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Mangawhai Wastewater Modelling

23 December 2020

CONFIDENTIAL

Model Build Report

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This report ('**Report**') has been prepared by WSP exclusively for Kaipara District Council ('**Client**') in relation to the model built for the Mangawhai wastewater collection system model build ('**Purpose**') and in accordance with the Offer of Service data 7 July 2020. The findings in this Report are based on and are subject to the assumptions specified in the Report. WSP accepts no liability whatsoever for any reliance on or use of this Report, in whole or in part, for any use or purpose other than the Purpose or any use or reliance on the Report by any third party.

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1 Background

1.1 Introduction

WSP were commissioned by Kaipara District Council (KDC) to develop a hydraulic model of the Mangawhai wastewater network. This report details activities completed as part of the model build phase of this of this work. As part of future phases of this project, the model will be calibrated to observed flows and used for network planning.

This report documents the following:

- All work to complete the model build in accordance with industry best practice.
- All assumptions made during the model build phase.
- Field testing and data collection that has been completed to date, including pumping station drawdown testing.
- Recommendations for completing model calibration and additional data collection activities that should be conducted as part of the next phase of this work.

1.2 Network Overview

The Mangawhai Community Wastewater Scheme (MCWS or the scheme) provides servicing to approximately 2,100 primarily residential properties. There are two major catchments within the network; Mangawhai Heads and Mangawhai Village.

The majority of wastewater generated within the catchment is conveyed to the wastewater treatment plant (WWTP) located on Thelma Road. Local reticulation throughout the scheme is a combination of pressure grinder pump systems, gravity network and small pumping stations. All pressure sewer areas ultimately discharge to the gravity network through which flows are conveyed to the WWTP by gravity and the 13 larger pumping stations throughout the scheme .

There are some properties throughout the scheme service area that currently discharge to private treatment facilities. These areas include properties on Grove Road and Ti Tree Place.

Figure 1-1 presents an overview of the MCWS, including the locations of key pumping stations, rising mains and the wastewater treatment plant. Figure 1-2 presents a schematic of the connectivity of the pumping stations.

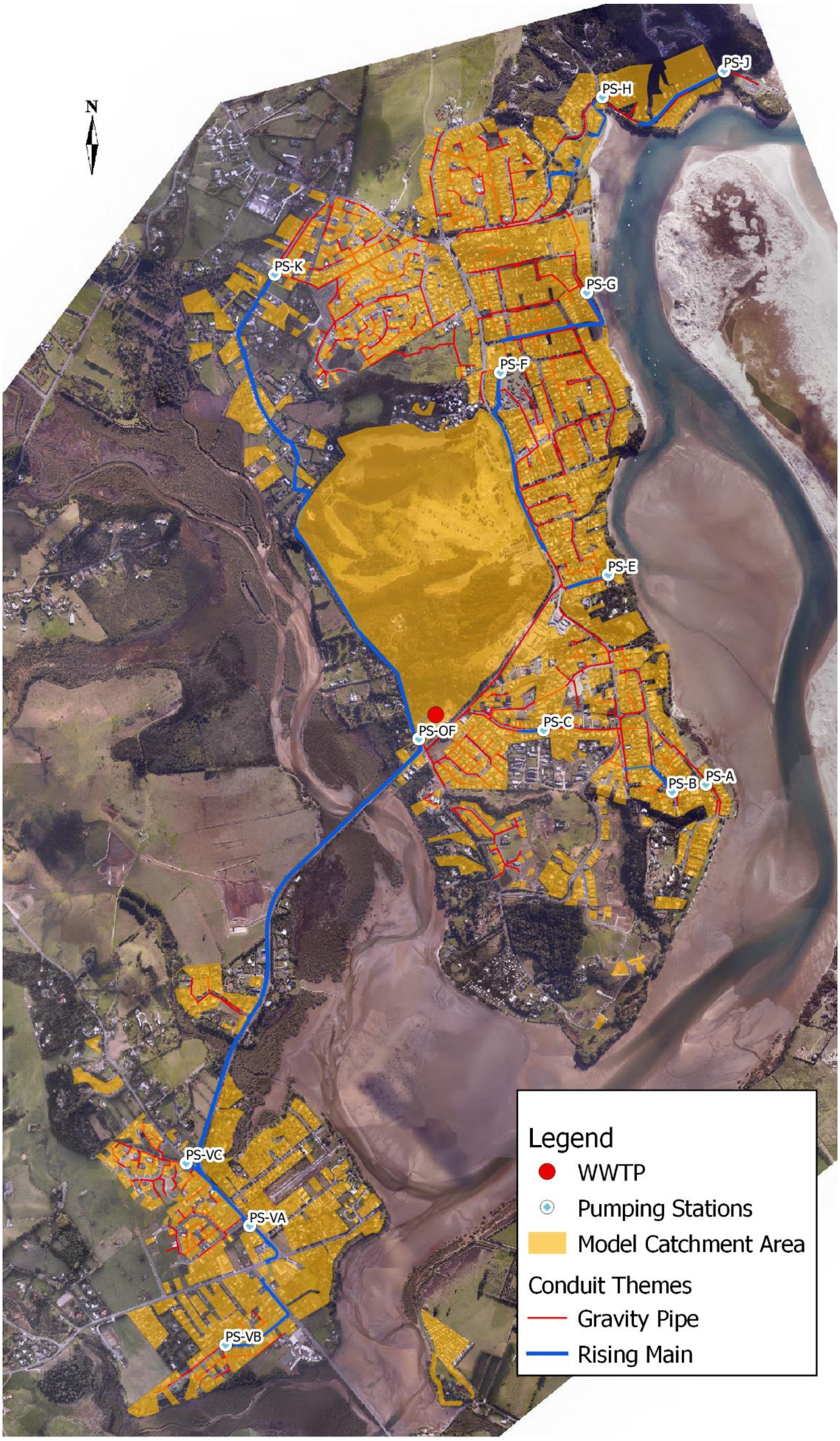

Figure 1-1: Overview of the Mangawhai Community Wastewater Scheme (pressure sewer pipes excluded)

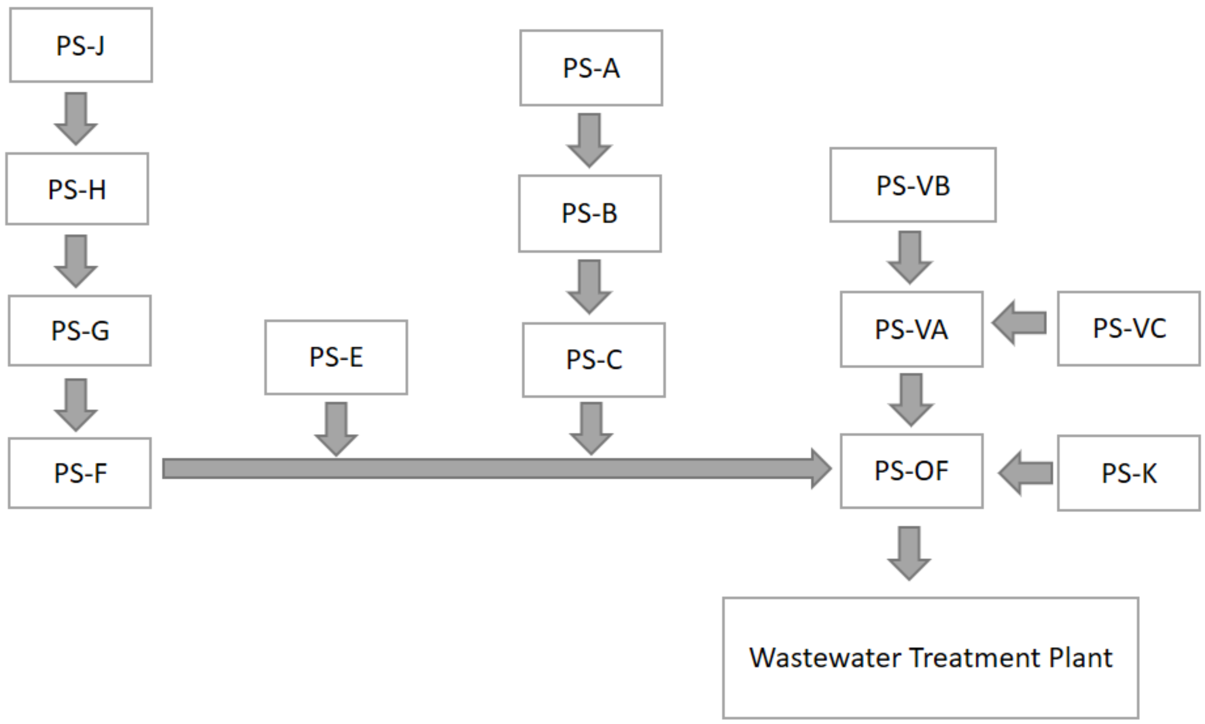

Figure 1-2: MCWS Pumping Station Connectivity Schematic

2 Model Build

2.1 Software

All modelling was completed using Innovyze's software package InfoWorks ICM, version 11.0.

2.2 Model Extent

The model extent includes all properties that discharge to the WWTP. The asset data used in the model is based on KDC's Geographical Information Systems (GIS) data (exported on 19/08/2020). Of the GIS data provided, the model network includes all gravity pipelines (excluding service laterals) and pump stations and associated larger rising mains are detailed in a later section of this report.

The following system elements are not included in the model:

- Local pressure reticulation networks (including grinder pumps, boundary kits and pressure pipes). These were represented in a simplified manner as is detailed in a later section of this report.
- Private pipes, pump stations and treatment facilities that do not discharge to the WWTP were not included in the model.
- Under the current model setup the WWTP is not explicitly modelled. The Thelma Road pumping station (PS-OF) was is modelled with a free outlet from the rising main. This assumption will be reviewed during the model calibration phase.

2.3 Data

2.3.1 Data Import

GIS data provided by KDC (export date 19/08/2020) was imported into a catchment group which formed the basis of the model. As part of the network clean-up the following pipes were removed from the model network:

- Pipes identified in GIS as service connections.
- Pipes that appear to be misidentified as gravity sewers that are service connections (40 mm diameter connections from properties in to main lines).
- Pipes identified in GIS as pressure reticulation. Details of how these areas were represented in the model are presented in a later section of this report.

A connectivity check was completed to ensure that all necessary pipes within the catchment were included in the model, with any omissions or modifications made discussed with KDC. The following amendments were made to the GIS provided:

- The pressure sewer network that services properties on Estuary Drive/ Minor Point Road was loaded to the 150 mm gravity main on Estuary Drive. KDC staff indicated that flows in this catchment have been directed away from Seabreze Road and PS-C, which is known to be approaching capacity.
- Properties on Grove Road and Ti Tree Place were confirmed to discharge to private wastewater fields. These properties and associated reticulation network were removed from the model.
- KDC staff confirmed that a pumping station identified in the contributing catchment to PS-K (south of Sandy Lane) had been decommissioned and it was removed from the model network.
- Inverts of the 150 mm sewer on Seabreeze Road (downstream of PS-C) were found to be below the invert level of the connecting downstream 375 mm pipe on Te Araroa Trail. The network maintenance contractor surveyed this connection point and confirmed the GIS inverts on Seabreeze Road to be incorrect. This was discussed with KDC staff and the model was updated with the survey data.

There are pipes in the contributing area to the Anchorage Road sewer (catchment area of PS-K) that do not have invert levels in the data provided. It is recommended that survey be carried out at select locations in order to improve network accuracy. Figure 2-1 presents the location of sewers with missing invert data.

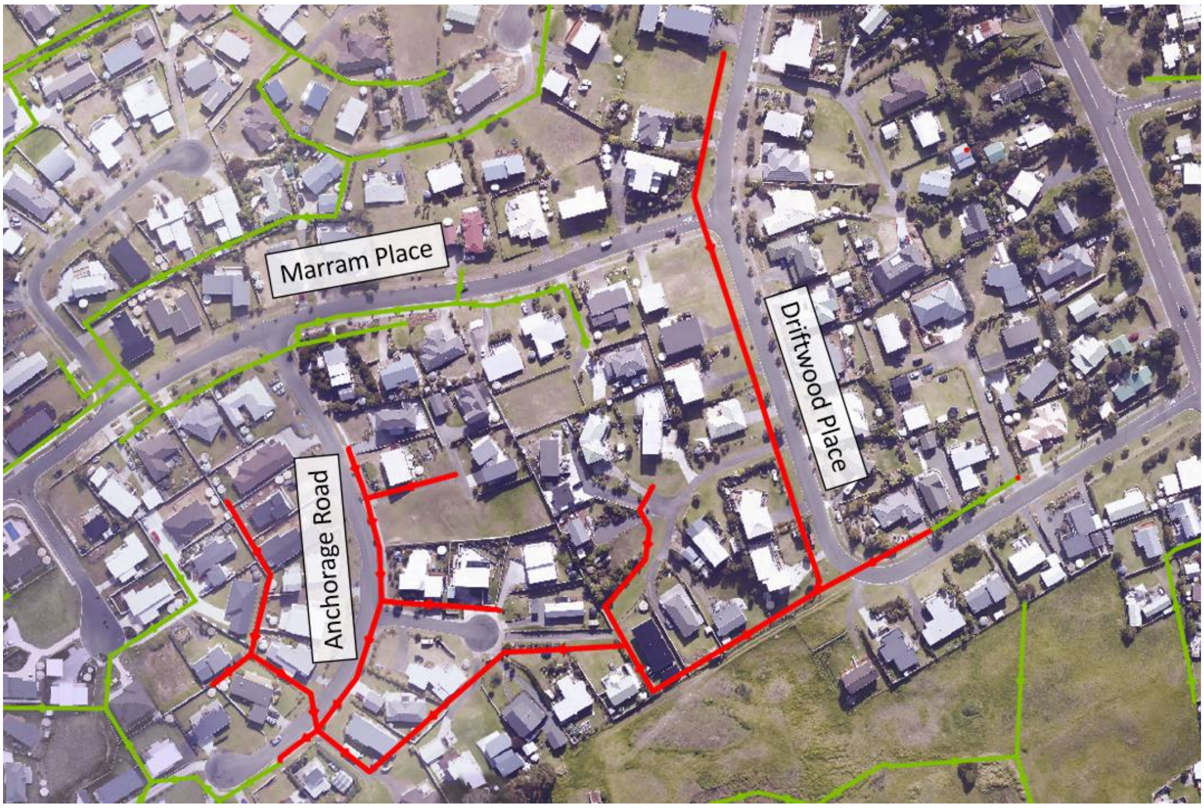

Figure 2-1: Recommended Survey Locations (Pipes Missing Data Shown in Red)

2.3.2 Data Flags

Infoworks software allows the use of data flags to track the source of data. The flags used in the model build are presented in Table 2-1.

Table 2-1: Data Flags

Code	Colour	R,G,B	Description
#A	Light Green	200,240,200	Asset Data
#D	Blue	166, 202, 240	System Default
#G	Green	0, 255, 0	Data from GeoPlan – system default - not used
#V	Orange	255, 128, 0	CSV import or Model Build[1]
GM	Blue	0,255,255	Ground level from LIDAR
CA	Grey	128,128, 128	Data which has been altered - calibration purposes
ES	Yellow	255, 255, 0	Data estimated from existing data – where data is missing. – note required.[1]
AM	Yellow	255, 255, 0	Data which has been added – Modelling fix
UM	Yellow	255, 255, 0	Data which has been altered – Modelling fix – note required.
IF	Red	255, 0, 0	Data which has been altered/added – Inference Tool
US	Green	90, 250, 125	Data which has been altered – based on survey data

Code	Colour	R,G,B	Description
UP	Green	90, 250, 125	Data which has been altered – based on field notes or plans
ED	Green	90, 250, 125	Data which has been added – As built drawings
UO	Yellow	255, 255, 0	Data which has been altered – other – Note required
AD	Yellow	255, 255, 0	Data which has been added – Assumed – note required
AS	Green	90, 250, 125	Data which has been added – based on survey data
AP	Green	90, 250, 125	Data which has been added – based on field notes or plans
AO	Yellow	255, 255, 0	Data which has been added – other – Note required
PT	Yellow	255, 255, 0	Added junction from Proximity Trace Tool
SG	Purple	190, 128, 255	Proposed Design –Growth Planning
SO	Purple	190, 128, 255	Proposed Design – Operations
SS	Purple	190, 128, 255	Proposed Design – Service Reliability / Asset Management
SD	Purple	190, 128, 255	Proposed Design – Design Consultant

2.3.3 Inference of Missing Data

Where there was missing data in the GIS and in the absence of any other data, the following methods were used to interpolate or infer the missing data:

- Interpolation of missing invert levels from the nearest upstream and downstream invert levels. System topography has also been used as a guide for interpolating the fall of sewers.
- Inference of missing manhole cover levels from LiDAR or contour data.
- Inference of pipe shape and dimension from upstream and downstream pipe information.

The appropriate data flags within InfoWorks ICM were applied to inferred or assumed data, based on the data flag system outlined in Table 2-1. An outline of the model inference hierarchy is detailed below in Table 2-2.

Table 2-2: Model Inference Process

Value Missing	Inference Process
Diameter	1. Infer from nearest upstream or downstream diameter available
	2. Apply engineering judgement
Cover Level	1. Infer from DTM or LiDAR data
	2. Infer from adjacent cover levels
Invert Level	1. Infer from nearest upstream and downstream invert

	2. Infer pipe grade from downstream pipe grade and invert level (where no invert level exists upstream) so long as reasonable cover is maintained
	3. Assume pipe invert is 1 m deep and set invert based on manhole cover level
	4. Infer from upstream assumed invert and nearest downstream invert
Chamber Floor Level	Set to match invert of lowest connected pipe
Pipe Length	Calculated automatically by the software based on object geometry
Pipe Grade	Calculated automatically by the software based on pipe length and invert levels
Chamber Diameter	Calculated automatically by the software based number and diameter of connected pipes

2.3.4 Data Hierarchy

Data has been imported as part of the model build process based on the following hierarchy, where data from survey/inspections/observations takes precedence over other data sources.

- As-builts
- Construction drawings
- Survey (completed by Ventia)
- Site observations
- Operation and Maintenance manuals
- GIS

2.4 Pipes and Nodes

2.4.1 Node Asset Types

There are several different asset types that were identified in the GIS node data provided. These included the following:

- Connection
- Drainage
- Dummy Node
- Flush Point
- Inspection Shaft
- Lamp hole
- Maintenance Shaft
- Manhole
- Rodding Eye
- Storage Tank
- Valve
- Boundary Kit
- Grinder Pump
- SS Kit

As pressure sewer areas were represented in a simplified manner (details in Section 2.5), assets in relation to these systems were removed from the input dataset. These included grinder pumps and SS Kits.

2.4.2 Pipe Roughness

The hydraulic roughness co-efficient for pipes has been based on Colebrook-White and has been assigned for each pipeline in the model network. The condition of all pipes is assumed to be normal and therefore a roughness value of 0.6 was assigned for all plastic pipes (uPVC, PCV, PE). GIS indicates that there are no concrete of metal pipes in the network. All pipes with an unknown material were assumed to be plastic and therefore assigned a roughness value of 0.6.

Pipe roughness may be refined as part of calibration or based on further network surveys.

2.4.3 Pipe Headloss

A default value of “Normal” has been used for pipes with solution model "Full", with default value of "Fixed" for pipes with solution model "Force Main".

For gravity pipes, calculation of upstream and downstream headloss coefficients has been inferred using the InfoWorks ICM Inference Tool.

2.4.4 Manhole Storage Type

Manhole storage type has been set to lost as default, this assumes that once a manhole overflows all water is lost to the stormwater network or flows overland and will not return into the wastewater system. This is often the manner in which manhole overflows behave when separated from the stormwater system.

Manhole entry and exit losses will be automatically calculated within the software based on the approach and exit angle and grade of pipework connected to the structure. The losses calculated will assume reasonable benching and manhole condition.

We have assumed that no sewer overflows can occur from nodes with asset types identified in GIS as dummy nodes, flush points and rodding eye. The flood type for these nodes has been set to sealed, which allows the water level to rise indefinitely without any flooding occurring.

2.5 Grinder Pump Areas

Where there are small bore (low) pressure systems, the reticulation network was modelled simplistically using assumptions to replicate the peak flow and storage provided by individual pump units. Model representation of these areas is based on the number of pumps in each pressure sewer catchment area, using similar assumptions to previous modelling work completed for the scheme (AECOM New Zealand Limited 2016).

The methodology used to represent low-pressure systems is detailed below:

- Each pressure sewer catchment was loaded to a single dummy node representing the total storage provided by all grinder pumps within the catchment.
- Each catchment dummy node was loaded to the model gravity network at the known outlet point of the gravity network by a single pump link.
- The number of equivalent pumps within each catchment was determined assuming that individual grinder pumps only operate on the order of 10 minutes per day and not simultaneously. Table 2-3 below presents the equivalent number of modelled pumps based on the number of properties connected to each dummy node (AECOM 2016).
- For each pressure sewer catchment, the equivalent storage volume was determined as the number of properties connected multiplied a single pump’s working volume. For the Mono single grinder pump the individual pump information used was:

  - Equivalent storage tank diameter = 750 mm
  - Depth of storage tank (lid to base) = 2,050 mm
  - Pump stop level = 70 mm above base

- Pump start level = 245 mm above base (1,200 L of working volume between start and stop levels)

Table 2-3: Simultaneous Grinder Pump Operation Based on Property Connections (AECOM 2016)

Number of Connected Properties	Equivalent Number of Pumps	Number of Connected Properties	Equivalent Number of Pumps	Number of Connected Properties	Equivalent Number of Pumps
1	1	34	5	203	9
2	2	55	6	262	10
4	3	91	7	321	11
18	4	145	8	380	12

If the number of properties within a catchment is between two values identified in Table 2-3 then the larger equivalent number pumps has been applied in the model.

2.6 Pumping Stations

2.6.1 Pumping Stations

There are 13 major wastewater pumping stations that have included in the model. These include three in Mangawhai Village, nine in Mangawhai Heads and the outfall pumping station. The majority of pumping stations modelled have two pumps that operate under a duty-standby configuration as was advised by the network maintenance contractor. The outfall pumping station (PS-OF) has two pumps that were confirmed to operate under a duty-assist configuration.

All pumping stations, except PS-OF, were included in the model as having two pumps that do not operate simultaneously. Each station was represented using a manhole chamber with the plan area set to match the area of the wet well. Station layouts, levels (including start/stop) and pipe sizes at the pump stations have generally been taken survey and as-built plans. For pumping stations where rising mains were represented, the pumps are modelled as a rotodynamic pumps, with the appropriate curve taken from the data provided by the maintenance contractor and flowrates checked against drawdown test results. All other pumps were modelled as fixed pumps, with pump rates determined from drawdown testing or flowrates indicated by the maintenance contractor.

The drawdown test methodology is detailed in Section 3.1 of this report, with tests having been completed at the following locations:

- PS-B
- PS-C
- PS-G
- PS-H
- PS-OF
- SP-VB

As part of the planned flow monitoring program, additional pumping station drawdown tests will be completed at PS-F, PS-K, PS-VA and PS-VC by a specialized flow monitoring contractor. For these stations, drawdown test results will be used to update the representation of pumps during the in the model during calibration. Table 2-4 presents information used to represent pumping stations in the model.

Table 2-4: Model Pumping Station Information

Site Name	Wet Well Dimensions	Wet Well Depth (m)	Wet Well Base Level (m AD)	Pump Make/ Models	Pump Start/ Stop Levels (m AD)
PS-A	Ø 2.25 m	2.46	0.32	2 x Grundfos SEV80.80.60.2	0.9/0.56
PS-B	Ø 2.25 m	4.2	15.64	2 x Grundfos SEV80.80.60.2.50B	16.24/15.74
PS-C	Ø 2.25 m	3.0	21.57	2 x Grundfos SEV80.80.13.4	22.02/21.82
PS-E	Ø 3.0 m	2.96	29.15	2 x Grundfos SEV80.80.22.4	29.9/29.45
PS-F	Ø 3.0 m	4.95	12.70	2x Grundfos S1304H1A511Z	14.24/13.45
PS-G	Ø 3.0 m	1.9	1.57	2 x Grundfos S1134H1A513Z012	2.17/1.87
PS-H	Ø 2.25 m	2.9	4.52	2 x Grundfos SEV80.80.92.2.51B	4.92/4.72
PS-J	Ø 2.25 m	3.9	7.42	2 x Grundfos SEV80.80.40.2.50B	8.68/7.71
PS-K	Ø 2.25 m	4.2	0.86	2 x Grundfos S1304H1A	2.01/1.61
PS-OF	Ø 3.0 m	5.55	9.27	1 x Grundfos S1134M1A511Z 1 x Sulzer ABS XFP 80C-2011G	10.27/9.47
PS-VA	Ø 2.25 m	3.35	2.90	2 x Grundfos S1134H1A513Z012	4.25/3.4
PS-VB	Ø 2.25 m	3.35	1.10	2 x Flygt 3127 060 1876002	2.1/1.6
PS-VC	To be confirmed during field tests	To be confirmed during field tests	1.70	2 x Flygt NP3085.160 MT 460	To be confirmed during field tests

In addition to the details listed above the following pumping station elements were included in the model from provided as-built drawings:

- PS-A: 1.375 m diameter retention pipe connected to wet well by 150 NB line. *The length of retention pipe needs to be confirmed as it was not indicated on as-built drawings.*
- PS-B: 3.0 m diameter emergency storage tank connected to wet well by a 150 NB line
- PS-C: 2.5 m diameter emergency storage tank connected to wet well by a 150 NB line
- PS-E: 3.0 m diameter emergency storage tank connected to wet well by a 150 NB line
- PS-H: 3.0 m diameter emergency storage tank connected to wet well by a 150 NB line
- PS-J: 3.0 m diameter emergency storage tank connected to wet well by a 150 NB line

- PS-OF: 2 x 3.0 m diameter emergency storage tank connected to wet well by a 375 mm overflow lines

As-built drawings were not provided for pumping stations PS-F, PS-K and PS-VC and therefore pumping station data provided by the network maintenance contractor used as the primary source for pumping station data. *No additional storage capacity was identified at these sites in the data sources reviewed.*

2.6.2 Rising Mains

Larger rising mains, and rising mains with changes in grade were represented explicitly in the model. This included rising mains from pumping stations PS-F, PS-J, PS-K, PS-OF and PS-VA. The rising main details for these stations are presented in Table 2-5, and details of internal risers (2 per station) are presented in Table 2-6. As no as-built drawings were available for rising mains, it was assumed all rising mains are at a depth of 0.9 m from the ground surface (ground surface from LIDAR). Rising mains not identified in the below tables were not represented in detail in the model, but rather as pump links discharging to the gravity network rising main outlet points.

All rising mains in the model were represented using the “Force Mains” solution model for uphill sections. The pipe internal diameter was assigned in the model based on the GIS identified material and assumed pipe pressure ratings. We have assumed PN12 for uPVC or PN12.5 for PE. The assumed pressure rating and internal diameters will be reviewed during the model calibration stage.

Table 2-5: Model Rising Main Information

PS Name	Material	Pressure Rating	Nominal Size DN	Modelled Internal Diameter (mm)
PS-F	PVC	PN12 (assumed)	250	253
PS-K	MDPE	PN12.5 (assumed)	225	176
PS-OF	uPVC	PN12 (assumed)	300	285
PS-VA	uPVC	PN12 (assumed)	150/200/250	143/203/253

Table 2-6: Pumping Station Riser Information

PS Name	Material	Pressure Rating	Diameter (mm)
PS-F	Unknown	Unknown	Unknown
PS-K	Unknown	Unknown	Unknown
PS-OF	UPVC	PN16	250
PS-VA	UPVC	PN16	150

2.6.3 Minor Pumping Stations

There are five minor pumping stations that have been represented in the model, these include stations on Sunlea Lane, Taimoana Close, The Riverside Holiday Park and two on Estuary Drive. As limited information was available on these pumping stations, so following assumptions have been made in representing each:

- Pumping stations operate under a duty/standby configuration (one pump link included in model)

- Wet well diameter = 1200 mm
- Wet well base = 0.75 m below invert of inlet pipe
- Pump on level = 0.6 m above wet well base
- Pump off level = 0.3 m above wet well base

Table 2-7 presents pump make and model information provided for the minor pumping stations included in the model. All pumps were modelled as fixed pumps, with pump links discharging to the know rising main outlet point. Pump rates were retrieved from manufacturer pump curves.

Table 2-7: Minor Pumping Station Pump Information

PS Name	Make/ Model	Modelled Flow (L/s)
Estuary Drive	Flygt 3068 170 0145 0210	2.5
Estuary Drive	Flygt 3068 170 0145 0210	2.5
Sunlea Lane	Flygt 3068 170 0145 0210	2.5
Riverside Holiday Pa	Grundfos SEG.40.40.2.50B	2.5
Taimoana	Zenit Bluepro	3

2.7 Subcatchments

2.7.1 Subcatchment Delineation

Model subcatchments were created from property rating information provided by KDC (shapefiles following approximate property boundaries). Minor adjustments were made to the rating shapefiles to remove overlaps and road area. Large subcatchments covering the area of the Mangawhai Golf Club and WWTP were modified to only include developed areas (affected rating locations with valuation numbers including 0122011801A, 0122011801C, 0122011804, 0122011877A, 0122011877B, 0122011877C and 0122011877D).

Subcatchment loading to the network was completed using service laterals contained in the pipe GIS layer provided. All subcatchments were assigned to the upstream node of the pipe to which the parcel connects.

2.7.2 Population

For model build purposes, each subcatchment was assigned a temporary population value of 1. ***Subcatchment populations will be updated during model calibration (Phase 2 of this project).***

2.7.3 Wastewater Discharge Profiles

Generic wastewater discharge profiles were developed from inflow data recorded at the WWTP and were applied to all the model subcatchments. Discharge profiles were developed for weekday and weekend flows and are presented below on Figure 2-2.

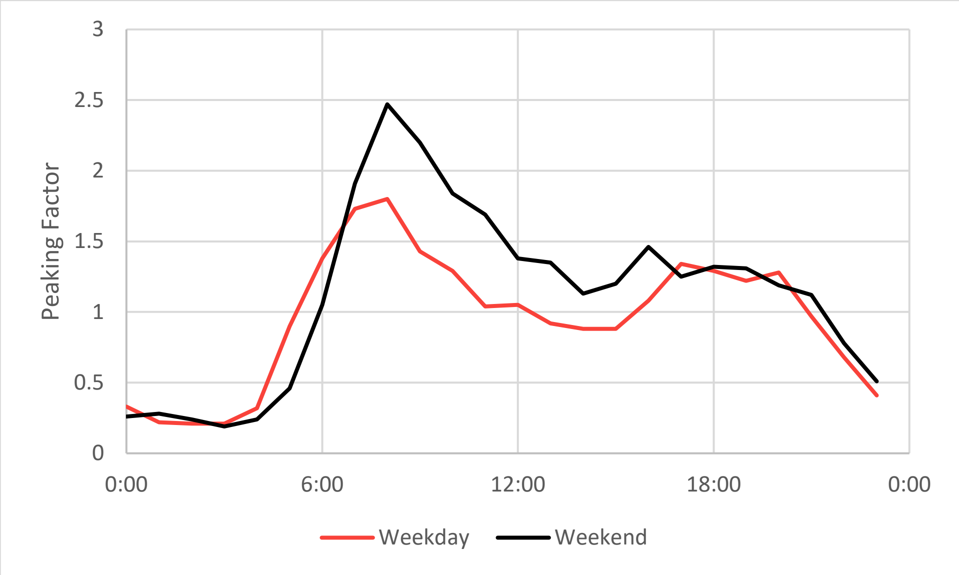

Figure 2-2: Discharge profile to WWTP

The wastewater discharge profiles presented on Figure 2-2 represents typical wastewater discharges into the WWTP and do not account for any wet weather ingress to the network. These profiles were developed from observed flows from 22/11/2017 to 9/12/2019 (18 days) for which the average wastewater flow was 222 L/property/day. These profiles will be refined, and per capita wastewater flows updated, during the model calibration phase.

3 Field Investigations

Drawdown testing was completed for key pumping stations to inform the system model. The testing methodology and results are detailed in the below sections.

3.1 Drawdown Testing Methodology

The following details the field testing methodology is described below. Each test detailed below as repeated three times for each pump.

Drawdown Test Preparation

- Pumping station wet wells were isolated from all inflows. If not possible, a wet well inflow test was completed prior to commencing the drawdown test.

Inflow Test

- The depth from wet well lid to water surface was measured and timer started.
- At 15 second increments, the depth from wet well lid to water level was recorded (for as long as possible, with a minimum duration of 2 minutes) while allowing wet well to fill as normal (i.e. not filling from tanker truck or hose).
- Two tests were completed at each site where wet wells could not be isolated, one before and one after the drawdown testing was completed.

Drawdown Test

- Ideally pumps were tested over the normal operating range (start level to stop levels), but as necessary the starting point was adjusted to operate the full test below any pipe inlets.
- A timer was started at the beginning of each test, with the depth from wet well lid to water surface measured. A minimum of 5 measurements were taken for each test, including the depth from wet well lid to water surface and time noted (typically conducted at 50-100 mm increments).

- Drawdown tests were completed at each station's normal operating speed as well as and at full speed.
- Where wet wells could not be isolated the calculated pump rates were modified to account for inflow test results.

3.2 Drawdown Testing Results

From drawdown test results, the average pumping rate was determined for each pump at the tested stations. Table 3-1 presents the calculated average flowrates for all pumping stations that were tested.

Table 3-1: Pumping Station Drawdown Test Results

PS Name	Pump	Existing Pump Speed (Hz)	Existing Pump Rate (L/s)	Full Speed Pump Rate (L/s)
PS-B	Pump 1	45	6.4	8.7
	Pump 2	45	6.1	8.6
PS-C	Pump 1	35	7.2	10.7
	Pump 2	35	6.3	10.7
PS-G	Pump 1	35	14.0	33.6
	Pump 2	35	17.0	34.3
PS-H	Pump 1	43	4.6	6.9
	Pump 2	43	4.4	6.9
PS-OF	Pump 1	45	63.7	64.7
	Pump 2	45	26.2	29.8
PS-VB	Pump 1	35	5.7	7.4
	Pump 2	35	5.1	6.7

The drawdown test results for existing pump speeds were used to represent pumping stations in the current model. As a part of future phases of this work, full speed pump rates will be used to optimize pumping station operation for existing and future flows.

4 Recommendations

Based on the model build detailed above the following recommendations are made:

- The current model network has been developed and all input data reviewed. It is recommended this model network be calibrated to observed flows (proceed with Phase 2 of this project).
- We recommend survey be completed at select locations in the contributing area to the Anchorage Road sewer (PS-K catchment) to fill in the areas of missing data highlighted in Section 2.3.1 above.
- We request that KDC confirm the following in order to improve accuracy of the model:
  - Confirm the length of the 1375 mm diameter retention pipe at pumping station PS-A.

- Confirm there is no additional storage capacity at pumping stations PS-F, PS-K and PS-VC

5 References

AECOM. (2016). Mangawhai Wastewater Modelling - Stage 2. ABN: 48053122562.

TRILITY. (2016). MCWS Capacity and Upgrade Study. Reference No. B-0100.PRE.73

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