Mangawhai Wastewater Modelling

Model Calibration and System Performance Planning

30 September 2021

Workshop Overview

- Project Approach/ Model Application
- Summary of Catchment
- Data Inputs
  - Network Inputs
  - Pump Station Inputs
  - Flow Inputs
- Calibration
- Discussion of Next Steps
  - Level of Service/ Network Performance Indicators
  - Representing Growth

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Project Summary and Background

Mangawhai Wastewater Modelling

How Hydraulic Models are Applied for Infrastructure Planning

Build and Calibration

- Understand current state of the system
- Define level of service

Growth Assessment

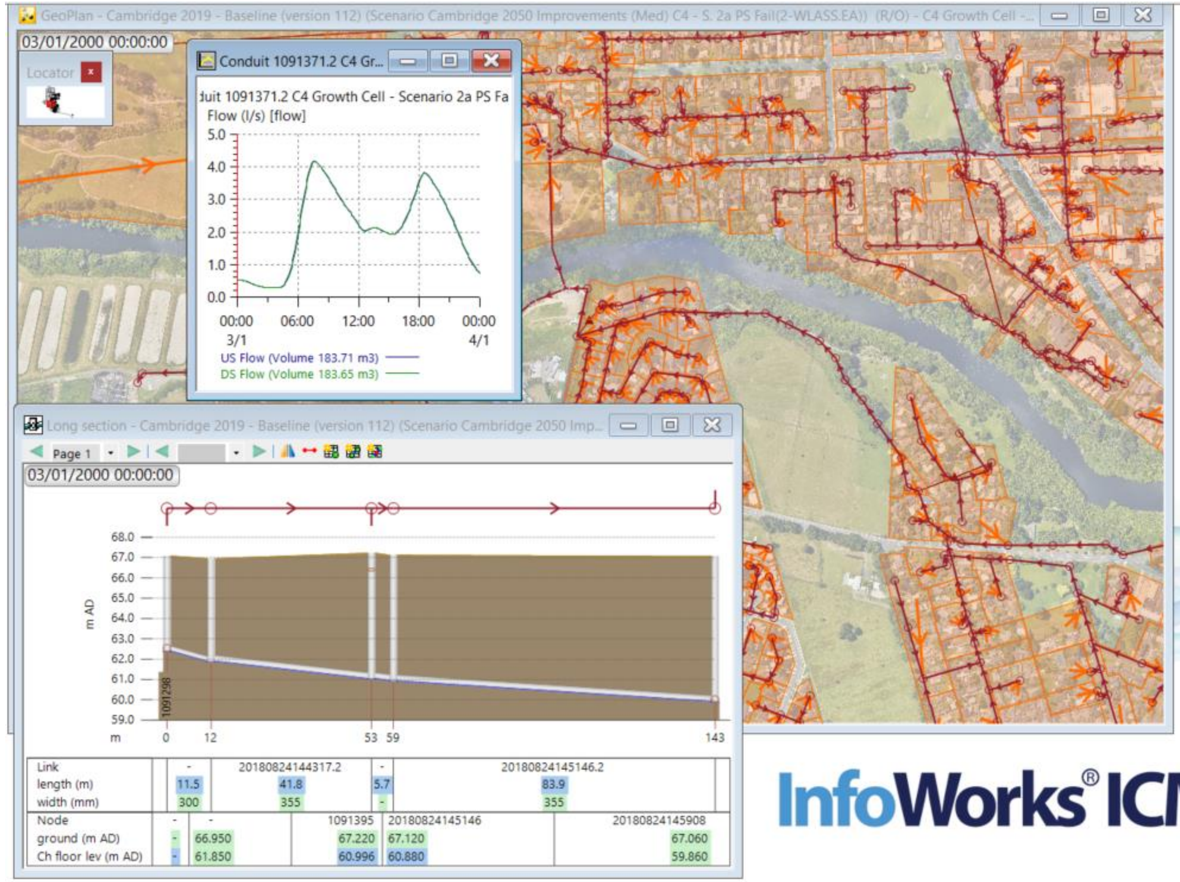
- Understand growth areas and apply design flows to the existing network

Network Planning

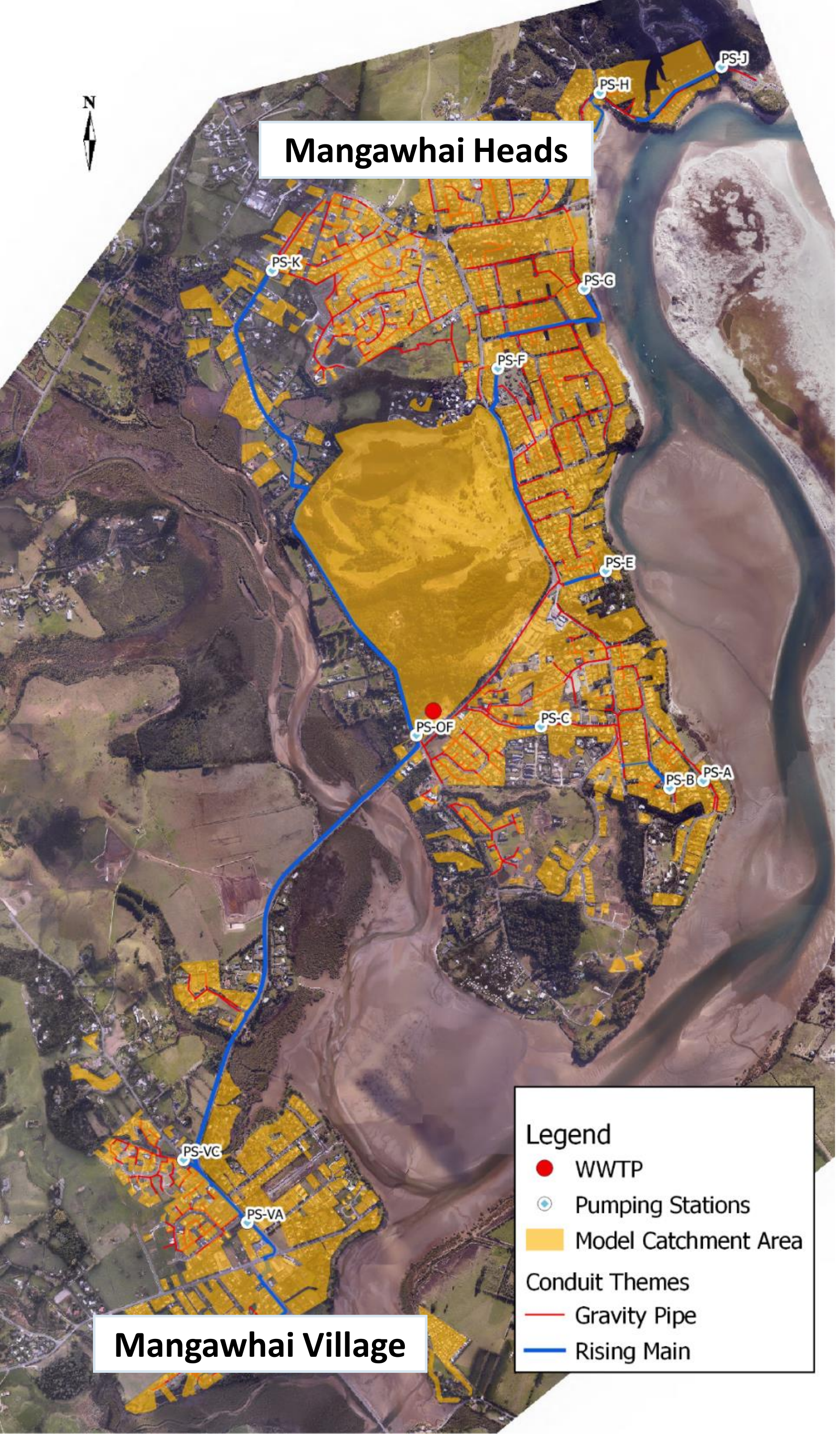
- Develop and evaluate alternatives to meet current and future level of service (staging)
- Multi-criteria analysis based on LoS and other factors

Modelling Software

- Model contained in InfoWorks ICM version 11.0
- Simulation Inputs:
  - Model network
  - Wastewater flow group
  - Rainfall/ evaporation file
  - Trade flow group
- Results Output:
  - Shapefiles
  - Tabular results (.csv)
  - Hydraulic grade line profiles

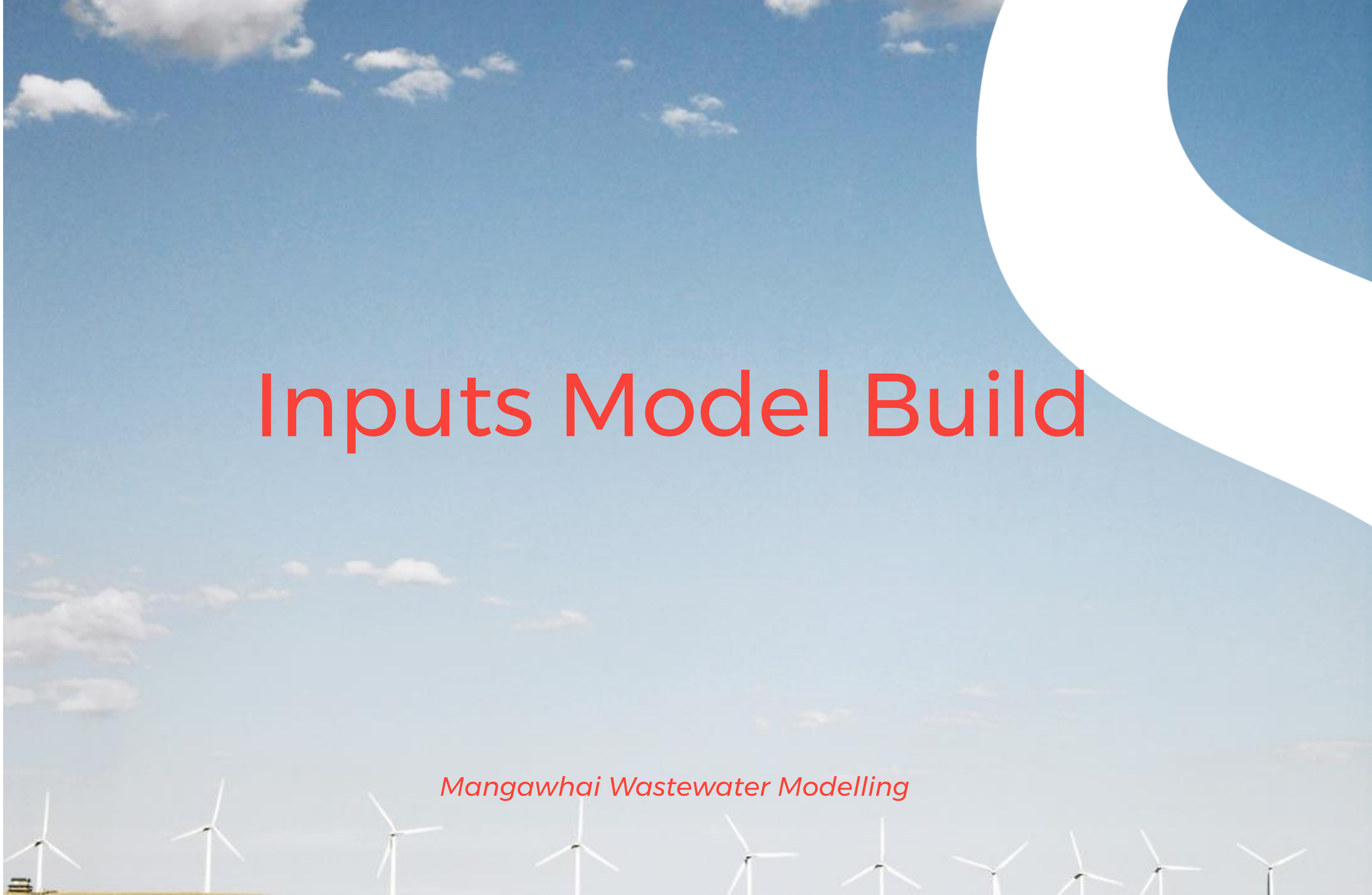


InfoWorks® ICM



Mangawhai Heads
PS-J
PS-H
PS-K
PS-G
PS-F
PS-E
PS-OF
PS-C
PS-B
PS-A
PS-VC
PS-VA
Mangawhai Village
Legend
WWTP
Pumping Stations
Model Catchment Area
Conduit Themes
Gravity Pipe
Rising Main

Mangawhai Community Wastewater Scheme
PAST
1999
Individual on-site sewage treatment and disposal system. No sewer network was present.
Poor harbour quality - contamination strongly related on-site sewage treatment and disposal systems
Unsafe for swimming
Unsafe for Kai
2010
Opening of the CWWTP
2010 to 2019
Harbour water quality improved
Additional connections to the scheme supporting the town's rapid growth
PRESENT
2020
Clean harbour and tourist destination
Serving 2,000 connections
Aeration system improved capacity of the plant to 3,000 connections
Irrigation of the fields extended to 65 ha
Scheme long term strategy available
'User pays' principle by way of targeted rates and development contributions
Disposal field (Brown Road farm)
Future Developments
Catchment Area
Potential Water reuse
Treatment plant
Outfall pump station
Mangawhai Heads
New Balance Tank (underway)
Coastline
Mangawhai Village
Mangawhai Harbour
FUTURE
2021
New balance tank construction
Catchment study to inform on reticulation strategy and renewal
Water reuse optioneering (Golf course, farms, gardens, etc)
Community engagement
2021-2028
Upgrade network
Increased treatment capacity
Increased disposal system
2028
Capacity improvements required for WWTP
2043
Mangawhai continuing to thrive for its beautiful beaches and clean harbour
Growth projected to 6000 connections (3x existing population)
KAIPARA DISTRICT



Inputs Model Build

Mangawhai Wastewater Modelling

Network Inputs

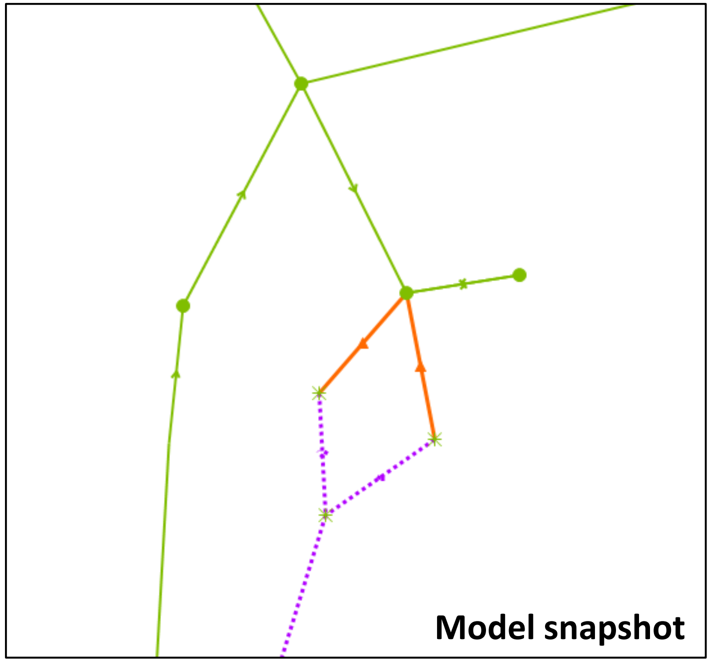
- Model extent: all properties that discharge to the WWTP (2021 rating information)
- Population from 2018 census data
- Model network based on GIS (export date 19/08/2020)
- Network includes:
  - All gravity pipes
  - All major (13) and minor (5) pumping stations
- Excludes
  - Local pressure reticulation networks

Grinder Pump Areas

- Reticulation simplified on catchment basis to replicate the peak flow and storage provided by individual pump units
- Single pump modelled per catchment:
  - Equivalent tank diameter = 750 mm
  - Tank depth = 2,050 mm catchment
  - Flowrate based on no. connected pump kits
  - Detailed assumptions in *Model Build report*

Pump Stations – Data Inputs

- Pump station layouts from as-built drawings
- Pump capacity from drawdown testing (typical and maximum operating speed)
- Rising main layouts and material information from GIS



Pump Stations - Drawdown Test Results

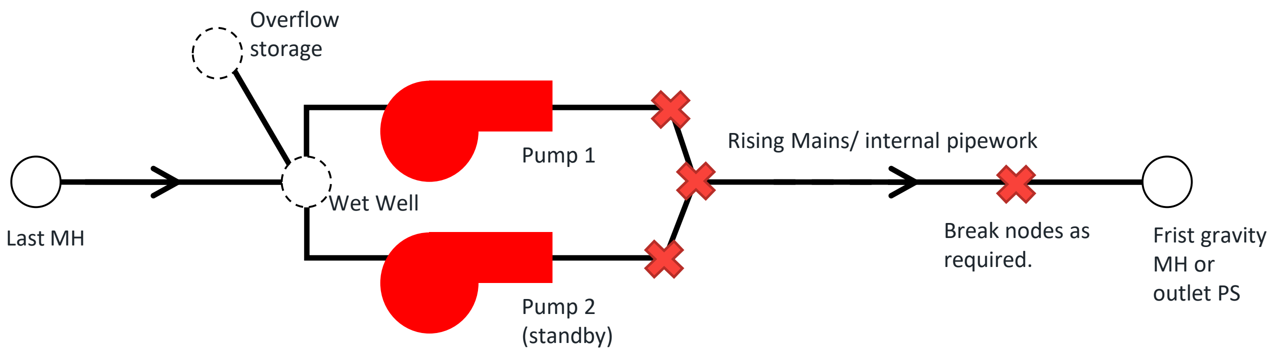
PS ID	Test Date	Current Speed (Hz)	Max Speed (Hz)	Pump 1 (L/s)	Pump 2 (L/s)	Pump 1 (L/s)	Pump 2 (L/s)
				Current Speed		Max Speed	
PS-A	N/A	45	50	Not tested, capacity from as-built spreadsheet			
PS-B	3/11/2020	45	50	6.4	6.1	8.7	8.6
PS-C	23/10/2020	35	50	7.2	6.3	10.7	10.7
PS-E	N/A	41	50	Not tested, capacity from as-built spreadsheet			
PS-F	23/10/2020	43	50	17.3	17.5	36.1	35.8
PS-G	23/10/2020	35	50	14	17	33.6	34.3
PS-H	3/11/2020	43	50	4.6	4.4	6.9	7.3
PS-J	N/A	35	50	Not tested, capacity from as-built spreadsheet			
PS-K	23/10/2020	38	50	25.7	25.5	43.9	45.7
PS-VA	23/10/2020	35	50	23.8	23.7	37.5	40
PS-VB	23/10/2020	35	50	5.7	5.1	7.4	6.7
PS-VC	23/10/2020	48	50	6.4	5.3	7.3	6.6
PS-OF	23/10/2020	45	50	**63.7**	**26.2**	**64.7**	**29.8**

Pump Stations - Model Representation

- All sites: Wet well, storage and pump operating levels
- Rising mains modelled at select sites:
  - Larger pump stations or where understanding operation of rising main is critical
  - Manufacturers pump curve, flowrate confirmed from drawdown testing
  - PS-VA, PS-K, PS-F, PS-OF
- Fixed Pumps:
  - All other pump stations
  - Pumps represented by pump links at fixed flowrate (from drawdown testing)

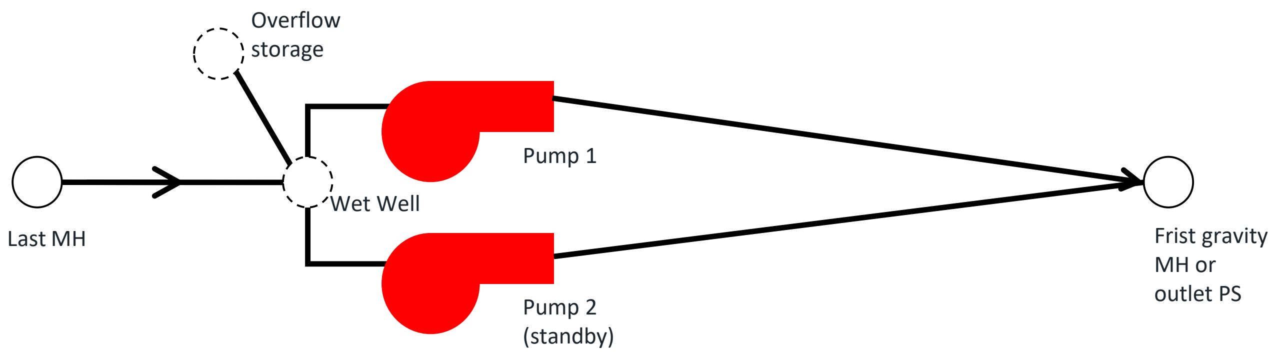
Pump Stations - Model Representation

Rotodynamic Pump



- Includes rising main and internal PS pipework
- Dynamic pump curve
- Used to understand losses/ hydraulics in pipework and interaction with other pumps

Fixed Pump



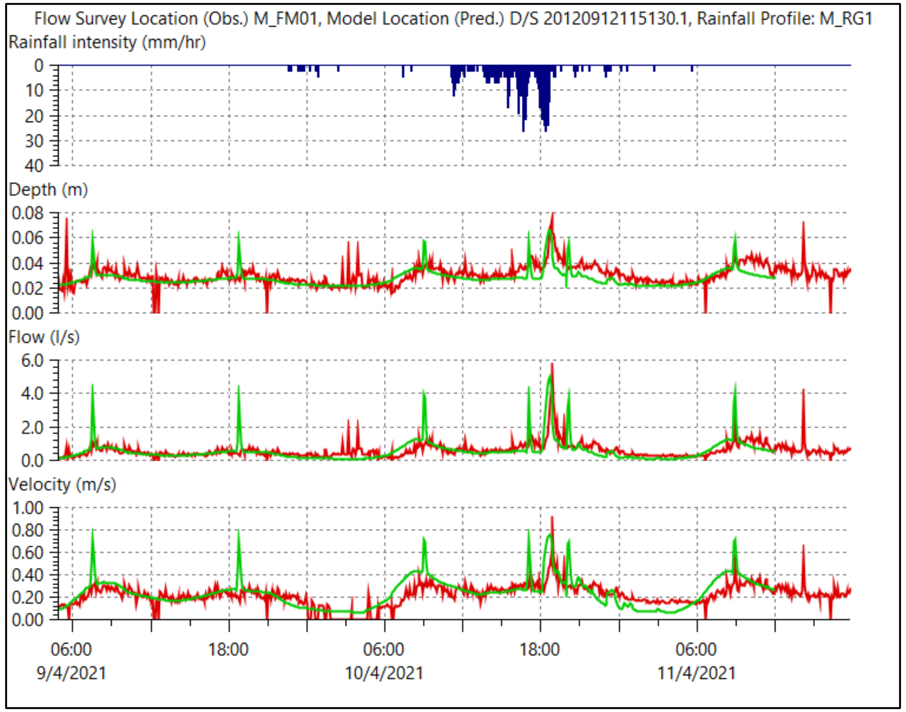
- Pumps and rising main modelled as a single pump link
- Fixed pump flowrate
- Simplified representation for smaller pumping stations

Model Calibration

Mangawhai Wastewater Modelling

Approach to Calibration

- Process of replicating observed network flows in the model
  - Completed for dry and wet weather flows
- Data hierarchy for calibration:

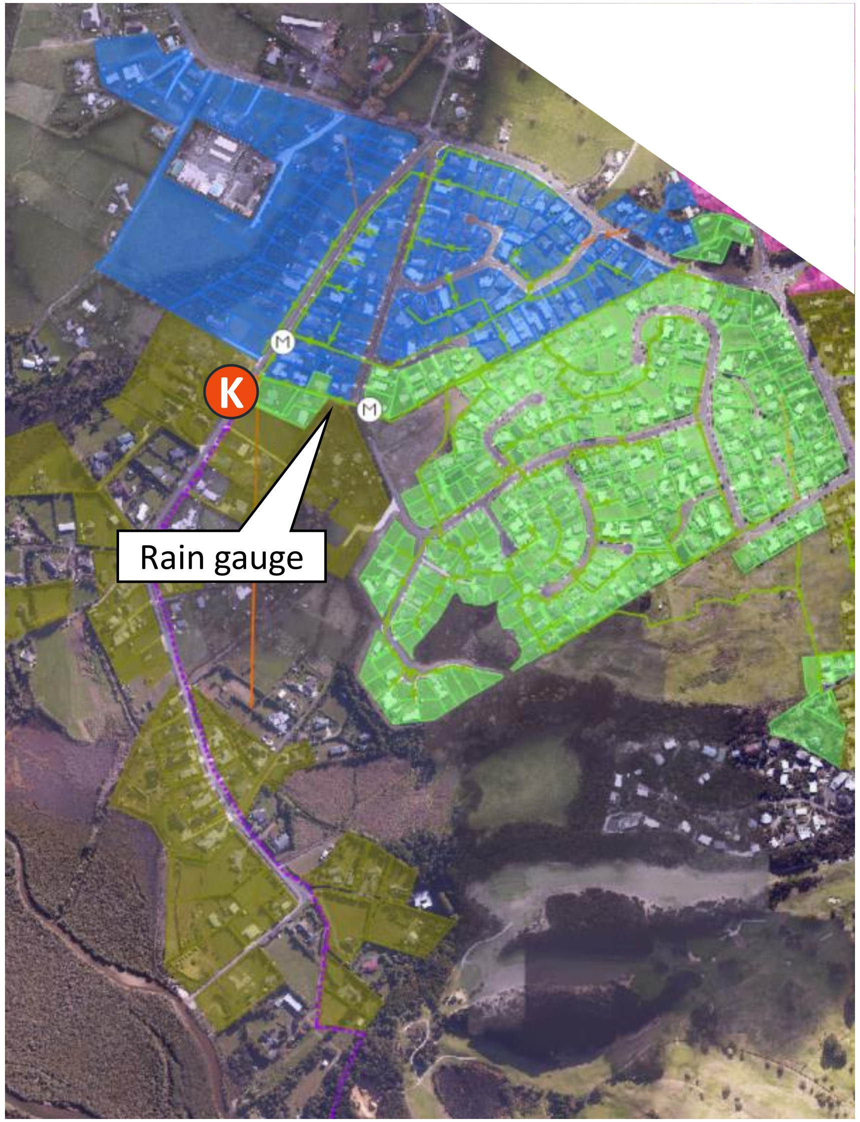


1. Flow monitoring data

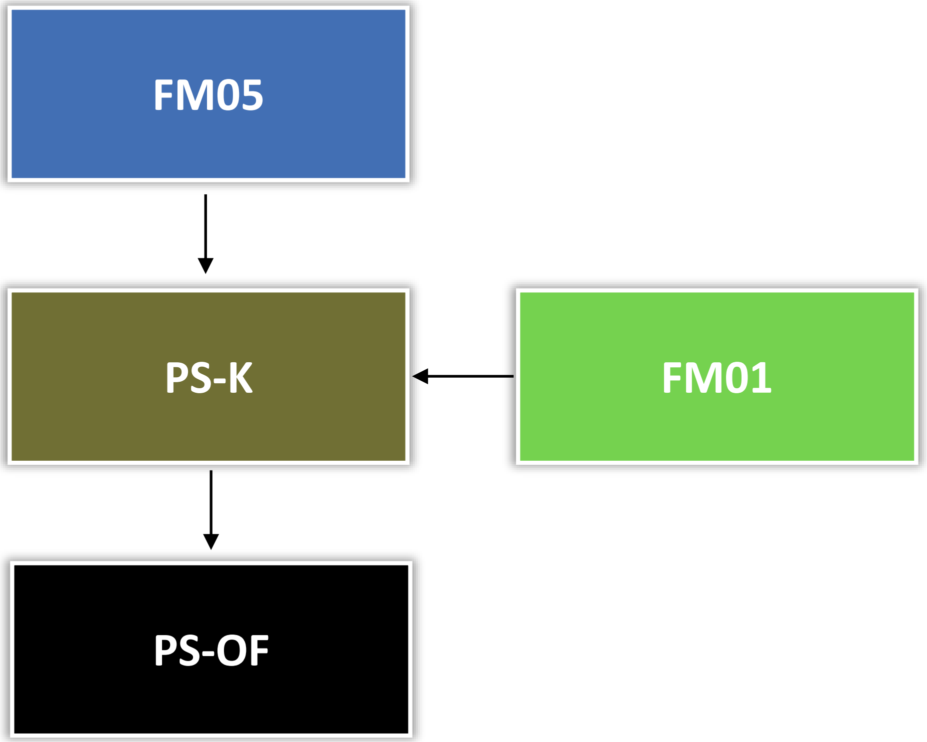
2. Pump station volume data (derived form wet well level)

3. WWTP inflows (daily totals)

Calibration Catchments - Mangawhai Heads 1



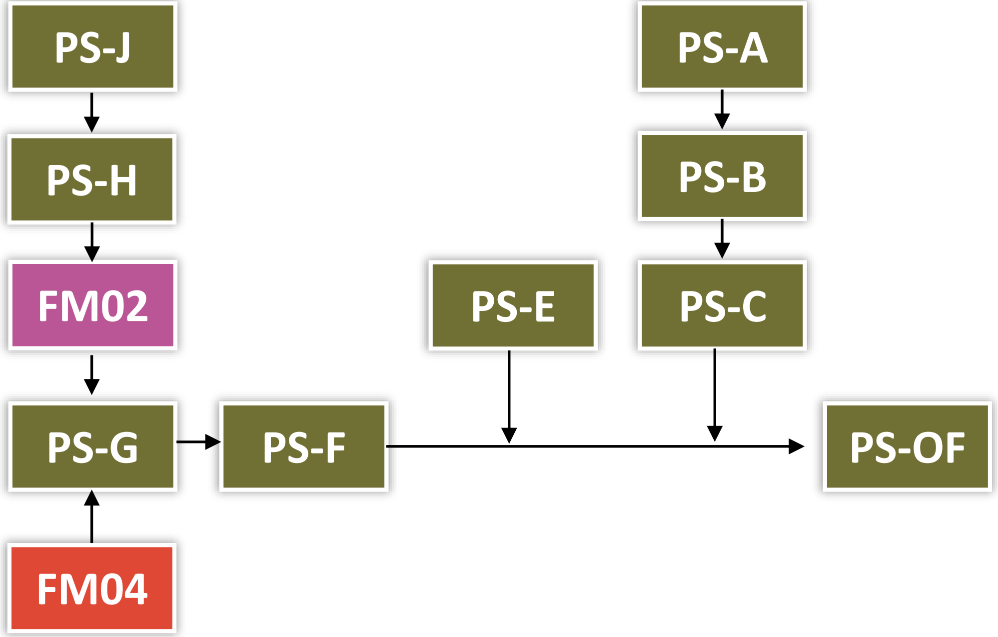
Jack Boyd Drive Catchment



Data available 21 December 2020 to 3 May 2021

Flow Monitoring Catchments – Mangawhai Heads 2

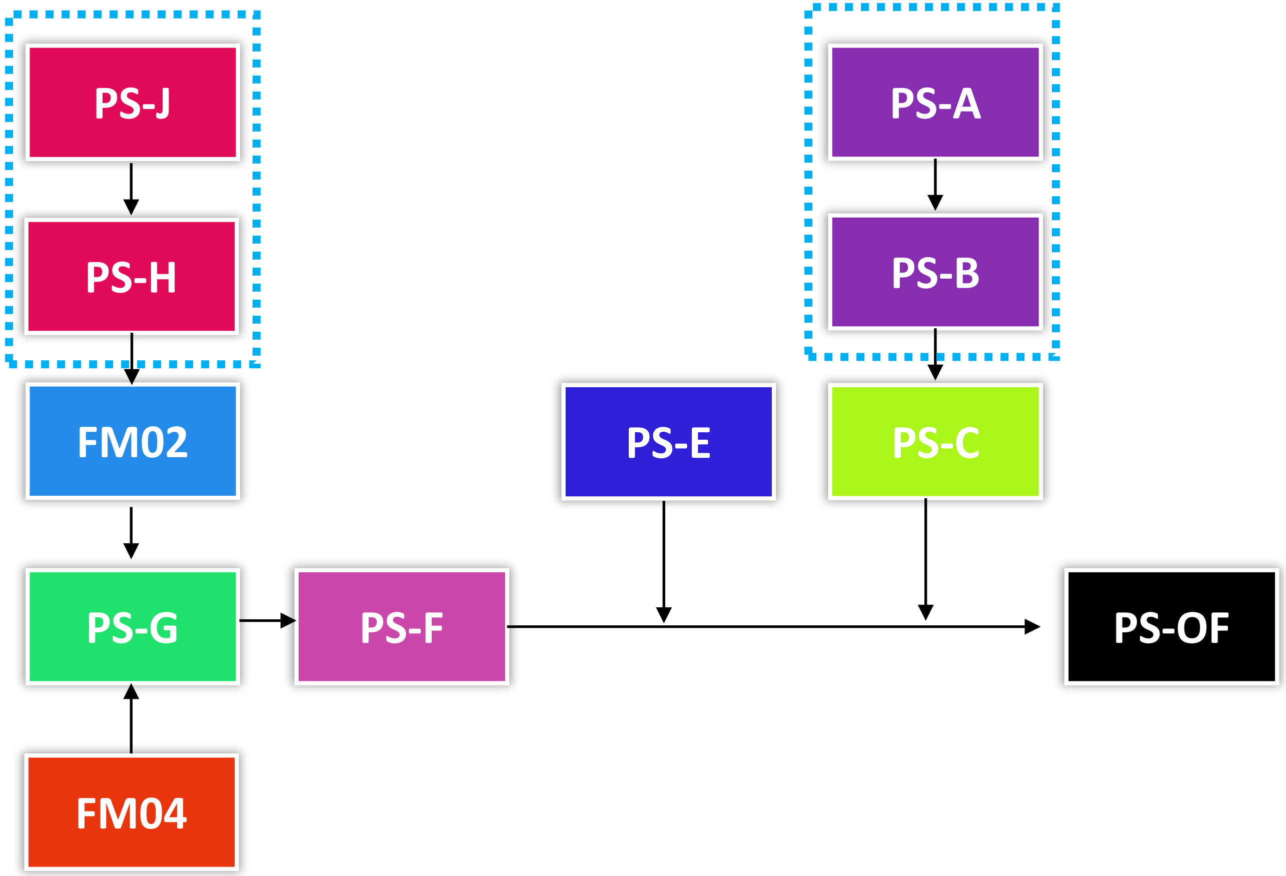
Molesworth Drive Catchment



Data available 21 December 2020 to 3 May 2021

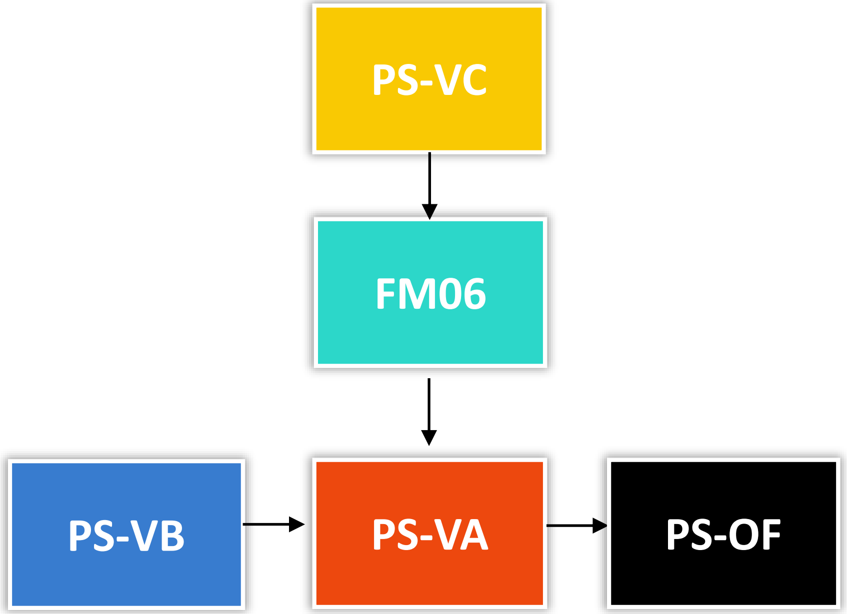
Calibration Catchments – Mangawhai Heads 2

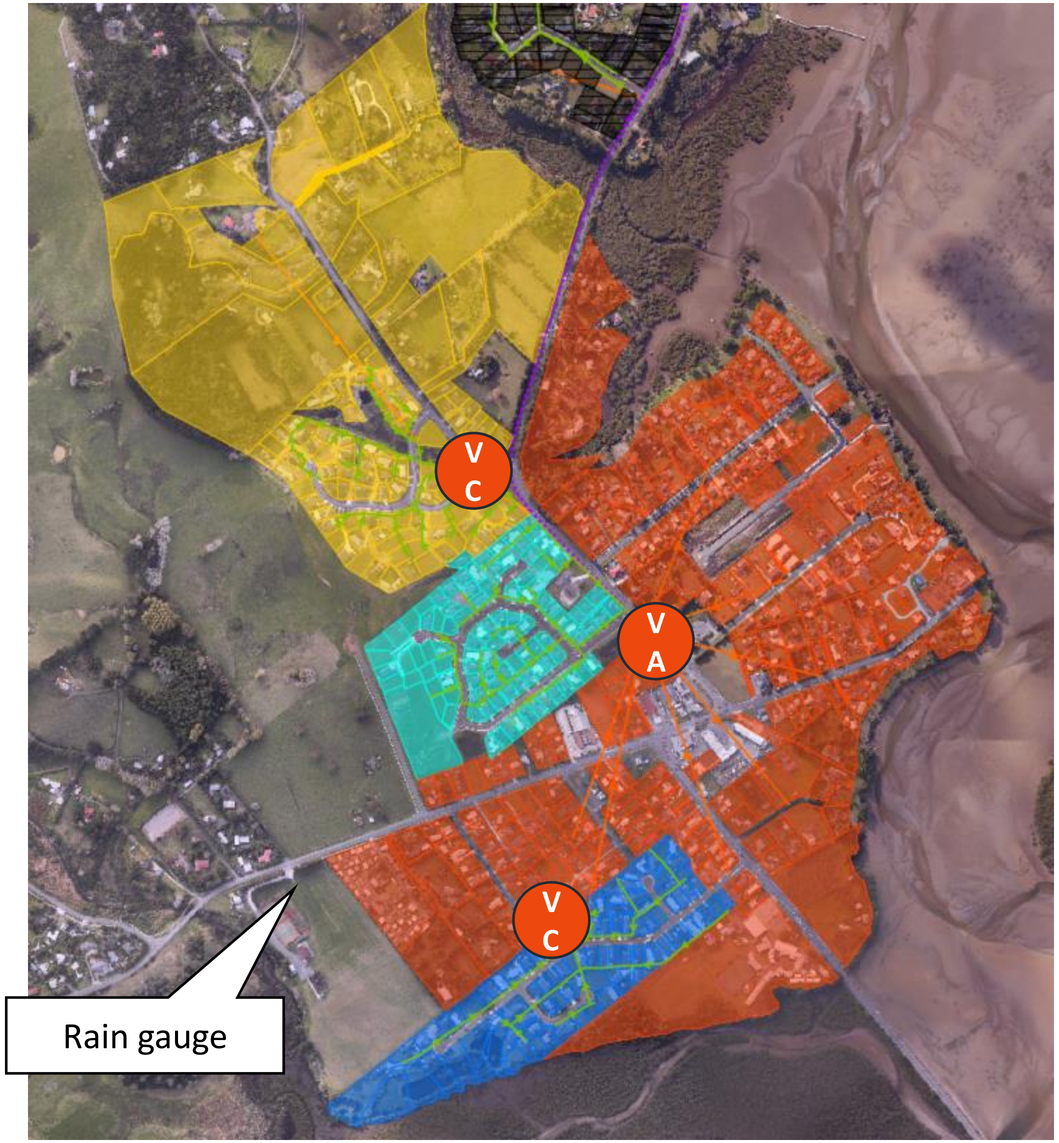
Molesworth Drive Catchment



Data available 21 December 2020 to 3 May 2021

Calibration Catchments – Mangawhai Village

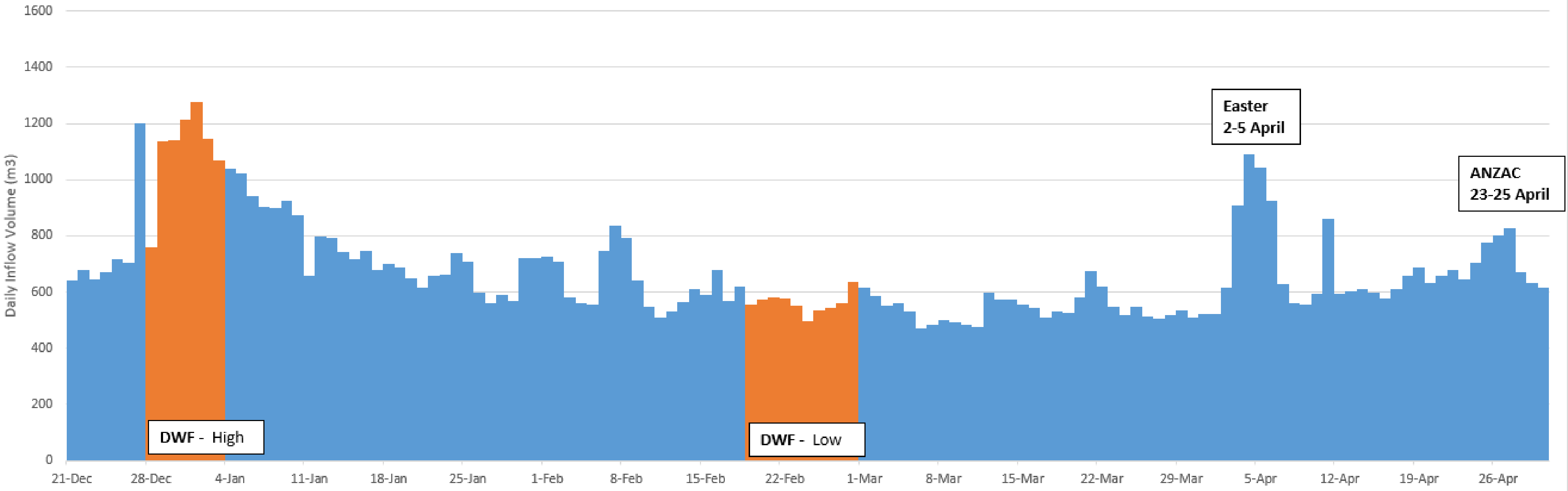




Data available 21 December 2020 to 3 May 2021

Approach to Calibration – Dry Weather

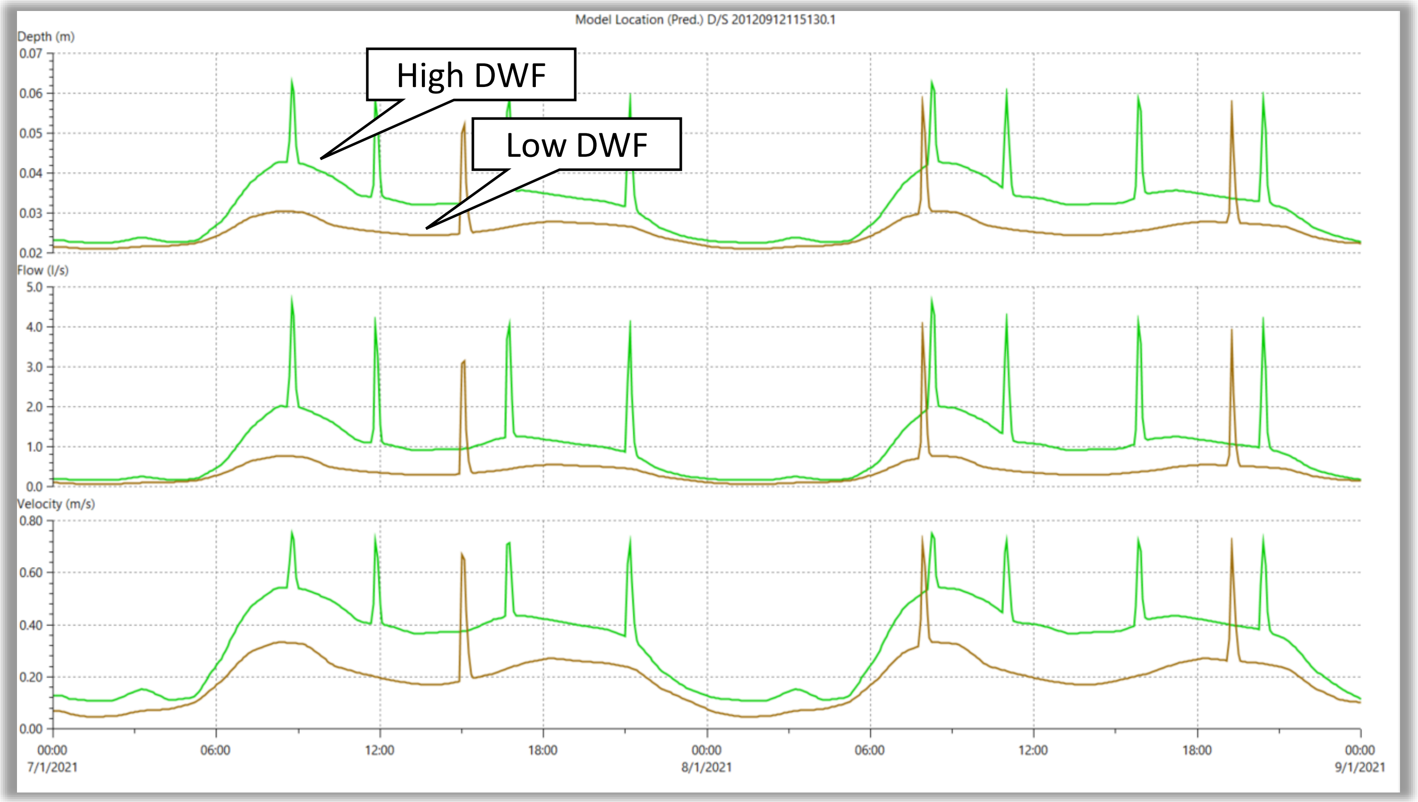
- **Purpose:** to represent typical wastewater flows
- WWTP inflow range: 500 – 1300 m^3/day for calibration period
- DWF calibration competed for two periods:
  - Peak summer conditions
  - Typical residential conditions



Approach to Calibration – Dry Weather

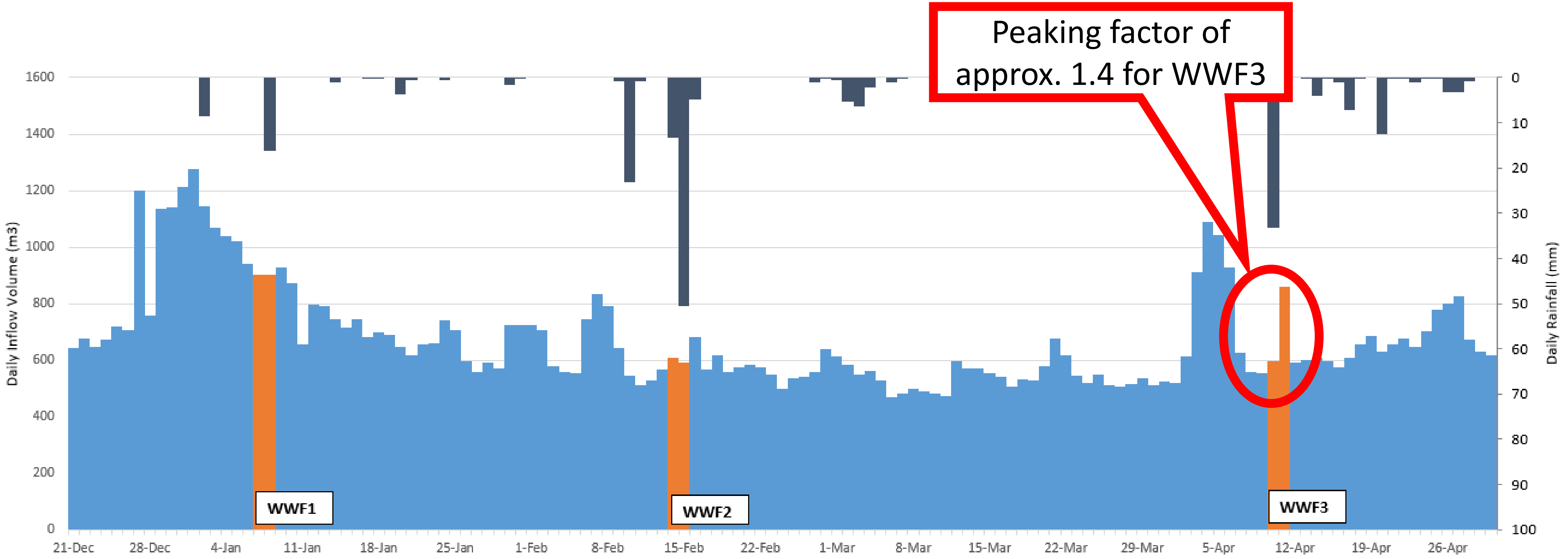
Catchment	High PCF (L/day)	Low PCF (L/day)
M_FM01	355	160
M_FM05	690	**565**
M_FM02	545	155
M_FM04	215	170
PS-H	450	105
PS-G	635	125
PS-F	625	**260**
PS-K	250	100
PS-A/ PS-B	450	145
PS-C	280	180
PS-E	450	140
PS-VC	165	145
M_FM06	475	90
PS_VB	105	90
PS-VA	475	225

- Model population from 2018 census data
  - Expected to correspond best to low calibration period
- PCFs generally as expected with non-reticulated water supply



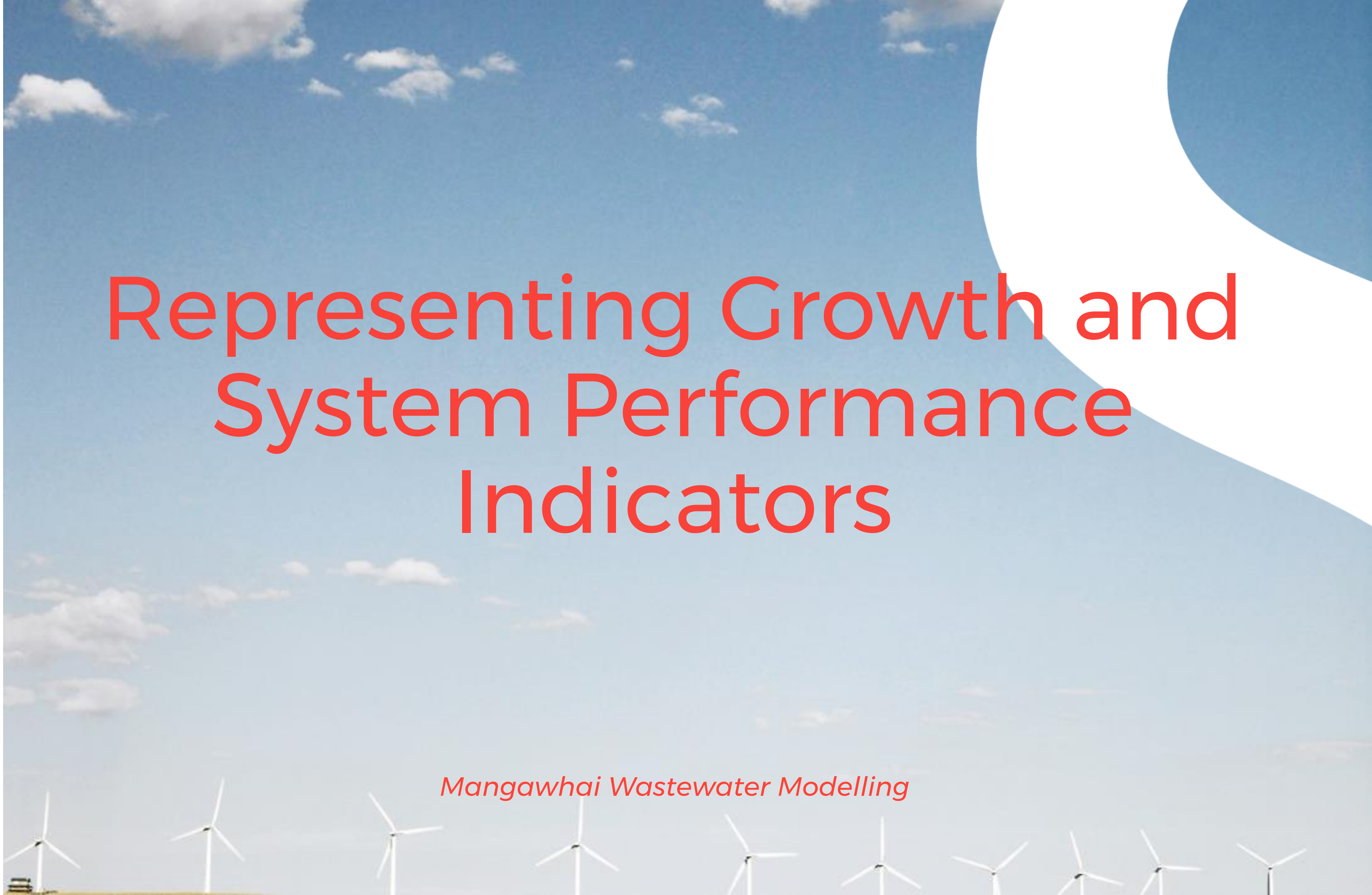
Approach to Calibration – Wet Weather

- **Purpose:** to represent peak (design) flows in the network
- 3 events selected for calibration



Summary of Rainfall Events

Rain Gauge ID	Event Date	Start Time	End Time	Rainfall Depth (mm)	Peak Intensity (mm/hr)	Event Duration (hrs)	Estimated ARI
WWF1							
RG1	07-Jan-2021	07/01/2021 23:30	08/01/2021 12:15	16.6	16.8	12.7	<2 years
RG2	07-Jan-2021	07/01/2021 23:30	08/01/2021 12:15	16.6	16.8	12.7	
WWF2							
RG1	14-Feb-2021	14/02/2021 19:55	15/02/2021 14:20	31.8	7.2	18.4	<2 years
RG2	14-Feb-2021	14/02/2021 19:20	15/02/2021 15:15	30	7.2	19.9	
WWF3							
RG1	09-Apr-2021	09/04/2021 22:35	11/04/2021 05:40	61	26.4	31.1	<2 years
RG2	09-Apr-2021	09/04/2021 23:30	11/04/2021 11:10	36.4	26.4	35.7	



Representing Growth and System Performance Indicators

Mangawhai Wastewater Modelling

Overview

- This section provides an introduction and overview of system performance indicators.
- Criteria provided as examples but further discussion is required to confirm which are consistent with, and appropriate for Council.
- The primary driver for confirming growth representation and system performance criteria is to reduce the possibility of rework – should criteria be modified after reporting is completed.

Key Considerations Prior to Assessment

- Considerations for scenarios/ growth assumptions
  - Residential growth: Number of lots or population of growth cells
    - High vs low DWF period
    - Reticulated water supply?
  - Commercial/ trade growth: wet or dry industries
  - Connection points
- Parameters to consider in selecting a Design Storm
  - Frequency of acceptable surcharge in pipes
  - Shape for synthetic storm
  - Who is going to use the system performance results, and what do they want to see?

Growth Scenario Examples

Scenario	Description	Network	Wastewater Loads	Operation
1	Existing	Existing	Current	Current
2	LTP Residential Growth	Existing + Committed Projects	Current + LTP Residential Growth	TBC
3	LTP Residential Growth + Commercial/ Trade	Existing + Committed Projects	Scenario 2 + Commercial/ Trade growth	TBC
4	LTP Residential Growth + Commercial/ Trade + Semi-rural areas	Existing + Committed Projects	Scenario 3 + Semi-rural areas	TBC
5	LTP Residential Growth + Commercial/ Trade + Semi-rural areas	Existing + Committed Projects + Commercial/ Trade areas	Scenario 3 + Semi-rural areas	TBC

Network Assumptions - Variation from the Calibrated Model

1. **Residential flows:** Is there seasonal population which needs to be accounted for in a specific area of the catchment?
2. **Commercial / trade flows:** Were certain commercial premises or traders operating at different rates during the calibration? Need to ensure worst case is included in the model used for assessments.
3. **Pipe roughness**: Consideration of deteriorating pipe condition over time.
4. **Ancillary modelling:** Was there an operational issue during the calibration period which should not be account for in the current model (ex. PS-OF operation).
5. **Boundary conditions:** Where there is an interaction with the river or tide levels, what is appropriate level for these?
6. **Antecedent conditions:** Need to understand what the antecedent conditions need to be within the model.
7. **Infiltration:** If there is a seasonal infiltration issue across the catchment then it may be necessary to include an inflow file to represent this. This is not apparent in WWTP inflow data reviewed to date – primary driver is seasonal population.

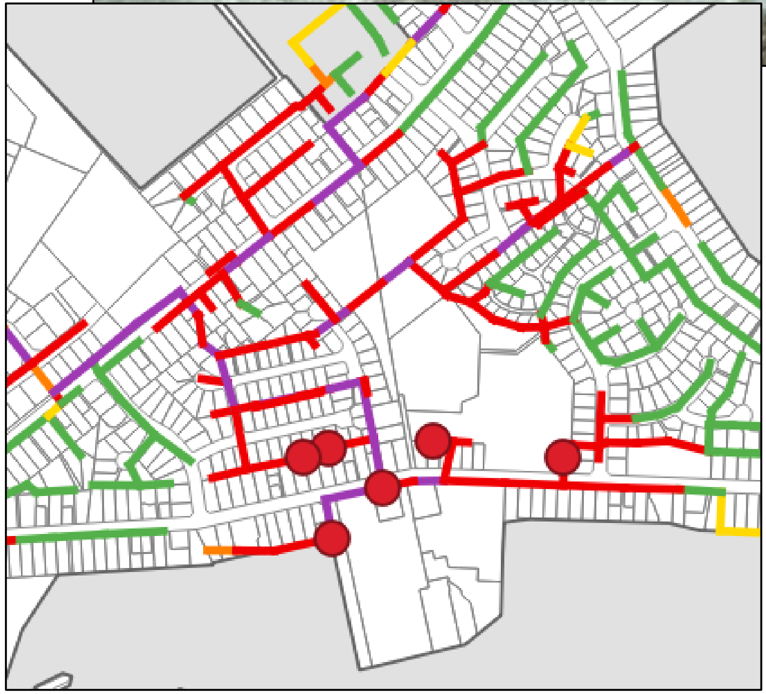
Design Flow Assumptions: New Growth

- **Residential flows:** Residential allowance from design standard or surrounding catchments?
- **Commercial / trade flows:** Type of trade flow to allow for heavy, medium light – design standard or observed flows?
- **Connection Points:** Where will the new developments connect to the network?
- **I&I amount:** How much I&I to allow for e.g. equivalent to 5x ADWF or similar to surrounding network?
- **Climate change:** Is an allowance for climate change included in the rainfall?
- **Consistency with other Waters:** what has been considered in planning of water and stormwater networks

Typical Performance Indicators

Level of Service (LoS)

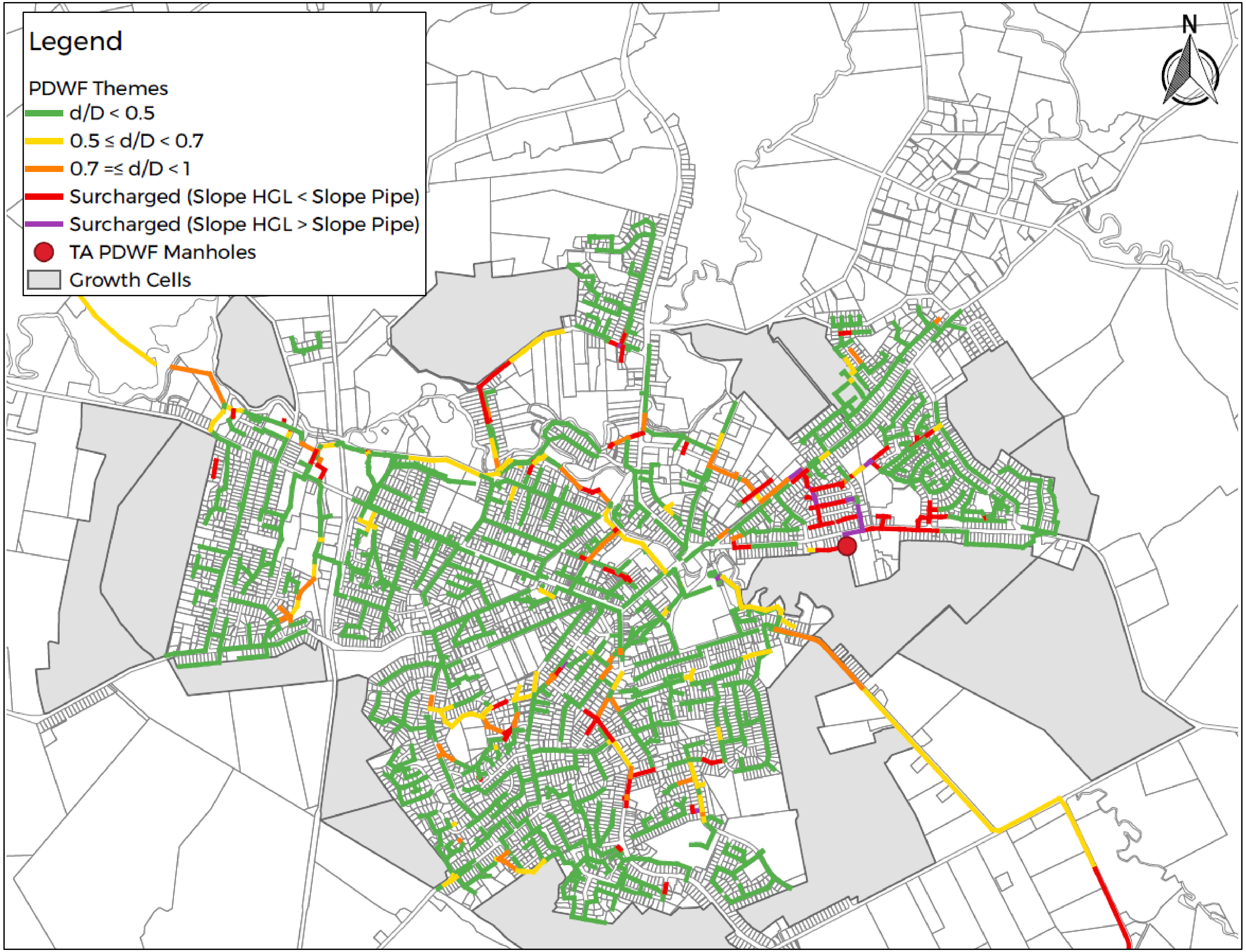
- Peak Dry Weather Flow
- Peak Dry Weather Velocity
- Peak Wet Weather Flow
- Pump Station Flow Capacity
- Pump Station Emergency Storage Capacity
- Rising Main Performance



Dry Weather: Flow Capacity Assessment

- **Manhole Performance:** Dry weather overflows (high scenario)
  - > 0: Fail;
  - Nil: Acceptable.
- **Pipe Performance:** Pipe capacity (high scenario)
  - Typically performance bands as per below

Category	Flow Depth @ PDWF
1	Flow Depth < 50% of pipe diameter
2	50% ≤ Flow Depth < 70% of pipe diameter
3	70 % ≤ Flow Depth < 100% of pipe diameter
4	Pipe surcharged due to limited downstream capacity (hydraulic gradient less than or equal to pipe grade)
5	Pipe surcharged due to limited capacity (hydraulic gradient greater than pipe grade)


Legend
PDWF Themes
d/D < 0.5
0.5 ≤ d/D < 0.7
0.7 =≤ d/D < 1
Surcharged (Slope HGL < Slope Pipe)
Surcharged (Slope HGL > Slope Pipe)
TA PDWF Manholes
Growth Cells
N

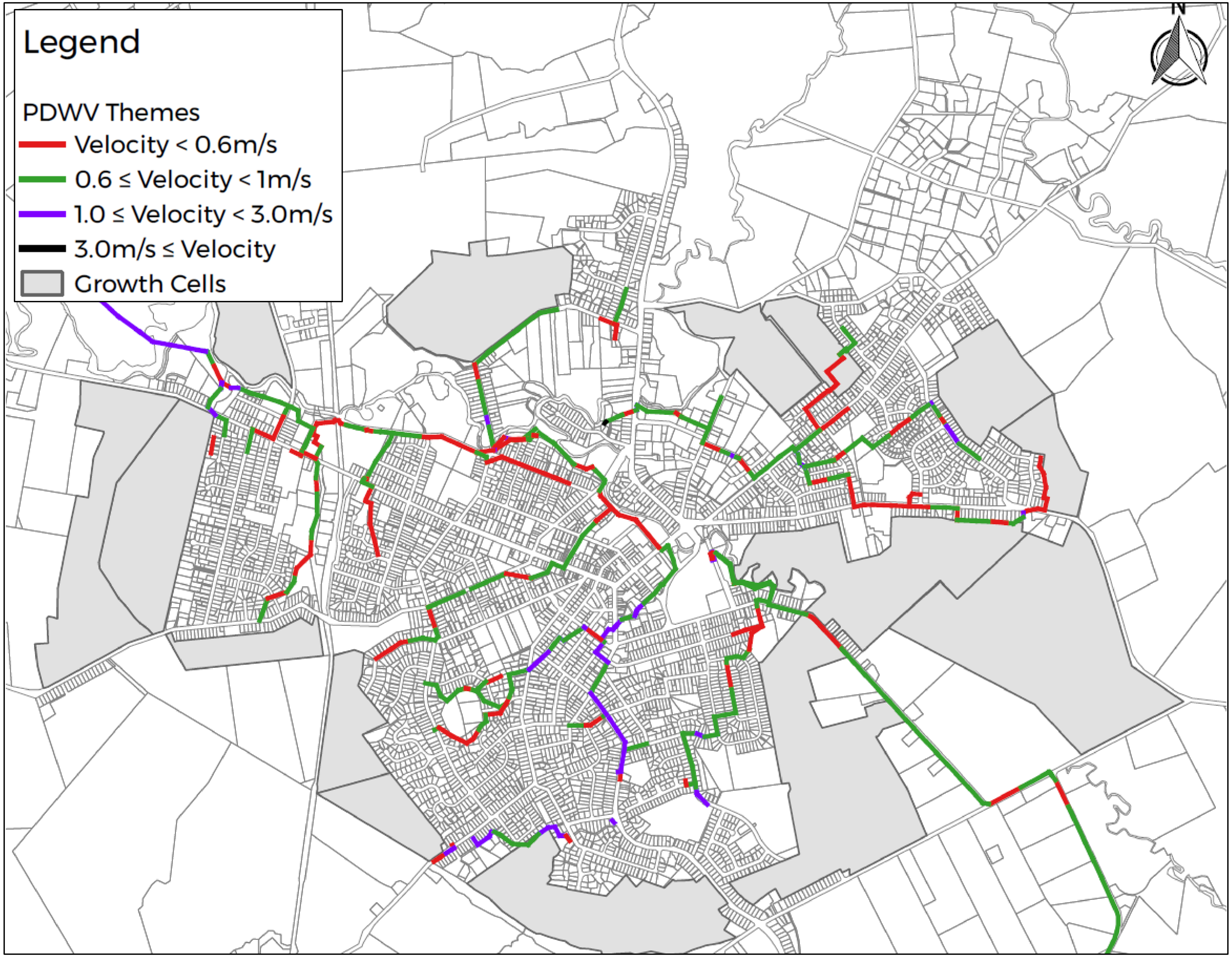
wsp

Dry Weather: Velocity Assessment

- Indicates area of potential sedimentation
- **Pipe Performance:** Pipe velocity (low scenario)
  - Typically performance bands as per below

Category	Velocity @ PDWF
1	Velocity < 0.60 (below self-cleansing velocity)
2	0.60 ≤ Velocity < 1.0
3	1.0 ≤ Velocity < 3.0
4	3.0 ≤ Velocity (greater than preferred maximum velocity)

- Limitations:
  - Review during calibration shows model is conservatively representative of flows from grinder pump areas
  - Analysis typically excludes pipes with depth less than 10% of the pipe diameter or flow less than 1.5 L/s
  - Limited ability to resolve any issues identified (flushing programme)


Legend
PDWV Themes
Velocity < 0.6m/s
0.6 ≤ Velocity < 1m/s
1.0 ≤ Velocity < 3.0m/s
3.0m/s ≤ Velocity
Growth Cells
N

Wet Weather: Design Rainfall Event

- Rainfall: Design Event
- Used to understand system wide network performance and enable a rapid assessment of proposed network upgrades/ capacity for development.
- Design Event ARIs are not standard across NZ:
  - Auckland (WSL): 6 month ARI
  - Christchurch CC: 2 Year ARI
  - Waipa DC: 5 Year ARI
  - Selwyn DC: 5 Year ARI
  - Queenstown Lakes DC: 5 Year ARI, with sensitivity to 10 years
  - Dunedin CC: 10 Year ARI

Wet Weather: Flow Capacity Assessment

- **Manhole Performance:** Wet weather overflows (high scenario + design storm)
  - Spill frequency < Design Event ARI – Acceptable;
  - Spill frequency > Design Event ARI – Fails.
    - < $10m^3$ - Minor;
    - 10 – $100m^3$ - Moderate;
    - > $100m^3$ – Significant.
- **Pipe Performance:** Pipe capacity (high scenario)
  - Typically performance bands (same as DWF)


Legend
PWWF Themes
d/D < 0.5
0.5 ≤ d/D < 0.7
0.7 =≤ d/D < 1
Surcharged (Slope HGL < Slope Pipe)
Surcharged (Slope HGL > Slope Pipe)
Spilling Manholes
Growth Cells
N

Pump Station: Capacity Assessment

- Comparison of pump station capacity to inflows under various conditions

Pump Station ID	Pump Capacity Pump Rate (L/s)	ADWF (L/s)	PDWF (L/s)	PWWF - Design Storm (L/s)	Model DWF - PS Runtime (% of day)
xx	XX	xx	xx	xx	xx

Pump Station: Emergency Storage Assessment

- Storage time from pump failure to high level alarm and first overflow
- Storage requirements not standard across NZ:
  - Waipa DC: 8 hours
  - Selwyn DC: 9 hours

Pump Station ID	ADWF	Hours to High Level Alarm	Hours to First Spill	Spill Level (m AD)	Spill Location – Asset ID
XX	XX	XX	XX	XX	XX

Rising Mains Assessment

- Only applicable where rising mains have been modelled

Rising Main Retention Time

Pump Station ID	Total Rising Main Length (m)	Total Rising Main Volume (m3)	Average Dry Weather Flow (L/s)	Retention Time (hours)
XX	XX	XX		XX

Criteria: *Typically designed for retention time to be minimized, with maximum of 8 hours to limit sedimentation and odour issues.*

Rising Main Peak Velocity

Pump Station ID	Rising Main Diameter (mm)	Pump Rate (L/s)	Velocity (m/s)
XX	XX	XX	XX

Criteria: *Typically designed for peak velocity between 0.6 and 1.8 m/s to minimise sedimentation and high pipe headloss.*

Thank you

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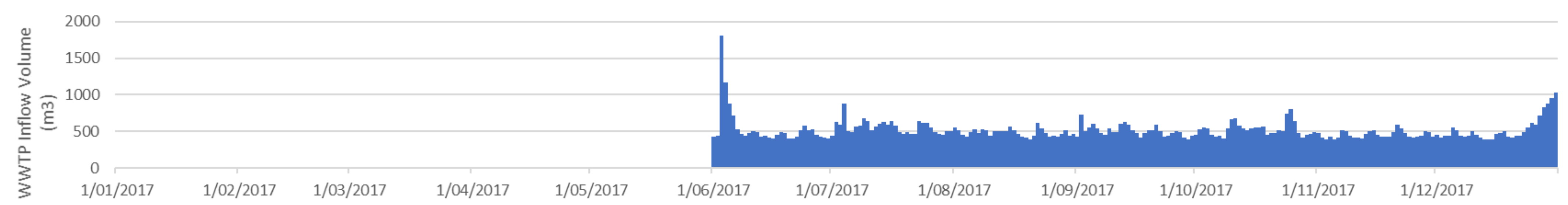
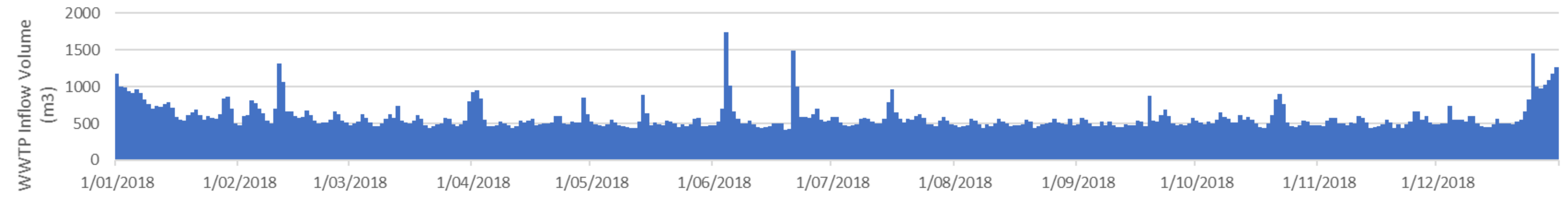
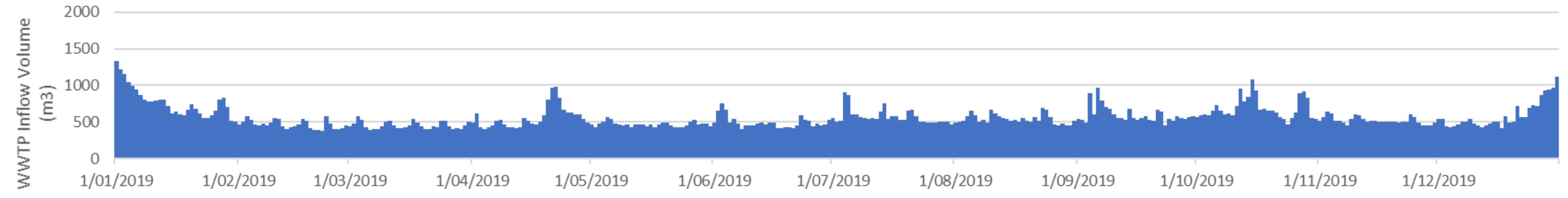
2017



2018



2019



2020