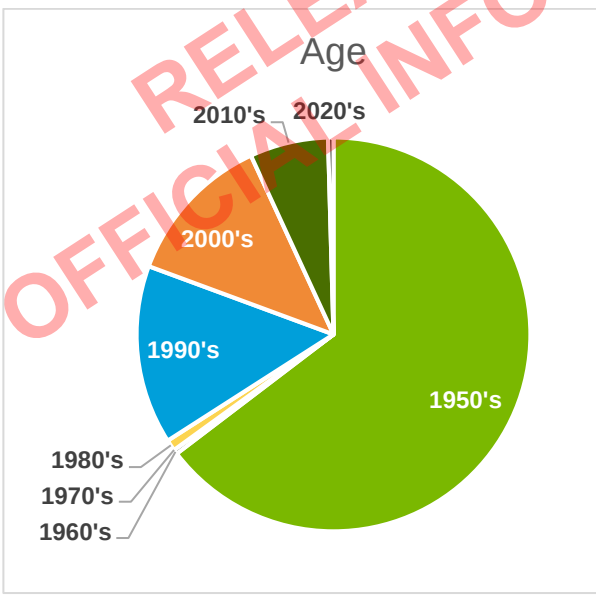


Figure 15: Stormwater Pipe Age

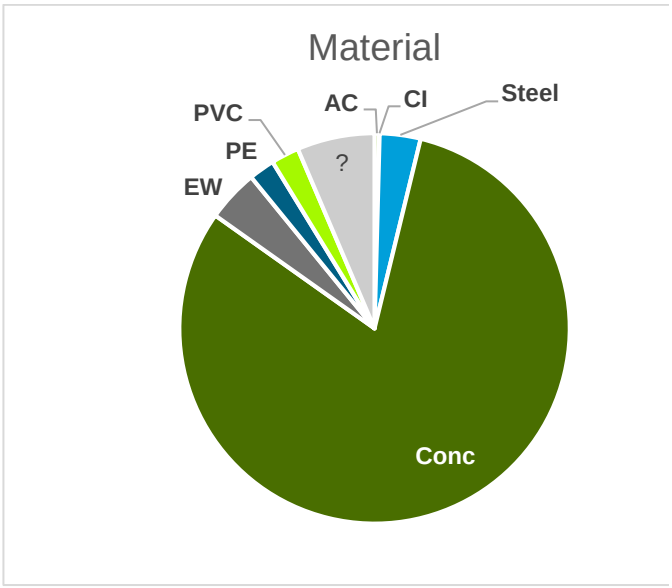


Figure 16: Stormwater Pipe Material

The vast majority of the network is constructed in concrete pipe (81%) with some earthenware, PVC, PE and Steel Pipes. 6% of the network is made of unknown materials.

65% of the network was installed in the 1950's and the rest of the pipe network has been installed in the last three decades. The length of pipe installed in each of these decades varies from 1km in recent times to 2.6km in the 1990's.

5.2.2 Network Condition

Auckland Council records condition ratings for 28% of their pipe network in this area. Where information exists 71% has a rating of 'Good' or better. Given condition information is not extensive an assessment of pipe remaining life has been completed based on pipe material and age. Figure 17 below demonstrates the lengths of pipe within the study area that have sufficient vs insufficient life.

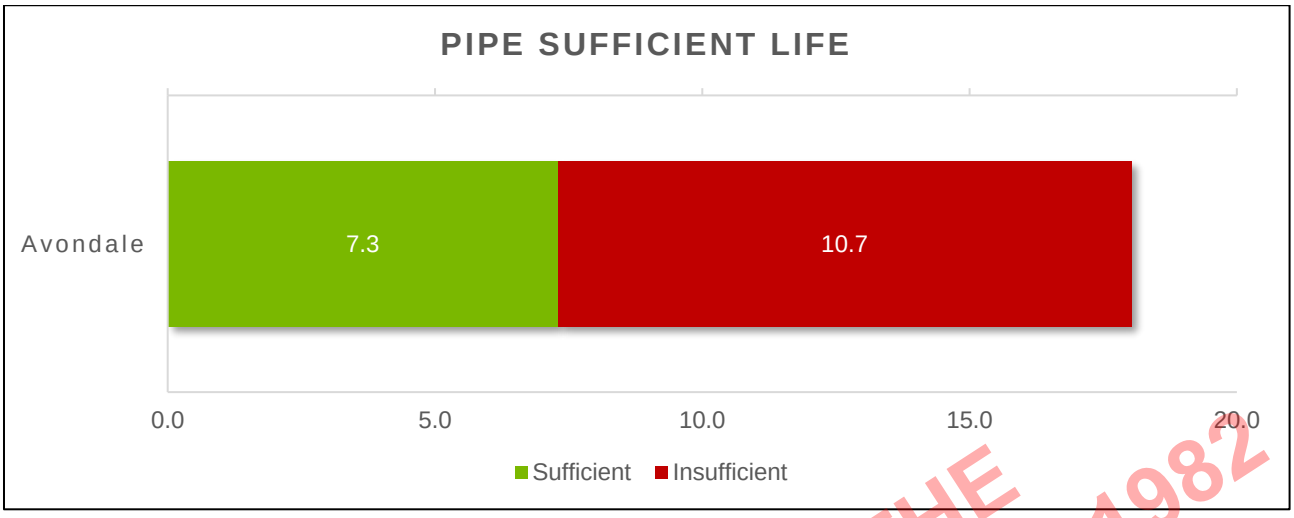


Figure 17: Stormwater Pipe Sufficient Length (km)

The oldest pipes in the networks are 70 years old, and some pipes are reaching the end of their expected lives. Sufficient remaining life of network was determined based on the requirement that pipes have 40% remaining in their design life 10 years after the commencement of the project (2040). Based on this assessment, approximately 59% of the network will have insufficient remaining life. This corresponds to the portions of the network that were installed in the 1950's.

The table below lists the design life assumptions made for certain pipe materials.

Table 7: Expected Pipe Life

Pipe Material	Design Life
Asbestos Cement	80 years
Cast Iron	125 years
PE	95 years
PVC	90 years
Steel	85 years
Concrete	90 years
Earthenware	80 years

5.2.3 Network Location

Within the project area there are 18.0km of stormwater pipework. Approximately 9.3km of the network is located within private property (52% of total), and of this, 2.7km is located within the Kāinga Ora site areas (15% of total). Figure 18 below shows where these lengths are located within the project area. This map is included in A3 format in Appendix B

Similar to wastewater, the eastern portions of the racecourse contain large diameter (900mm) public stormwater pipes conveying stormwater from portions of the Town Centre. This pipe is approximately 3m deep to invert and constructed of concrete pipe. No specific condition information is available however, the pipe was installed in 2001 and likely has significant remaining life. It is anticipated that approvals will be required from Healthy Waters for any works in close proximity to the asset. If building over the main, the

foundations of the housing will need to be designed to ensure the pipeline is protected, and there aren't unnecessary building foundation restrictions in its future replacement.

Figure 18: Stormwater Network Location

5.2.4 Consultation

Consultation between Healthy Waters, Aurecon, Beca and Kāinga Ora was completed on the 9th of November. Key outcomes of this meeting are as follows:

- Current pipe network has a level of service less than the 10-year ARI rainfall event;
- A rapid flood hazard model, and detailed ICM model exist for this area. Copies of models, reports and results provided by Healthy Waters;
- This area was excluded from assessment of floor flooding;
- Existing pond on Wingate St and the stream downstream do not have capacity for additional flows;
- Treatment will be expected for all new or 'redeveloped' roads;
- Some of the smaller streams tying into the Whau River have issues currently with erosion of banks and riparian zones;
- The Motu Manawa-Pollen Island Marine Reserve is located at the outlet of the Whau River. For this reason, quality objectives will need to align with Regional Network Discharge Consent requirements as a minimum. It was suggested that measures in keeping with the management plan developed for the Oakley Stream would be appropriate.

5.3 Network Capacity

5.3.1 Level of Service

Based on the Code of Practice for Land Development and Subdivision – Stormwater, Auckland Council (2015) the level of service is the 10-year ARI event with provision for the 100-year ARI event in overland flow paths.

Advice from Healthy Water indicates that the existing network has an existing level of service less than the 10-year ARI event required by the Code of Practice.

5.3.2 Current Capacity

The constraints shown below in Figure 19 are based on the Whau Framework Model completed for this area, dated April 2018 and provided by Healthy Waters to Aurecon on the 12th of November 2020. It was noted in consultation with Healthy Waters that this model was not developed to provide information for individual properties and that an additional model alteration would need to be completed to gain that level of information. No changes to the model information have been made as part of this assessment.

Figure 19 below shows the capacity of key portions of the network in a 10-year event for the existing scenario. These results are also presented in Appendix B. Green pipe lengths have capacity, red do not have capacity and yellow lengths do not have capacity due to downstream effects. The figure shows that very minimal portions of the network have capacity in the primary event. Without pipe upgrades, or other improvement works, it is unlikely that development increases in peak stormwater flows will be able to be discharged directly to the network without management.

Figure 19: Stormwater Network Constraints - Existing 10-year event

It is noted that not all stormwater networks are included in this modelling assessment. Reporting states that pipes greater than 550mm in diameter were assessed for system performance. The report, “Whau Framework Model” prepared by Ewaters New Zealand Ltd for Healthy Waters lists the networks in this area as having capacity of less than the 2-year event.

5.4 Flood Risks

5.4.1 Overland Flow Paths

The general fall of the site is from the ridge along Rosebank Road, towards the Whau River. Auckland Council have identified the indicative overland flow paths (OLFP) through the area, and a number are located within or adjacent to the properties considered in this assessment.

These existing overland flow paths will need to be managed during the development of these properties. In cases where the overland flow path travels through private property downstream, increases in flows during the 100-year ARI event will need to be managed to prevent worsening of downstream flooding due to development.

A large number of the properties considered in this assessment contain overland flow paths with 26 of the 38 sites intersecting with an overland flow path. Of these sites, 20 contain OLFP's which may require diversion or specific design to suit the development. Figure 20 below shows the OLFP's identified by Healthy Waters, sourced from Auckland Council in November 2020, based on modelling completed in 2016 to the MPD scenario. Aerial imagery used and does not reflect recent development in the area. This information is also captured in Appendix B. Flood plains identified relate to the 1% AEP event, and flood prone areas are those that may be susceptible to flooding due to blockage in the network.

Figure 20: Flood Risks (source: Auckland Council, Nov 2020)

5.4.2 Key Areas of Flood Risk

Healthy Waters identifies both flood prone areas and areas considered a flood plain. See Figure 20 above for the location of these areas relative to each project area.

The key areas of flooding within the site area are largely within the racecourse. There are also areas of flooding at Riversdale Rd near the intersection with Rosebank Rd and to the north of Rosebank Rd between Victor & Aspen Streets. Healthy Waters also noted that the open stream to the south of the racecourse

between Wingate St and Great North Rd is at full capacity and any additional flows will cause flooding. Overland flow from Ash St to a small tributary stream causes flooding through a number of the sites.

Additionally, flood model results from the Whau Frame work model are reported in Figure 21 and Figure 22 below. It is noted that only areas contributing to the pipe networks assessed were included in this model. Key areas missing from assessment are portions of the racecourse, southern stream and the town centre.

These maps do not directly correspond to overland flow paths and flood layers in Geomaps as these have been assessed through a combination of Rapid Flood Hazard Mapping Assessment which assumes that most pipe networks are fully blocked (except for key crossings), and historic Integrated Catchment Modelling completed in 2005.

Figure 21: Modelled flood depths, 10-year event (sourced from Healthy Waters, November 2020)

Figure 22: Modelled flood depths, 100-year event (sourced from Healthy Waters, November 2020)

5.4.3 Building Floor Levels

The Whau Framework model reporting identifies areas with buildings that may be at risk of flooding. This information is unable to be presented in this report due to low resolution, however, high risk areas with large numbers of affected properties with buildings at risk exist between Ash and Canal St's. There are a number of Kāinga Ora properties in this area. Flood modelling results above would indicate that these heights are likely to be less than 500mm.

5.5 Design Requirements

5.5.1 Quantity

Given the existing network capacity and sensitive nature of some of the receiving environments it is likely that attenuation to match pre-development flow will be required in instances where increases in stormwater flows are caused by development.

To enable an assessment of quantity impacts of development the Unitary Plan zoning has been used to determine the maximum impervious area on site. It has been assumed that each site will be developed to its maximum impervious area under the Unitary Plan. In cases where no maximum is listed in planning documents, a maximum of 90% is assumed. The developed impervious area percentages are below:

- Town Centre – 90% impervious
- Mixed Use – 90% impervious
- Terraced Housing and Apartment Buildings (THAB) – 70% impervious
- Mixed Housing Urban – 60% impervious
- Special Use (Race-course area) – to be rezoned, assumed to THAB for purposes of assessment

A summary of the properties of each site and resulting increases in flows are included in Appendix C. TP108 methods have been used to estimate these flows. Existing impervious areas have been estimated based on aerial imagery available from LINZ and actual hard stand areas may differ from this aerial.

Given the limited capacity of the network in this area, increases due to development will need to be managed prior to discharge to the network. For properties adjacent to the Whau River, direct discharge may be possible, however consideration of erosion risk and impact on stream environments will be required.

5.5.2 Quality

The area of consideration is located close to the Motu Manawa-Pollen Island Marine Reserve and it has been noted that a higher level of quality management will be required.

In discussions with Healthy Waters on the Avondale Precinct they have advised that treatment will be required for all new or redeveloped roads, as well as carparks that are considered high contaminant generating. Appropriate at source devices could include treatment swales or bioretention devices. Geotechnical advice should be used to choose appropriate devices.

Typical contaminant profiles from these surfaces are oil and grease, hydrocarbons and metals.

Based on Auckland Council guidance, the 90th percentile rainfall for this area is 26.2mm (including climate change allowance). Based on TP108, and an assumption of a 10-minute time of concentration, the Water Quality Volume for 100m^2 of roading is 2.2m^3. The quality flow rate for this equivalent area is 0.95m^3/hr (based on a rainfall intensity of 10mm/hr). This corresponds to an approximate bioretention device area of 2m^2 per 100m^2 of road area (in line with a minimum device area of 2% of the catchment area as outlined in GD01).

Alternatively, in locations where space restraints allow, swales can be used to provide the treatment function. These devices take up more space but are easily maintained and inspected.

5.6 Network Constraints

- Based on the material and age information available within the Auckland Council GIS, it is estimated that a high portion of stormwater network within the study area (59%) does not have sufficient useful remaining life. It is therefore anticipated that renewals of affected pipes may be required to service the development, the extent of which to be agreed with Healthy Waters.
- The networks in the area do not have capacity for the primary stormwater event in the current development scenario. This will further worsen with additional infill development that is projected to 2068. Upgrades of the downstream existing network or management of stormwater flows may be required in order to facilitate the development. In some areas, new networks and outlets to the Whau River to facilitate large development areas may be most appropriate.
- The area is not located in SMAF area, however management of peak flows to predevelopment levels is likely required due to lack of capacity of pipe networks.
- It is estimated that 2.7km of existing stormwater pipes are located within Kāinga Ora sites. These stormwater mains will need to be protected or diverted during construction. Works over permits may be required and if building over, specific foundation design to ensure the pipe is protected.
- Development in areas of flooding will need to raise floor levels a suitable level to meet building code requirements.
- Development in and upstream of flood risks areas will need to manage effects of intensification in the 100-year event to prevent additional flooding risk to at risk properties.
- Treatment of all new or redeveloped roads is expected by Healthy Waters.

7 Utilities

7.1 Power

Vector power records indicates good coverage through the Avondale Precinct study area. Through consultation, Vector has indicated that the existing feeders in Ash Street and Racecourse road have some capacity to supply new load. However, the overhead supply along Wingate Street is too small hence a new 11kV feeder will be required. Vector has advised that the new feeder will need to be installed from Avondale substation to the proposed Avondale Racecourse site. This is shown within Figure 23 below, with arrows indicating where existing feeders can be extended to supply new housing. Vector has noted that the cable route is indicative only and would need to be confirmed once the road layout though the racecourse is established.

Vector has noted that they are anticipating load growth on the network in the future as a result of major developments within the Avondale town centre and surrounding areas. It is anticipated that with time this will trigger the requirement to upgrade capacity within the Avondale substation. Vector intends to monitor this load growth and carry out the required reinforcement projects when required.

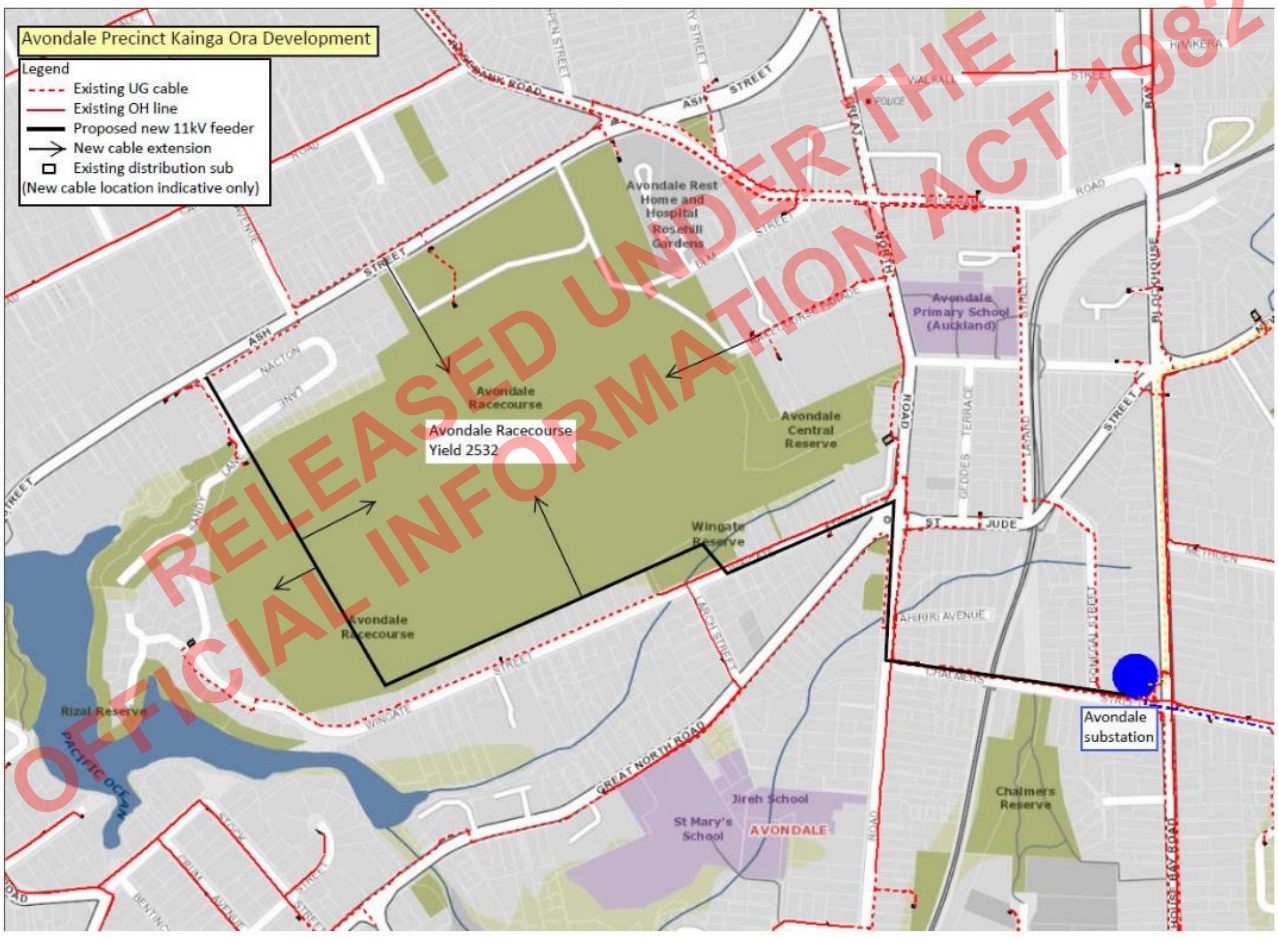


Figure 23: Proposed new 11kV electrical feed (Source: Vector, November 2020)

7.2 Communications

Chorus layout plans have confirmed good coverage of communications networks within the area. Vector plans have also shown fibre located within the roadway of Ash Street, Great North Road, Blockhouse Bay Road and Rosebank Road. No information has been received from Chorus to confirm anticipated constraints within the network, however it is anticipated that connection to the existing network be a straightforward process with Chorus generally undertaking design internally.

7.3 Gas

Vector gas records indicate that there is good coverage of gas mains within the site study area. This is shown in Figure 24 below, with green lines representing low pressure assets (4 bar residential PE) and blue lines representing high pressure assets (<20 bar steel). Confirmation of gas servicing will need to be confirmed during design based on Kāinga Ora building requirements. It is understood that gas is generally not required for Kāinga Ora properties, but may be desirable for any market properties.

Vector has not identified any immediate servicing constraints within the network, but this will be dependent on the uptake of gas required. Hence, confirmation of network constraints will need to be confirmed with Vector once the specific buildings requiring gas connections are known.

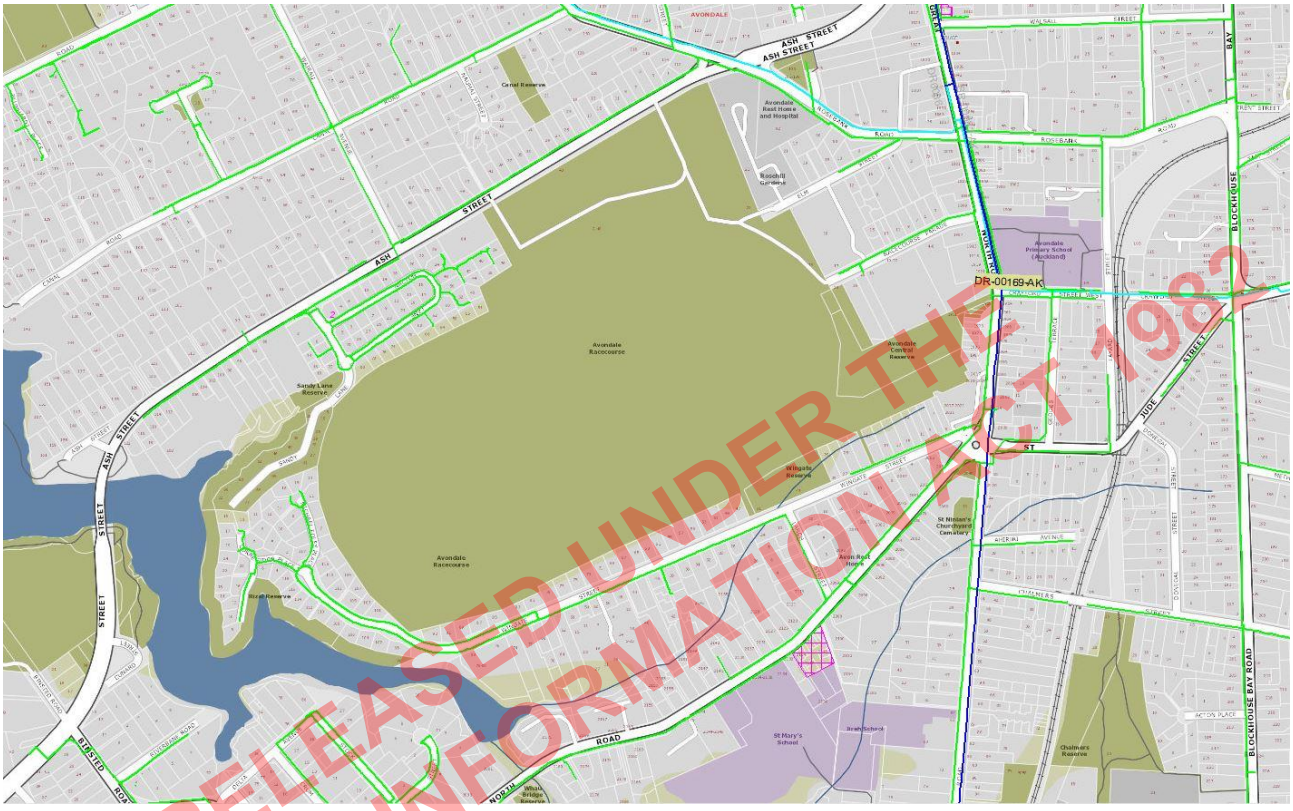


Figure 24: Vector gas records (Source: Vector, November 2020)

8 Summary of Constraints and Risks

Table 8 below summarises the key infrastructure constraints anticipated for this development.

Based on the information available at the time of the infrastructure assessment, upgrades are likely to be required to the service networks to accommodate the development. The level of certainty of the works required is summarised in the table below, dependent on the definition of network upgrade scope provided by service providers. The impact of each constraint on the overall development will be dependent on negotiations with the service providers and agreed cost apportionment.

Table 8: Summary of network constraints

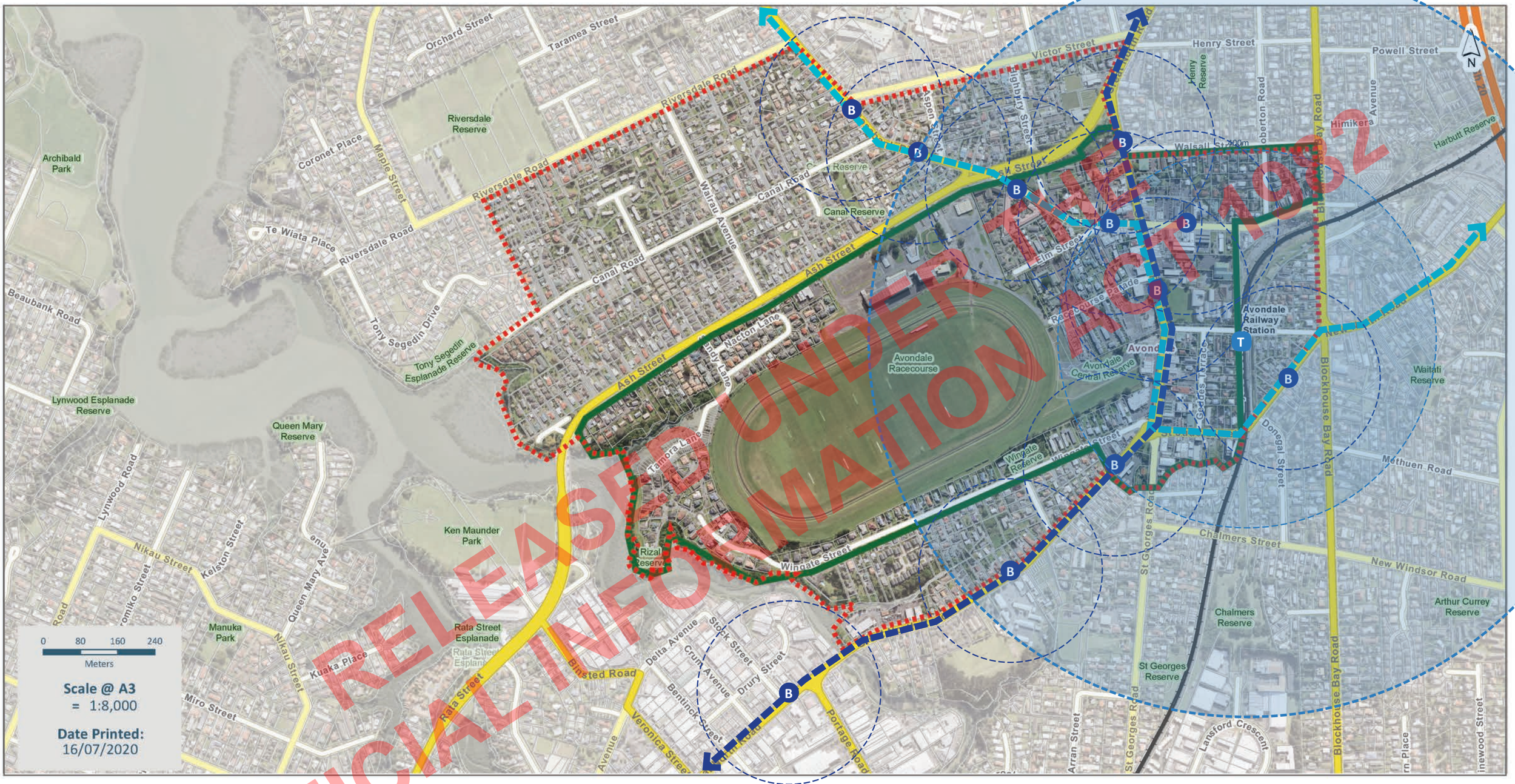
Item No.	Constraint	Constraint Description	Level of certainty (H/M/L)
1	Wastewater Network Capacity	High-level capacity checks of the network indicate that 33% of the network downstream to the Kāinga Ora sites will have insufficient capacity following the proposed Kāinga Ora development. It is likely that these wastewater mains will require upgrades in order to service the development. The two existing pump stations on Ash and Wingate Street will also require upgrades to ensure sufficient capacity to accommodate development flows.	**M** – Confirmation will be required from Watercare so to extent of any network upgrades. Further network modelling or capacity checks may be required.
2	Wastewater Network Condition	76% of the pipework in this area has insufficient remaining life in 2040. Some pipe renewal works may be required.	**M** – Confirmation will be required from Watercare as to scope of network renewals required during design prosses.
3	Water Supply Network Capacity	No network capacity information was made available from Watercare at the time of the assessment. It is anticipated that many of the 100mm diameter water supply mains within the area will require upgrades to meet future demand requirements but confirmation with Watercare will be required.	**L** – No model information was made available from Watercare at time of assessment. Confirmation will be required on extent of upgrades required.
4	Water Supply Network Pressure	Water supply network pressure will require confirmation with Watercare but is anticipated to improve as Watercare is undertaking pressure management within the area. Hydrant pressure and flow testing will be required to inform design.	**L** – Confirmation of network pressures required from Watercare. Should pressures not be sufficient, network upgrades or booster pump may be required.
5	Water Supply Network Condition	61% of the pipework in this area has insufficient remaining life in 2040. Some pipe renewals may be required.	**M** – Confirmation will be required from Watercare as to scope of network renewals required during design process.
6	Stormwater Network Capacity	Modelling shows that the existing stormwater network does not have capacity for the design event in the existing scenario, and management of increases in stormwater flows will likely be required.	**M** – Confirmation of site-specific works to manage stormwater quantity required.

Item No.	Constraint	Constraint Description	Level of certainty (H/M/L)
7	Stormwater Network Condition	65% of pipework in this area has insufficient remaining life in 2040. Some upgrade works may be required.	**M** – Confirmation will be required from Healthy Waters as to specific scope of network renewals required during design process.
8	Power Network Capacity	Vector has indicated that an additional 11kV feed will be required from the Avondale substation to service the development within the recourse site.	**H** – Vector has confirmed scope of network upgrades required to facilitate the development
9	Communications Network Coverage	Chorus fibre records indicate good coverage within the area. Confirmation is required from Chorus as to any constraints or upgrades required.	**M** – Confirmation of any upgrades within the network requires confirmation from Chorus
10	Gas Network Coverage	Vector has provided records of the existing gas network in the area indicating good coverage. Confirmation of capacity will need to be confirmed during design once required gas connection numbers are known.	**M** – Should gas be required, confirmation of gas requirements for each block should be confirmed with Vector. They do not anticipate any major upgrades will be required.

Appendix A

Kāinga Ora Study Area Layouts

Avondale Strategic Development Study Area



Kāinga Ora
Homes and Communities

Legend

Influential area boundary

Focused area boundary

s 9(2)(a)

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s 9(2)(a)

Appendix B

GIS Maps and Figures

s 9(2)(a)

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Legend

- Overland Flow Path
- Flood Prone Areas
- Flood Plains
- Analysis Extent
- Analysis Extent

Data Notes

1 - Services information sourced from https://www.watercare.co.nz/ and used under CC BY-NC-ND 3.0 NZ License
2 - Site layers provided by Beca, October 2020
3 - Indicative boundaries sourced from LINZ Data Service (https://data.linz.govt.nz/) and used under CC BY 4.0 License
4 Basemap data sourced from Land Information New Zealand (https://basemaps.linz.govt.nz/v1/tiles/aerial/)

aurecon

Date: 26/11/2020

0 20 40 60 80 100 120 140 160 180 200 m

Project Number: 510663

Projection: NZTM

CLIENT BECA

FIGURE KK-0033: STORMWATER FLOOD MAP

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Appendix C

Stormwater Calculations

	Site Name	Zoning	Existing Impervious Area	Zoned Impervious Area	Pre Dev 10 year peak flow (L/s)	Post Dev 10 year peak flow (L/s)	Pre Dev 100 year peak flow (L/s)	Post Dev 100 year peak flow (L/s)	10 year flow increase (L/s)	100 year flow increase (L/s)
1	s 9(2)(a)	MHU	31%	60%	593	689	1013	1125	96	112
2		MHU	45%	60%	23	25	38	40	2	2
3		MHU	31%	60%	11	12	18	20	1	2
4		THAB	47%	70%	213	243	357	387	30	30
5		MHU	37%	60%	10	11	17	18	1	1
6		MHU	59%	60%	91	92	149	150	1	1
7		THAB	43%	70%	11	13	19	21	2	2
8		THAB	30%	70%	32	37	55	61	5	6
9		MHU	50%	60%	11	11	18	18	0	0
10		MHU	24%	60%	21	26	37	42	5	5
11		MHU	66%	60%	27	26	44	43	-1	-1
12		MHU	23%	60%	23	26	39	42	3	3
13		MHU	52%	60%	18	18	30	30	0	0
14		MHU	27%	60%	33	39	57	64	6	7
15		MHU	45%	60%	32	34	53	56	2	3
16		MHU	51%	60%	80	84	134	137	4	3
17		MHU	45%	60%	21	23	36	38	2	2
18		MHU	29%	60%	11	13	19	21	2	2
19		MHU	38%	60%	11	12	19	20	1	1
20		THAB	55%	70%	137	148	227	236	11	9

	Site Name	Zoning	Existing Impervious Area	Zoned Impervious Area	Pre Dev 10 year peak flow (L/s)	Post Dev 10 year peak flow (L/s)	Pre Dev 100 year peak flow (L/s)	Post Dev 100 year peak flow (L/s)	10 year flow increase (L/s)	100 year flow increase (L/s)
21	s 9(2)(a)	THAB	24%	70%	10	13	18	21	3	3
22		MU	0%	90%	10	16	19	25	6	6
23		THAB	46%	70%	113	127	189	203	14	14
24		MU	62%	90%	57	63	92	96	6	4
25		MHU	38%	60%	9	10	16	17	1	1
26		MHU	24%	60%	11	12	18	19	1	1
27		MHU	36%	60%	121	136	206	223	15	17
28		MHU	66%	60%	83	80	133	131	-3	-2
29		THAB	26%	70%	14	18	24	28	4	4
30		MU	70%	90%	185	197	295	302	12	7
31		TC	62%	90%	155	172	252	264	17	12
32		MU	41%	90%	156	192	264	295	36	31
33		THAB	45%	70%	19	22	33	36	3	3
34		MU	15%	90%	42	59	74	91	17	17
35		THAB	51%	70%	15	17	26	27	2	1
36		MU	48%	90%	26	31	43	47	5	4
37		THAB	60%	70%	95	100	155	159	5	4
38	Racecourse	Special Purpose/TC/MU	17%	72%	4164	5821	7260	9258	1657	1998

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