



**WILLIAMSON**  
WATER & LAND ADVISORY

## Catchment Hydrology Assessment

### Milldale Stages 14-17 Fast-Track

FULTON HOGAN LAND DEVELOPMENT LTD

WWLA1603 | Rev. 3

11 August 2026



## Milldale Stages 14-17 Fast-Track

Project no: WWLA1603  
Revision: 3  
Date: 11 August 2026  
Client name: Fulton Hogan Land Development Ltd  
Project manager: Jon Williamson  
Author(s): Josh Mawer  
File name: G:\Shared drives\Projects\Fulton Hogan Land Development Ltd\WWLA1603\_Milldale North Stgs 14-17\Deliverables\Reports\Catchment Hydrology\WWLA\_Rep\_Milldale Stages 14-17 - Catchment Hydrology\_Rev 3.docx

Williamson Water & Land Advisory

Auckland | Whangārei | Tauranga  
New Zealand  
[REDACTED]

### Document history and status

| Rev | Date           | Description                           | By         | Review         | Approved       |
|-----|----------------|---------------------------------------|------------|----------------|----------------|
| 1   | 28 July 2026   | First draft for client review         | WWLA       | Jon Williamson | Jon Williamson |
| 2   | 4 August 2026  | Updated following client feedback     | Josh Mawer | Jon Williamson | Jon Williamson |
| 3   | 11 August 2026 | Minor edits following planning review | Josh Mawer | Josh Mawer     | Jon Williamson |
|     |                |                                       |            |                |                |
|     |                |                                       |            |                |                |
|     |                |                                       |            |                |                |
|     |                |                                       |            |                |                |

### Distribution of copies

| Rev | Date issued    | Issued to                         | Comments                              |
|-----|----------------|-----------------------------------|---------------------------------------|
| 1   | 28 July 2026   | Fulton Hogan Land Development Ltd | First draft for client review         |
| 2   | 4 August 2026  | Fulton Hogan Land Development Ltd | Updated following client feedback     |
| 3   | 11 August 2026 | Fulton Hogan Land Development Ltd | Minor edits following planning review |
|     |                |                                   |                                       |
|     |                |                                   |                                       |
|     |                |                                   |                                       |

## Contents

|           |                                                                       |           |
|-----------|-----------------------------------------------------------------------|-----------|
| <b>1.</b> | <b>Introduction.....</b>                                              | <b>2</b>  |
| 1.1       | Background.....                                                       | 2         |
| 1.1.1     | Proposed Potable Supply Raw Water Take.....                           | 2         |
| 1.1.2     | Proposed Treated Wastewater Discharges .....                          | 3         |
| 1.2       | Report Structure.....                                                 | 5         |
| <b>2.</b> | <b>Catchment Hydrology Model .....</b>                                | <b>6</b>  |
| 2.1       | Overview.....                                                         | 6         |
| 2.2       | Hydrology Calibration .....                                           | 8         |
| <b>3.</b> | <b>Water Quality Model.....</b>                                       | <b>10</b> |
| 3.1       | Overview.....                                                         | 10        |
| 3.2       | Water Quality Model Calibration.....                                  | 10        |
| 3.3       | Wastewater Discharge Quantity and Quality.....                        | 12        |
| <b>4.</b> | <b>Land Use Change Scenarios .....</b>                                | <b>14</b> |
| 4.1       | Existing Land Use Scenario.....                                       | 14        |
| 4.2       | Basecase Scenario .....                                               | 14        |
| 4.3       | Full Development Scenario.....                                        | 14        |
| <b>5.</b> | <b>Results.....</b>                                                   | <b>19</b> |
| 5.1       | Catchment Hydrology.....                                              | 21        |
| 5.1.1     | Comparison to Flows Simulated for the Surface Water Take Report ..... | 25        |
| 5.2       | Catchment Water Quality.....                                          | 26        |
| 5.2.1     | Nitrogen.....                                                         | 26        |
| 5.2.2     | Phosphorus.....                                                       | 29        |
| <b>6.</b> | <b>Assessment of Effects.....</b>                                     | <b>31</b> |
| 6.1       | Hydrology .....                                                       | 31        |
| 6.1.1     | Effects on Downstream Flows.....                                      | 31        |
| 6.1.2     | Effects on Downstream Water Users.....                                | 31        |
| 6.2       | Water Quality.....                                                    | 31        |
| 6.2.1     | Nitrogen.....                                                         | 31        |
| 6.2.2     | Phosphorus.....                                                       | 32        |
| <b>7.</b> | <b>Recommendations .....</b>                                          | <b>33</b> |
| <b>8.</b> | <b>Summary and Key Conclusions.....</b>                               | <b>34</b> |

### Authors

My full name is Joshua Carl Mawer.

I am a Senior Hydrologist at Williamson Water & Land Advisory. I hold a Master of Science (MSc) Degree with first class honours, majoring in Earth and Ocean Sciences, from the University of Waikato.

I have approximately 12 years of work experience at environmental consultancies in New Zealand, Australia, and the United Kingdom. My specific experience related to this project include: catchment scale hydrology and water quality modelled assessments undertaken for Bay of Plenty Regional Council, Hawkes Bay Regional Council, and Muriwai Downs Golf project.

### Reviewer

My full name is Jonathan (Jon) Lindsay Williamson.

I am the Managing Director at Williamson Water & Land Advisory. I hold the qualifications of Bachelor of Science, and Master of Science and Technology (Earth Science) from the University of Waikato and have over 30 years' professional experience in the field of hydrology and hydrogeology. My experience includes professional consultancy with experience in research and assessment of environmental impacts for a wide range of projects. My experience includes appearances at Council, Environment Court, Board of Enquiry, and EPA Fast-track Legislation Hearings, along with involvement in joint witness processes.

### Ethical Declaration

We have been engaged by Fulton Hogan Land Development Limited (FHLD) (the Applicant) to undertake an assessment of environmental effects associated with the Milldale Stages 14-17 project and to prepare this report in support of the substantive application under the Fast-track Approvals Act 2024 (FTAA).

While this is not an Environment Court proceeding, we confirm that we have prepared this assessment in accordance with the applicable professional and ethical obligations of our profession and that the opinions expressed are within our area of expertise.



# 1. Introduction

Williamson Water & Land Advisory (WWLA) was commissioned in February 2026 to undertake a catchment hydrology and water quality assessment to characterise and quantify the potential change in hydrology and water quality of the Orewa River resulting from the proposed Milldale North Stages 14-17 development (**Figure 1**).

The specific objective of this assessment was to characterise and quantify the potential effects of:

1. Land use change on catchment hydrology;
2. Land use change on catchment water quality;
3. The proposed surface water take on downstream flows; and
4. The proposed wastewater discharges on downstream flows and water quality.

This report has been prepared in support of the substantive application for the Milldale Stages 14-17 (Milldale North) Project under the Fast-track Approvals Act 2024 (FTAA).

The Project relates to approximately 231 ha of land centred around Wainui Road in Wainui, Auckland. The proposal provides for a comprehensively planned urban development including residential neighbourhoods, a supporting commercial node, transport and servicing infrastructure, open space, wetland and ecological restoration, and associated enabling works.

The application seeks approvals necessary to facilitate the staged development of the Project, including a suite of resource consents required under the FTAA framework.

The substantive application is supported by a comprehensive set of technical assessments and plans addressing the environmental, servicing and infrastructure matters associated with the proposal. This report should be read alongside the Planning Report and the appended technical reports and drawings lodged in support of the substantive application.

## 1.1 Background

The proposed Milldale Stages 14-17 development comprises up to 1,425 residential dwellings, and commercial and community facilities across the 231-ha site. In addition, approximately 129 ha of ecological restoration will be undertaken, including extensive riparian and wetland enhancement.

The development will also include a surface water take from the Orewa River for the purposes of municipal supply and treated wastewater discharges from the development. Both of these aspects of the proposed development could have the potential to adversely affect catchment hydrology and water quality and hence are assessed as part of this report.

The proposed surface water take and treated wastewater discharges are described in the sub-sections below.

### 1.1.1 Proposed Potable Supply Raw Water Take

The proposed surface water take is described in WWLA (2026)<sup>1</sup>, and summarised as below.

Woods has advised that an average daily demand of 880 m<sup>3</sup>/day is required for potable supply. This is equivalent to a constant abstraction rate of 10.2 L/s, and an annual volume of 321,200 m<sup>3</sup>/year. The average daily demand includes an allowance for treatment plant efficiency (the plant will be 95% efficient – i.e., 5% of raw water is lost during treatment).

---

<sup>1</sup> WWLA. 2026. Milldale North – Surface Water Potential for Community Water Supply. 17 June 2026. Prepared for Fulton Hogan Land Development.

Raw water will be sourced from a combination of groundwater and surface water. Groundwater abstractions will supply 454.5 m<sup>3</sup>/day, with the remaining 425.5 m<sup>3</sup>/day supplied via stored surface water.

As is further detailed in **Section 5.1**, flows in the Orewa River can drop to very low (well below 10.2 L/s) during summer periods and hence a run-of-river water take is not considered a viable or reliable water supply option. Therefore, a high-flow surface water take and water storage reservoir is proposed.

A 95,000 m<sup>3</sup> water storage reservoir is proposed, located near the western boundary of the site, on the northern bank of the Orewa River (**Figure 1**). The reservoir is proposed to be filled via high-flow surface water abstractions from the Orewa River, immediately south of the reservoir. A maximum abstraction rate of 25 L/s would occur when flows are above median at the point of take (>36.6 L/s), and be restricted to taking no more than 30% of the river flow rate at any point in time when operating. In other words, the maximum abstraction rate of 25 L/s could only occur when flows at the point of take are in excess of 83.3 L/s.

### 1.1.2 Proposed Treated Wastewater Discharges

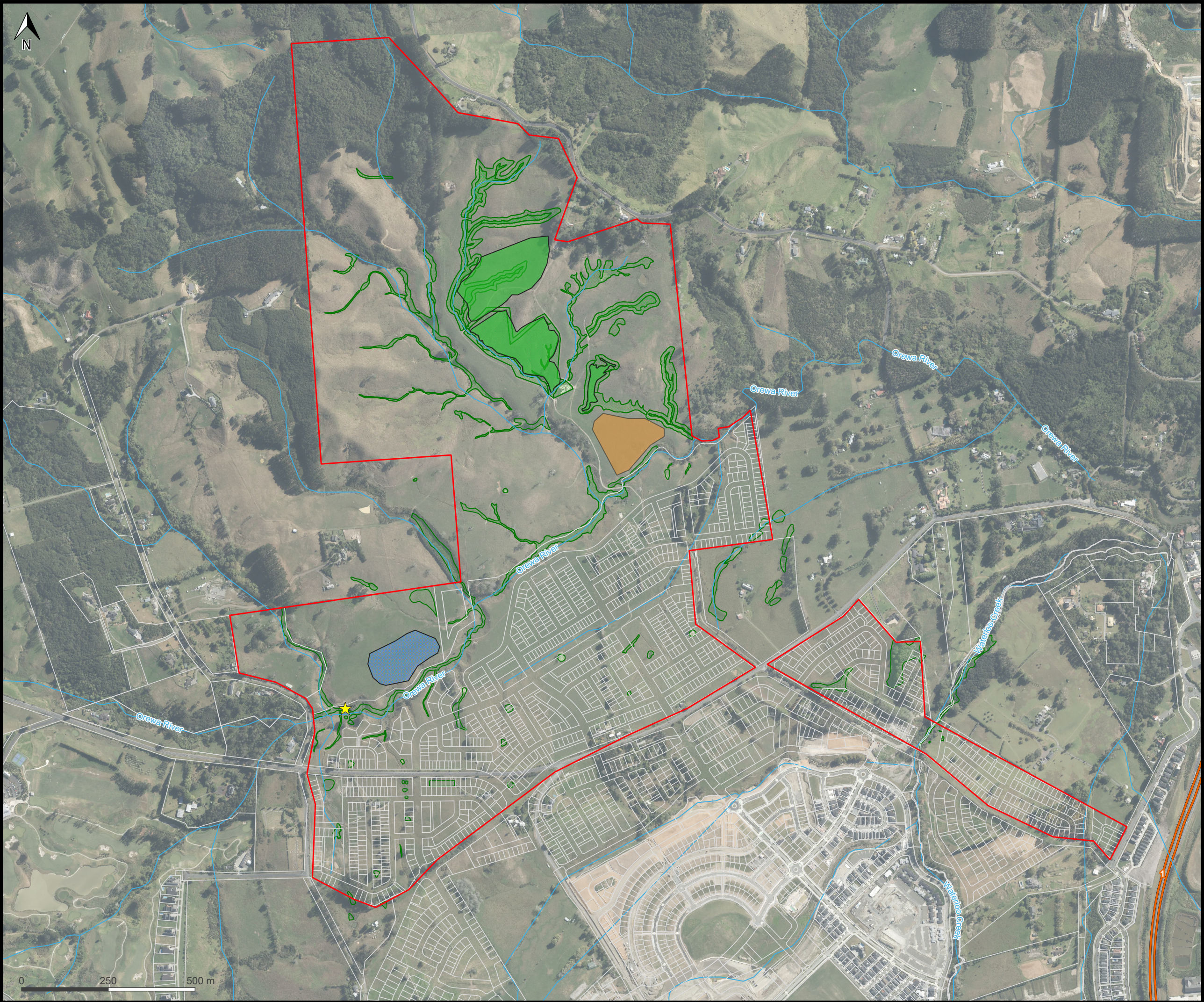
Apex Water wastewater engineers<sup>2</sup> has advised that approximately 660 m<sup>3</sup>/day of treated wastewater effluent is anticipated to be discharged to a constructed wetland daily. The constructed wetland will provide additional treatment to the wastewater discharges, which will be pre-treated using a combined Membrane Aerated Biofilm Reactor (MABR) with a Membrane Bioreactor (MBR) treatment process. The location of the proposed constructed wetland for wastewater discharges is illustrated in **Figure 1**. Please refer to WWLA (2026)<sup>3</sup> for details of the treated effluent quality, wetland design, and anticipated wetland treatment assumptions.

---

<sup>2</sup> Nuobelle Fong (APEX Water). 15 June 2026. RE: Milldale 14-17 Revised Reservoir Size (Email)

<sup>3</sup> WWLA 2026. Wastewater Disposal Wetland – Milldale Stages 14-17 Fast-Track. 24. June 2026. Prepared for Fulton Hogan Land Development.

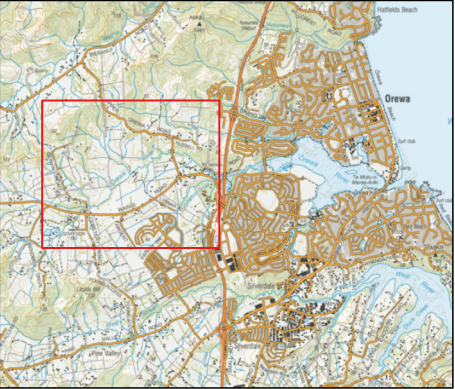




Map Title:  
**Location Overview**

Project:  
**Milldale North Stages 14-17**

Client:  
**Fulton Hogan Land Development Ltd**



- Legend**
- ★ Inlet Works Location
  - State Highway
  - Proposed Lots
  - ▭ Proposed Milldale North Extent
  - ▭ Reservoir
  - ▭ WWTP Compound
  - ▭ Constructed Wetlands Extent
  - ▭ Raiparian Planting

Data Provenance  
Aerial imagery from LINZ NZ

Drawn by: Josh Mawer  
21/07/2026

Layout & Project File  
A3 Landscape Template



Figure 1.



## 1.2 Report Structure

The report structure is as summarised in **Table 1**.

Table 1. Report structure.

| Section | Heading                   | Description                                                                                 |
|---------|---------------------------|---------------------------------------------------------------------------------------------|
| 1       | Introduction              | Provides an overview of the project.                                                        |
| 2       | Catchment Hydrology Model | Describes the development and calibration of the hydrology model.                           |
| 3       | Water Quality Model       | Details the development and calibration of the water quality components of the model.       |
| 4       | Land Use Change Scenarios | Outlines the three land use change scenarios assessed.                                      |
| 5       | Results                   | Presents the hydrology and water quality results of the proposed land use change scenarios. |
| 6       | Assessment of Effects     | Describes the effects associated with the proposed development.                             |
| 7       | Recommendations           | Outlines the recommendations result from the assessment of effects.                         |
| 7       | Key Conclusions           | Documents the key conclusions of the assessment.                                            |

## 2. Catchment Hydrology Model

### 2.1 Overview

A continuous simulation, rainfall runoff model was developed to simulate the hydrology of the Orewa River catchment. WWLA's Soil Moisture Water Balance Model (SMWBM) was utilised, inside the eWater SOURCE modelling framework. The SMWBM is further described in **Appendix A**.

The hydrology model comprised 16 sub-catchments (**Figure 2**), and the key model parameters configured representing the area weighted average of three dominant land use types (Pasture, Forested, and Urban) for each sub-catchment. Refer to **Appendix A** for details of the model parameters and their relation to catchment characteristics (including land use).

The model was configured using measured rainfall data from Auckland Council's Orewa at Treatment Ponds monitoring site, and potential evapotranspiration (PET) data from NIWA's Northshore climate site. No allowance or adjustments were made for potential changes in climatic conditions associated with climate change as projections over the duration of consent sought (35-years) are fairly neutral on average. For example, the Ministry for the Environment (MfE) climate data webmap<sup>4</sup> indicates a -0.7% change in total rainfall for the period 2041-2060 under the intermediate SSP2-4.5 climate change scenario. We note, heavy rainfall events (99<sup>th</sup> percentile) are projected to increase by approximately 6.8% under the same scenario; however these events are not a focus of this assessment and hence it was determined further assessment of potential climate change effects were not required.

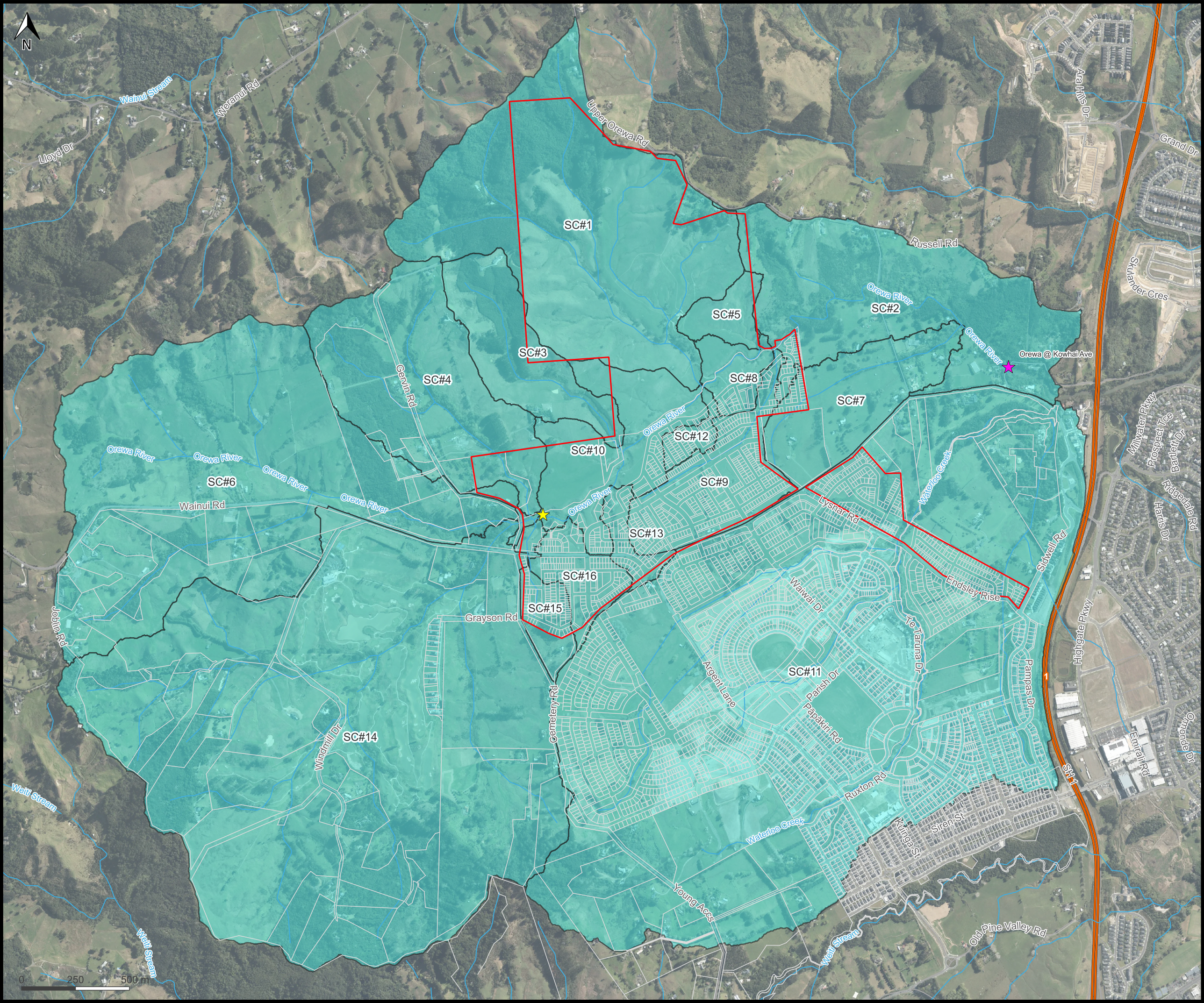
Please note, the hydrology model presented here differs in structure and functionality from the model documented in the Surface Water Take for Community Water Supply<sup>5</sup> report. Please refer to **Section 5.1.1** for a description of minor the differences and the reasons for these.

---

<sup>4</sup> <https://map.climatedata.environment.govt.nz/>

<sup>5</sup> WWLA. 2026. Surface Water Take for Community Water Supply. Milldale Stages 14-17 Fast Track. Consultancy report prepared for Fulton Hogan Land Development Limited. WWLA1603. Rev 1.

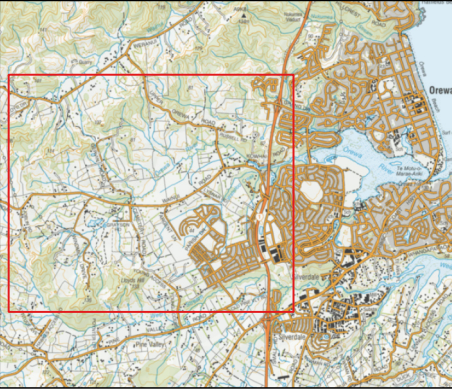




Map Title:  
**Catchment Hydrology Model Extent and Sub-Catchments**

Project:  
**Milldale North Stages 14-17**

Client:  
**Fulton Hogan Land Development Ltd**



- Legend**
- ★ Inlet Works Location
  - ★ Flow Monitoring Site
  - Road
  - State Highway
  - Proposed Lots
  - ▭ Proposed Milldale Stages 14-17
  - ▭ Hydrology Model Sub-Catchment

Data Provenance  
Aerial imagery from LINZ

Drawn by: Josh Mawer  
21/07/2026

Layout & Project File  
A3 Landscape Template



Figure 2.



## 2.2 Hydrology Calibration

The hydrology model was calibrated to measured flow data from Auckland Council's Orewa River at Kowhai Ave monitoring site, which is located approximately 1.5 km downstream of the proposed development. A comparison of the measured and simulated flow hydrograph and flow duration curve are presented in **Figure 3**.

The flow hydrograph shows a good general agreement between measured and model data. There are periods of overprediction and periods of underprediction. The comparison of the flow duration curve shows the model simulates flows throughout the flow regime well. The visual discrepancy at the low flow end is a result of the Orewa River essentially running dry occasionally during summer periods. The measured data during these periods reflect a value of zero, whereas the model simulates very low flows (i.e., less than 1 L/s) during these periods. In absolute terms, this is insignificant – however, visually it appears larger due the log scale y-axis of the flow duration chart in **Figure 3**.

Auckland Council<sup>6</sup> note the Orewa River is the only known stream that is monitored which occasionally ceases to flow during summer months.

Overall, the level of calibration achieved is considered appropriate for the purposes of catchment-scale modelling for resource consenting purposes.

---

<sup>6</sup> Auckland Council. 2025. Hydrological State and Trends for Tamaki Makaurau / Auckland 2025. Technical Report 2025/27.



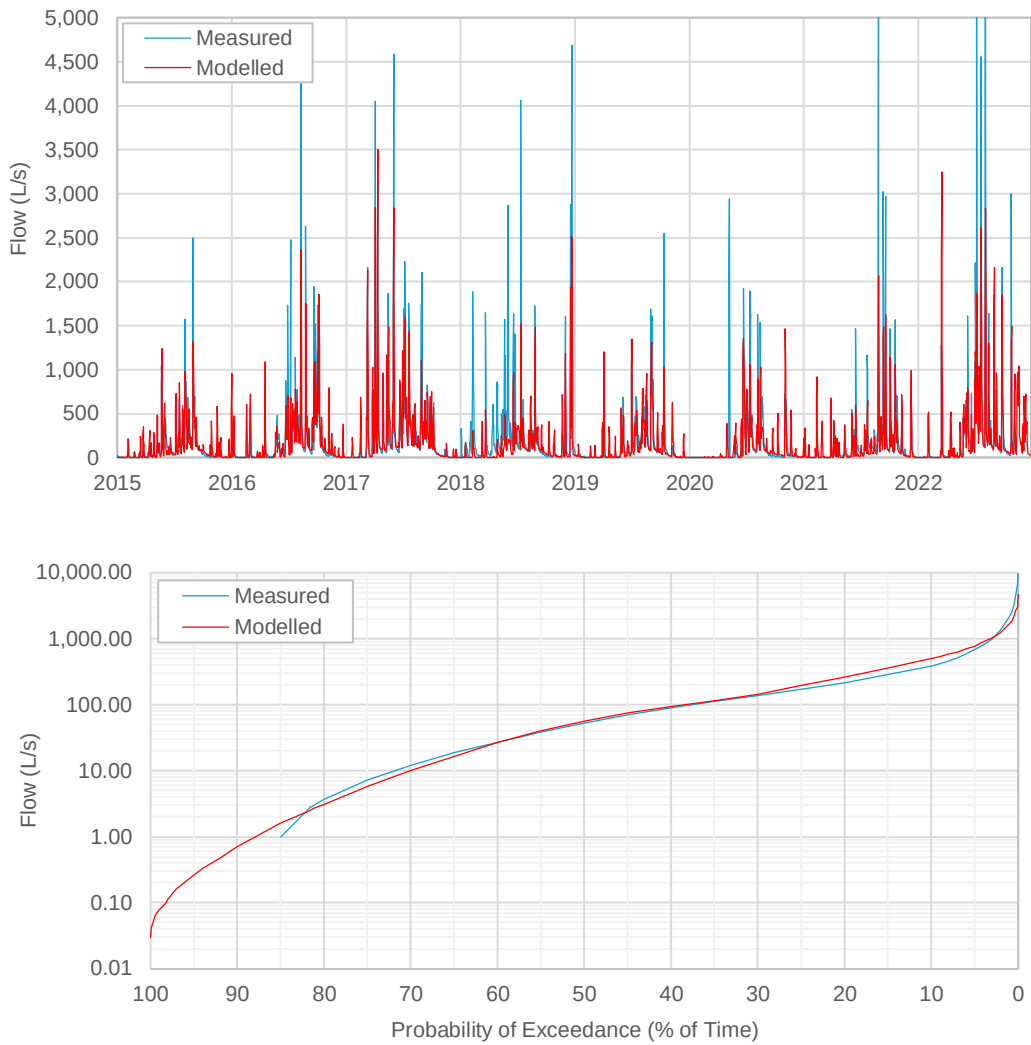


Figure 3. Comparison of measured and simulated flows – Orewa River at Kowhai Ave. (Top: Flow hydrograph, Bottom: Flow duration curve).



### 3. Water Quality Model

#### 3.1 Overview

In-stream water quality was simulated by simulating nutrient generation rates for a range of different land use types and combining these via the catchment hydrology model (**Section 2**). Nutrient generation was simulated using an Event Mean Concentration (EMC) and Dry Weather Concentration (DWC) approach.

EMC concentrations are 'attached' to quickflow runoff (i.e., surface runoff) of the hydrology model, while DWC concentrations are 'attached' to baseflow contributions from the hydrology model. Representative EMC and DWC values were determined for the range of land use categories as defined in **Table 2**. Concentrations were initially set based on available published literature<sup>7-8,9</sup>, and adjusted within reasonable bounds to improve the match to measured instream concentrations from Auckland Council's Orewa River at Kowhai Ave monitoring site (**Figure 2**).

Table 2. Land use water quality parameters.

| Land Use Type                                 | Total Nitrogen (mg/L) |      | Total Phosphorus (mg/L) |      |
|-----------------------------------------------|-----------------------|------|-------------------------|------|
|                                               | EMC                   | DWC  | EMC                     | DWC  |
| Urban Area                                    | 1.50                  | 0.40 | 0.20                    | 0.02 |
| Native Forest                                 | 0.40                  | 0.10 | 0.03                    | 0.03 |
| Exotic Forest                                 | 0.40                  | 0.10 | 0.03                    | 0.03 |
| High Producing Exotic Grassland / Agriculture | 2.00                  | 0.32 | 0.40                    | 0.03 |
| Cropland / Orchard/ Horticulture              | 3.50                  | 1.00 | 0.02                    | 0.02 |

The EMC and DWC were applied as area weighted average concentrations based on land use coverage in each of the 16 sub-catchments. The land use coverage adopted for the model calibration scenario and the two exploratory assessment scenarios are detailed in **Section 4**.

#### 3.2 Water Quality Model Calibration

A comparison of the measured and simulated Total Nitrogen (TN) and Total Phosphorus (TP) concentrations for the Orewa River at Kowhai Ave are presented in **Figure 4** and **Figure 5**, respectively. Whilst only limited spot measurements of TN and TP concentrations are available, the catchment water quality model was demonstrated to provide reasonable agreement to the general magnitude and range of observed concentrations.

Overall, the level of calibration achieved is considered acceptable for the objectives of this assessment i.e., catchment scale water quality and relative land use change assessment.

<sup>7</sup> Bartley & Spiers. 2010. Review and summary of constituent concentration data from Australia for use in catchment water quality models.

<sup>8</sup> Bartley. 2012. A review and summary of constituent concentration data from Australia for use in catchment water quality models.

<sup>9</sup> Fletcher., et al. 2004. Stormwater Flow and Quality and the Effectiveness of Non-proprietary Stormwater Treatment Measures.



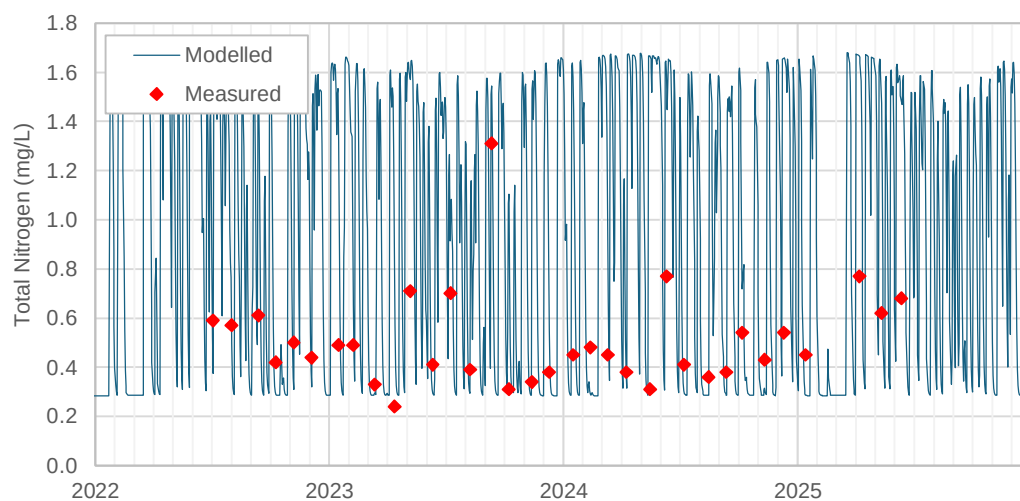


Figure 4. Comparison of measured and simulated TN concentrations – Orewa River at Kowhai Ave.

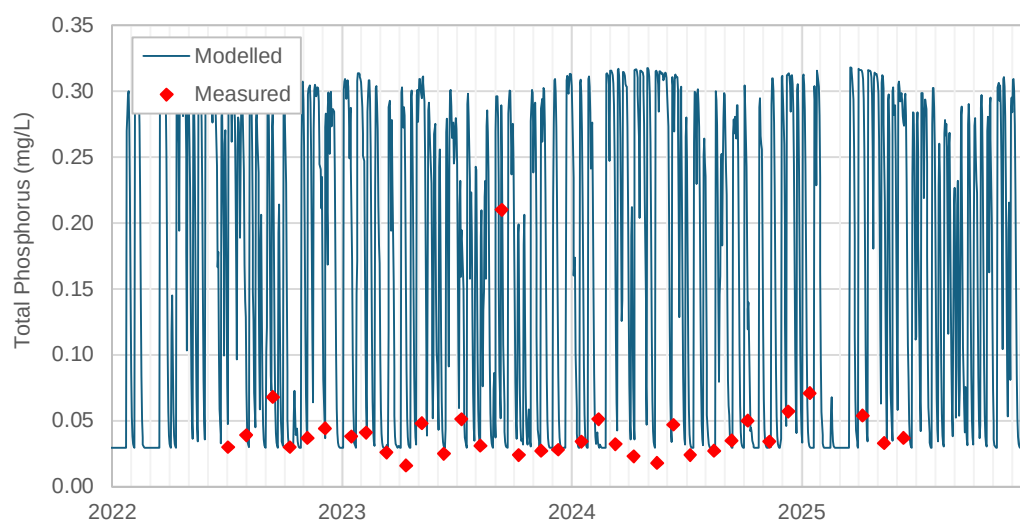


Figure 5. Comparison of measured and simulated TP concentrations – Orewa River at Kowhai Ave.

Five additional water quality samples were collected by WWLA and Virdis in recent months. These were all collected in the reach of the Orewa River between the proposed surface water take site and the proposed Infrastructure area (**Figure 1**). Given the relatively short distance along this reach and similar landcover the sampling data were compared as a single site.

A comparison of simulated TN and TP concentrations to these samples are provided in **Figure 6** and **Figure 7**.

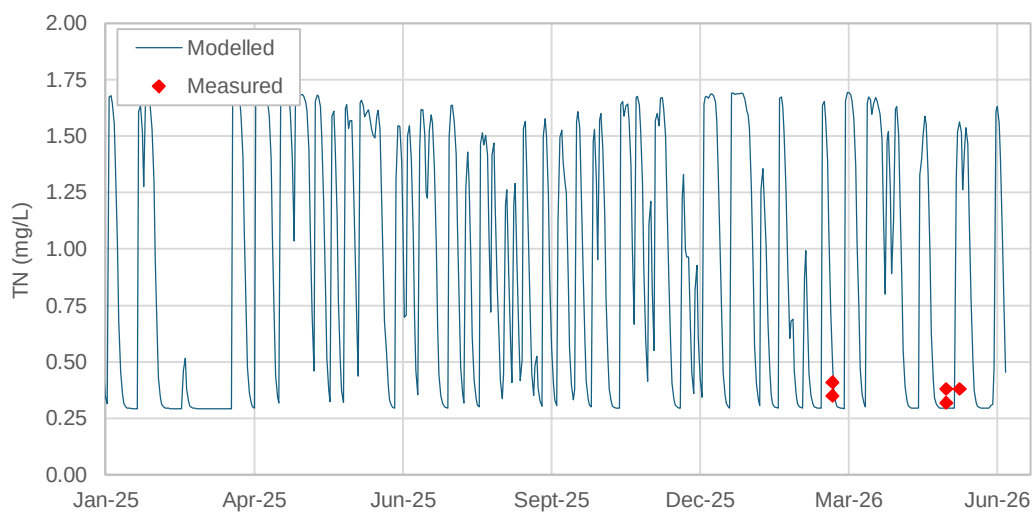


Figure 6. Comparison of measured and simulated TN concentrations – Orewa River d/s of Surface Water Take.

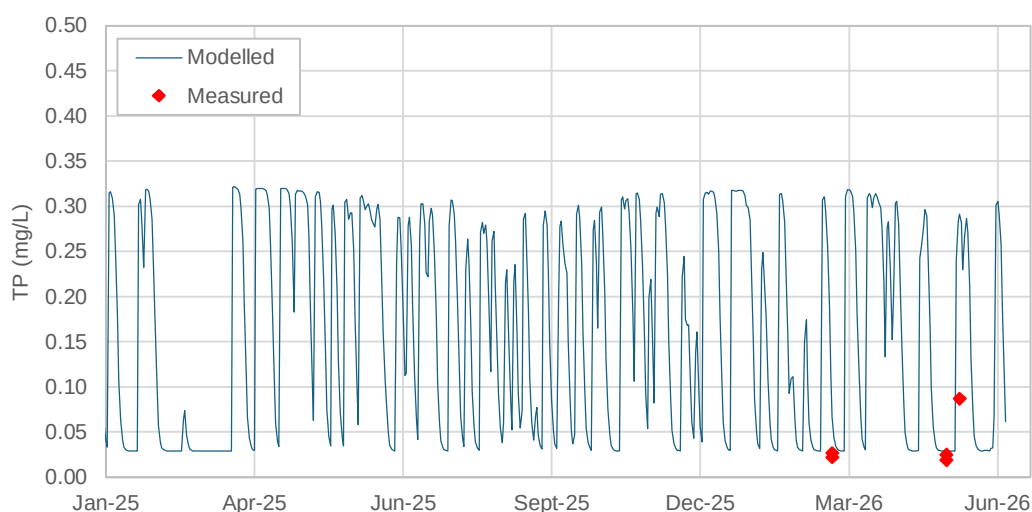


Figure 7. Comparison of measured and simulated TP concentrations – Orewa River d/s of Surface Water Take.

### 3.3 Wastewater Discharge Quantity and Quality

Treated wastewater effluent entering the wetland (660 m<sup>3</sup>/day) is anticipated to be further treated/polished by natural (physical, biological and chemical) processes occurring within the wetland. A comparison of the concentrations of the effluent entering the wetland, compared to that exiting the wetland is presented in **Table 3**. Effluent concentrations are anticipated to be reduced by 0-85% across the various key constituents assessed.

The anticipated reduction in constituent concentration applies to the surface runoff from the wetland, while the constituent concentrations within the groundwater flow from the wetland catchment is anticipated to be similar to concentrations observed in a near-by bore.



Table 3. Anticipated design constituent concentrations entering and exiting the wetland.

| Constituent              | Treated Wastewater Concentration | Anticipated Concentration at Wetland Outflow Surface Runoff | Anticipated Concentration at Wetland Outflow Groundwater Flow |
|--------------------------|----------------------------------|-------------------------------------------------------------|---------------------------------------------------------------|
| TN (mg/L)                | 5                                | 0.75                                                        | <0.002                                                        |
| AMM-N (mg/L)             | 2                                | <0.002                                                      | <0.002                                                        |
| TP (mg/L)                | 2                                | 0.06                                                        | 0.0018                                                        |
| E.coli (MPN/100mL)       | <4                               | <1                                                          | <1                                                            |
| cBOD <sub>5</sub> (mg/L) | 5                                | 2.75                                                        | Negligible                                                    |
| TSS (mg/L)               | 4                                | 4                                                           | Negligible                                                    |

Please refer to WWLA (2026)<sup>b10</sup> for details regarding design constituent reduction and wetland outflows.

The simulated wetland outflows were represented in the SOURCE catchment model as two points sources at the location of the proposed constructed wetland. The first point source represented surface runoff outflow from the wetland, and the second point source represented groundwater baseflow discharges from the wetland.

The surface water runoff and groundwater flow components were configured with the TN and TP concentrations for discharges exiting the wetland as detailed in **Table 3**.

<sup>10</sup> WWLA 2026. Wastewater Disposal Wetland – Milldale Stages 14-17 Fast-Track. 24. June 2026. Prepared for Fulton Hogan Land Development.

## 4. Land Use Change Scenarios

This section provides an overview of the three land use scenarios assessed. These were:

- **Existing Land Use** – this scenario represents the current land use of the catchment, as defined by Landcare Researches Land Cover Database Version 5 (LCDBv5 – year 2023). This scenario was used for the calibration assessments detailed in **Section 2.2** and **Section 3.2**.
- **Basecase** – this scenario represents the Existing Land Use Scenario, with the already consented stages of the Milldale Development (South of Orewa River) converted to 'urban' land use.
- **Full Development** – the scenario represents the full completed development and 100% planting and establishment of the northern catchment.

Each of these scenarios are further detailed in the sub-sections below.

### 4.1 Existing Land Use Scenario

The Existing Land Use Scenario represents the catchment as it exists at present and provides the 'existing conditions' to demonstrate calibration of the catchment model to available measured flow and water quality data.

The land use classification adopted for this scenario is illustrated in **Figure 8**.

This scenario did not include the proposed surface water take or proposed wastewater discharges.

### 4.2 Basecase Scenario

The Basecase scenario represents the Existing Land Use Scenario, plus the already consented stages of the Milldale Development (South of Orewa River) converted to 'urban' land use. This scenario provides the consented 'basecase' from which to assess the potential effects of the Milldale Stages 14-17 development against.

The land use classification adopted for this scenario is illustrated in **Figure 9**.

This scenario did not include the proposed surface water take or proposed wastewater discharges for the Milldale Stages 14-17 development.

### 4.3 Full Development Scenario

The Full Development Scenario represents the catchment once fully developed. This includes the full development of Milldale North, and assumes the ecological planting in the catchments to the north are fully established. The land use classification adopted for this scenario is illustrated in **Figure 10**.

For the urban developed areas it was assumed that these comprise of 65% urban land use and 35% pasture/grassland, representing gardens, back yards, and parks etc.

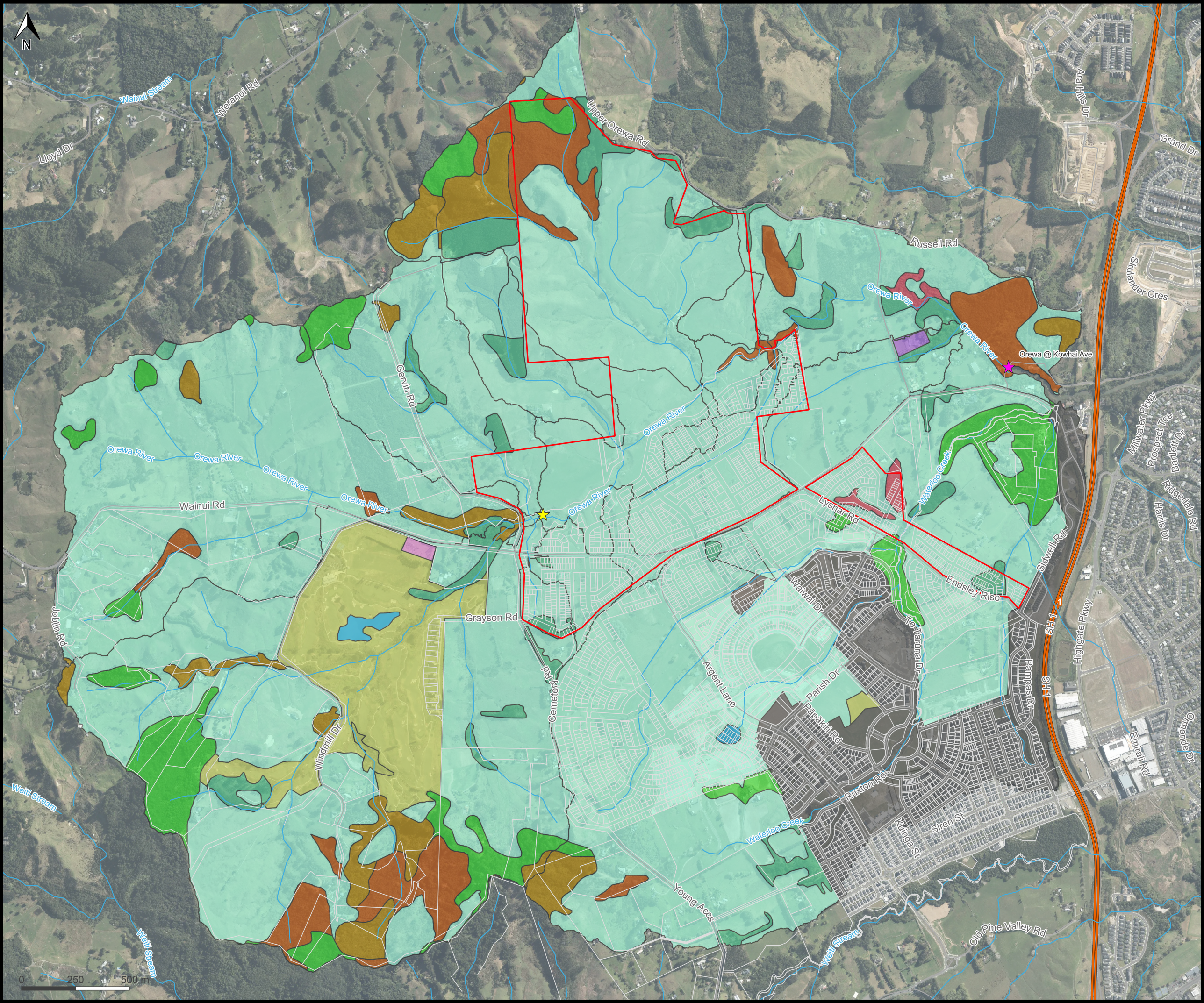
The full development scenario assumes the proposed surface water take (raw water for municipal supply) and proposed wastewater discharges (as detailed in **Section 1.1.1**, and **Section 1.1.2**, respectively) are operational. The simulation is considered conservative in the fact that it assumed water is abstracted at all times available. In reality, there will be periods when the reservoir is full and hence abstractions would not be required (i.e., typically later winter).

Note, the catchment model does not include the urban stormwater network or stormwater management devices as it operates at a distributed sub-catchment level, rather than the individual lot level. The model also simulates daily average flows, and hence in the current configuration does not represent peak stormwater flows or stormwater management.



Catchment areas outside of the proposed Milldale North boundary remain unchanged from the Basecase Scenario – i.e., no assumptions were made around development of the wider catchment).

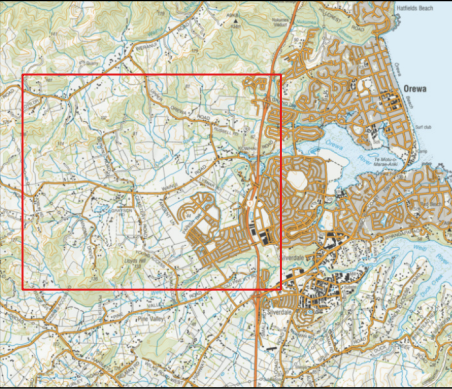




Map Title:  
**Existing Landuse Scenario - Land Cover**

Project:  
**Milldale North Stages 14-17**

Client:  
**Fulton Hogan Land Development Ltd**



- Legend**
- Road
  - State Highway
  - ▭ Proposed Milldale North Extent
  - Land Cover Classes**
  - ▭ Broadleaved Indigenous Hardwoods
  - ▭ Built-up Area (settlement)
  - ▭ Deciduous Hardwoods
  - ▭ Exotic Forest
  - ▭ High Producing Exotic Grassland
  - ▭ Indigenous Forest
  - ▭ Lake or Pond
  - ▭ Manuka and/or Kanuka
  - ▭ Orchard, Vineyard or Other Perennial Crop
  - ▭ Short-rotation Cropland
  - ▭ Urban Parkland/Open Space

**Data Provenance**  
Aerial imagery from LINZ, land cover from LCDBv6.

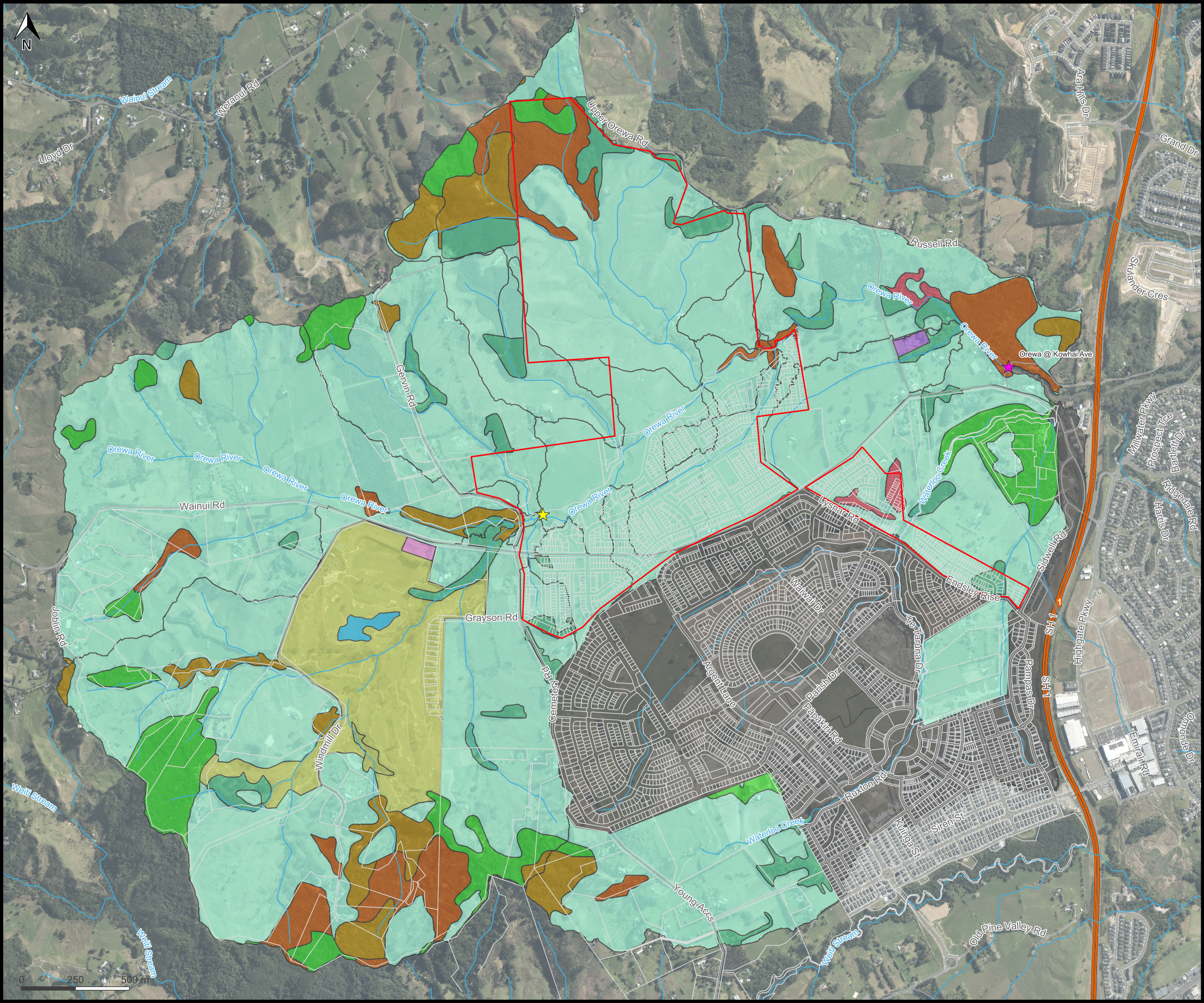
Drawn by: Josh Mawer  
21/07/2026

Layout & Project File  
A3 Landscape Template



Figure 8.

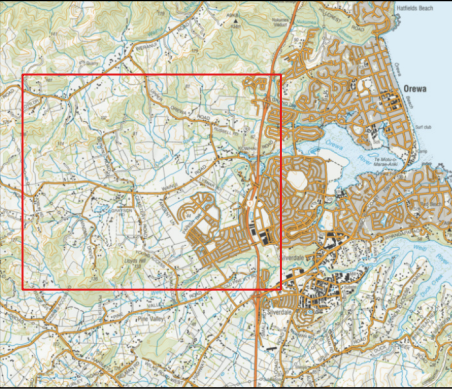




Map Title:  
**Basecase Scenario - Land Cover**

Project:  
**Milldale North Stages 14-17**

Client:  
**Fulton Hogan Land Development Ltd**



- Legend**
- Road
  - State Highway
  - Proposed Milldale North Extent
  - Land Cover Classes**
  - Broadleaved Indigenous Hardwoods
  - Built-up Area (settlement)
  - Deciduous Hardwoods
  - Exotic Forest
  - High Producing Exotic Grassland
  - Indigenous Forest
  - Lake or Pond
  - Manuka and/or Kanuka
  - Orchard, Vineyard or Other Perennial Crop
  - Short-rotation Cropland
  - Transport Infrastructure
  - Urban Parkland/Open Space

**Data Provenance**  
Aerial imagery from LINZ, land cover from LCDBv6.

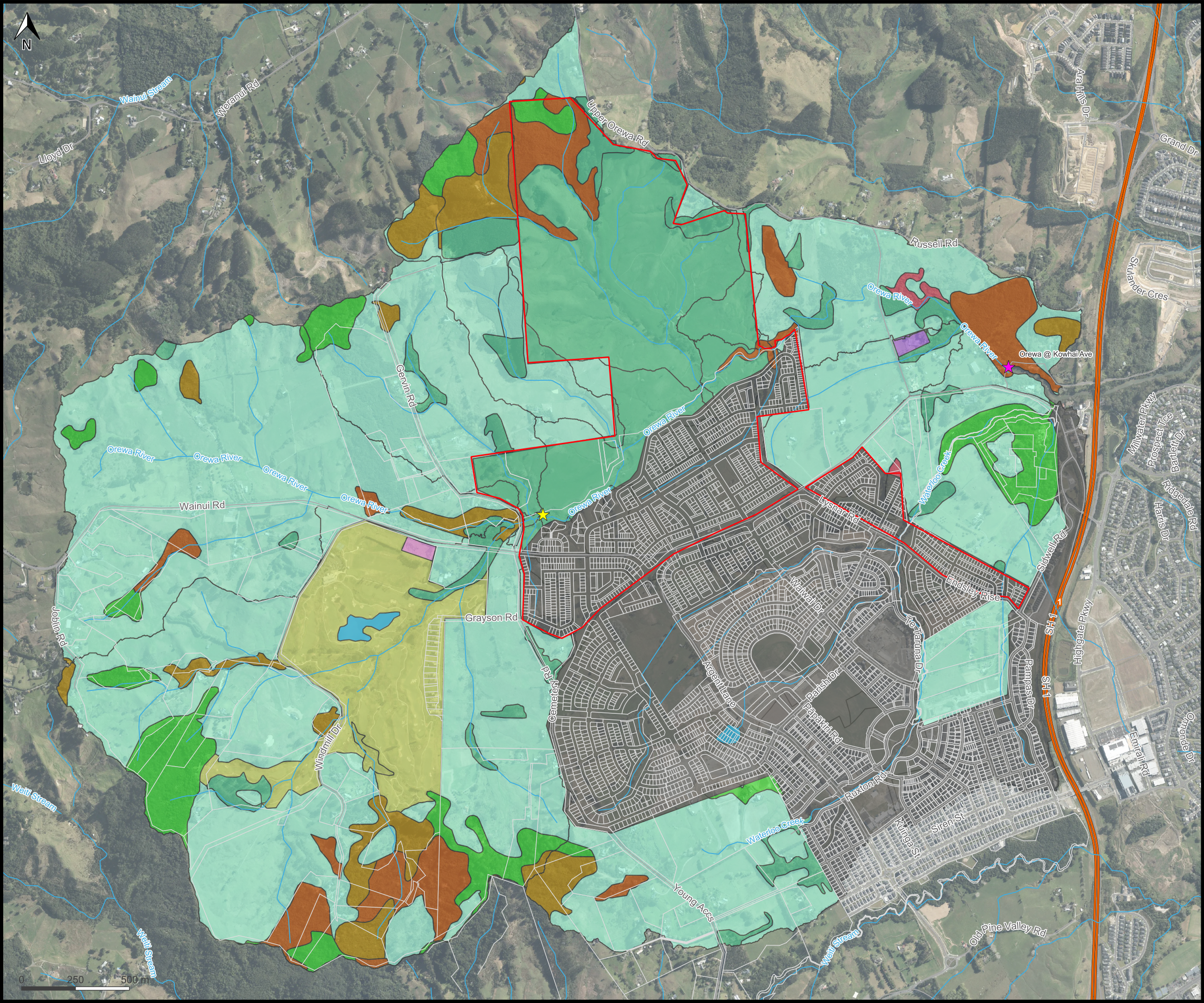
**Drawn by:** Josh Mawer  
21/07/2026

**Layout & Project File**  
A3 Landscape Template



Figure 8.

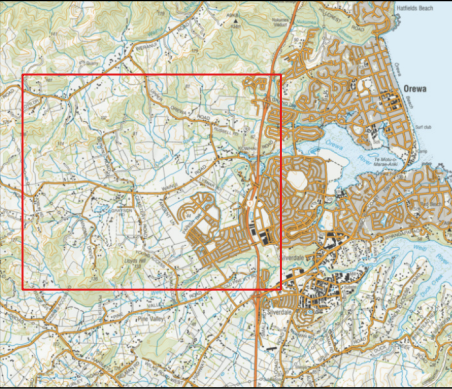




Map Title:  
**Full Development Scenario - Land Cover**

Project:  
**Milldale North Stages 14-17**

Client:  
**Fulton Hogan Land Development Ltd**



- Legend**
- Road
  - State Highway
  - ▭ Proposed Milldale North Extent
  - Land Cover Classes**
  - ▭ Broadleaved Indigenous Hardwoods
  - ▭ Built-up Area (settlement)
  - ▭ Deciduous Hardwoods
  - ▭ Exotic Forest
  - ▭ High Producing Exotic Grassland
  - ▭ Indigenous Forest
  - ▭ Lake or Pond
  - ▭ Manuka and/or Kanuka
  - ▭ Orchard, Vineyard or Other Perennial Crop
  - ▭ Short-rotation Cropland
  - ▭ Urban Parkland/Open Space

**Data Provenance**  
Aerial imagery from LINZ, land cover from LCDBv6.

Drawn by: Josh Mawer  
21/07/2026

Layout & Project File  
A3 Landscape Template



Figure 10.



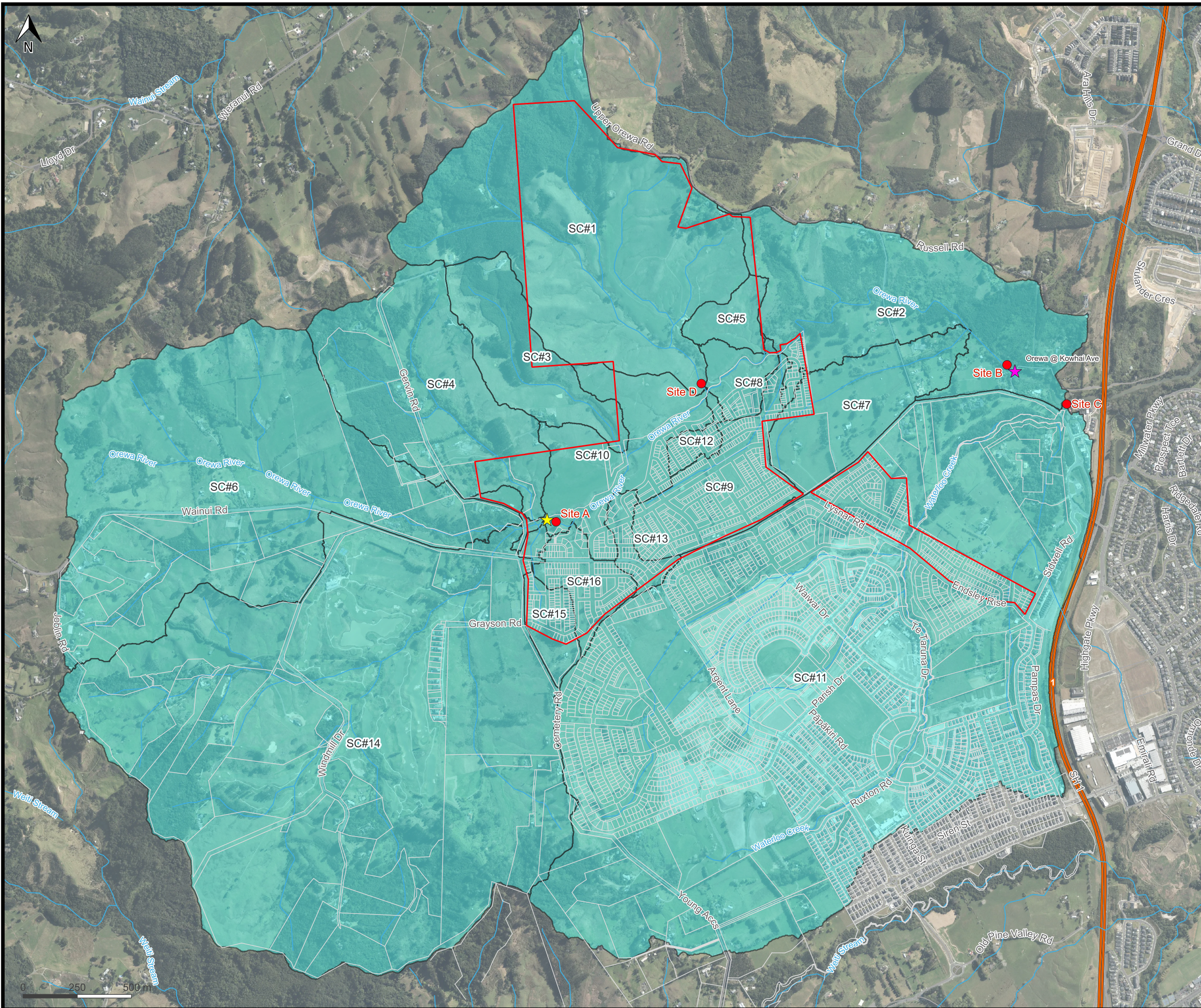
## 5. Results

The effects of land use change and the proposed Milldale Stages 14-17 development on catchment hydrology and water quality were assessed at four representative assessment locations. These were:

- Site A – immediately downstream of the proposed surface water abstraction site;
- Site B – Orewa River at Kowhai Ave (Council's monitoring site);
- Site C – Orewa River, immediately downstream of the confluence with Waterloo Creek; and
- Site D – The unnamed tributary of the wastewater receiving wetland.

The locations of these sites are illustrated in **Figure 11**. Comparisons of the simulated changes in catchment hydrology across the three land use change scenarios are presented in **Section 5.1**, and on water quality in **Section 5.2**. An assessment of the effects of these changes resulting from the proposed Milldale Stages 14-17 development is then presented in **Section 6**.

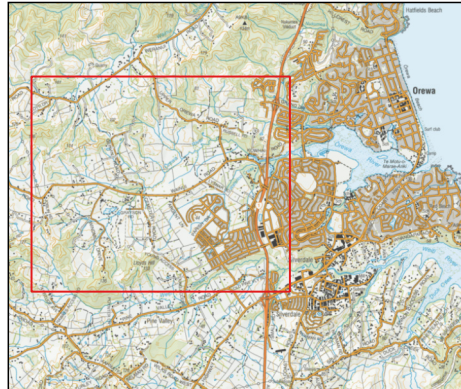




Map Title:  
**Representative Assment Locations**

Project:  
**Milldale North Stages 14-17**

Client:  
**Fulton Hogan Land Development Ltd**



**Legend**

Rain and River Monitoring Sites

- Council Monitoring Site (Orewa River @ Kowhai Ave)
- Proposed Stream Abstraction Site
- Representative Assessment Site

— Road

— State Highway

— Stream / River

□ Proposed Milldale North Extent

Data Provenance  
Aerial imagery from LINZ, land cover from LCDBv6.

Drawn by: Josh Mawer  
21/07/2026

Layout & Project File  
A3 Landscape Template



## 5.1 Catchment Hydrology

This section presents the simulated changes in catchment hydrology across the three land use scenarios (**Section 4**), at the four representative assessment locations (**Section 5**).

Simulated flow hydrographs are provided in **Figure 12** to **Figure 15**, and tabular results presented in **Table 4**.

Site A (**Figure 12**) is located immediately downstream of the proposed surface water abstraction site for potable use. Therefore, this site shows the largest effect resulting from the proposed surface water abstraction. As the take only operates during periods of above median flow, low flow conditions remain unaffected. Flows above the median are reduced by a maximum of 25 L/s.

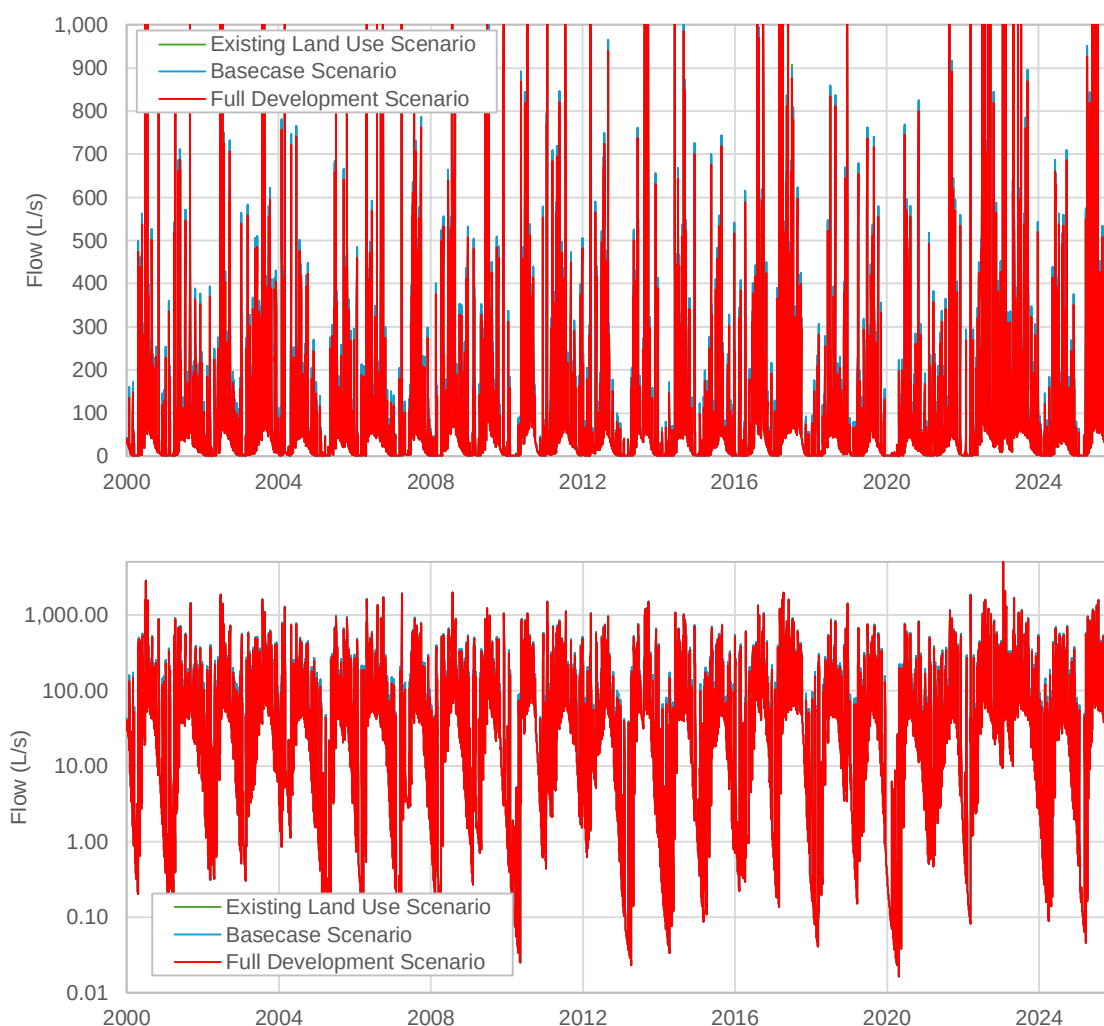


Figure 12. Comparison of simulated flow hydrographs – Site A (d/s of take site).

Site B is located at the Auckland Council monitoring site *Orewa River at Kowhai Ave*. As demonstrated in **Figure 13**, low flows are increased, due to the addition of the wastewater disposal at the wetland, increasing from approximately 0.5 L/s to just over 7 L/s. Thus, the Orewa river is anticipated to be continuously flowing year-round due to the addition of treated wastewater disposal upstream in the catchment. High-flows are largely unaffected as the additional discharge partially compensates for water abstracted for the reservoir, and is also marginally increased due to increased urbanisation creating more runoff (i.e., increased impervious coverage).



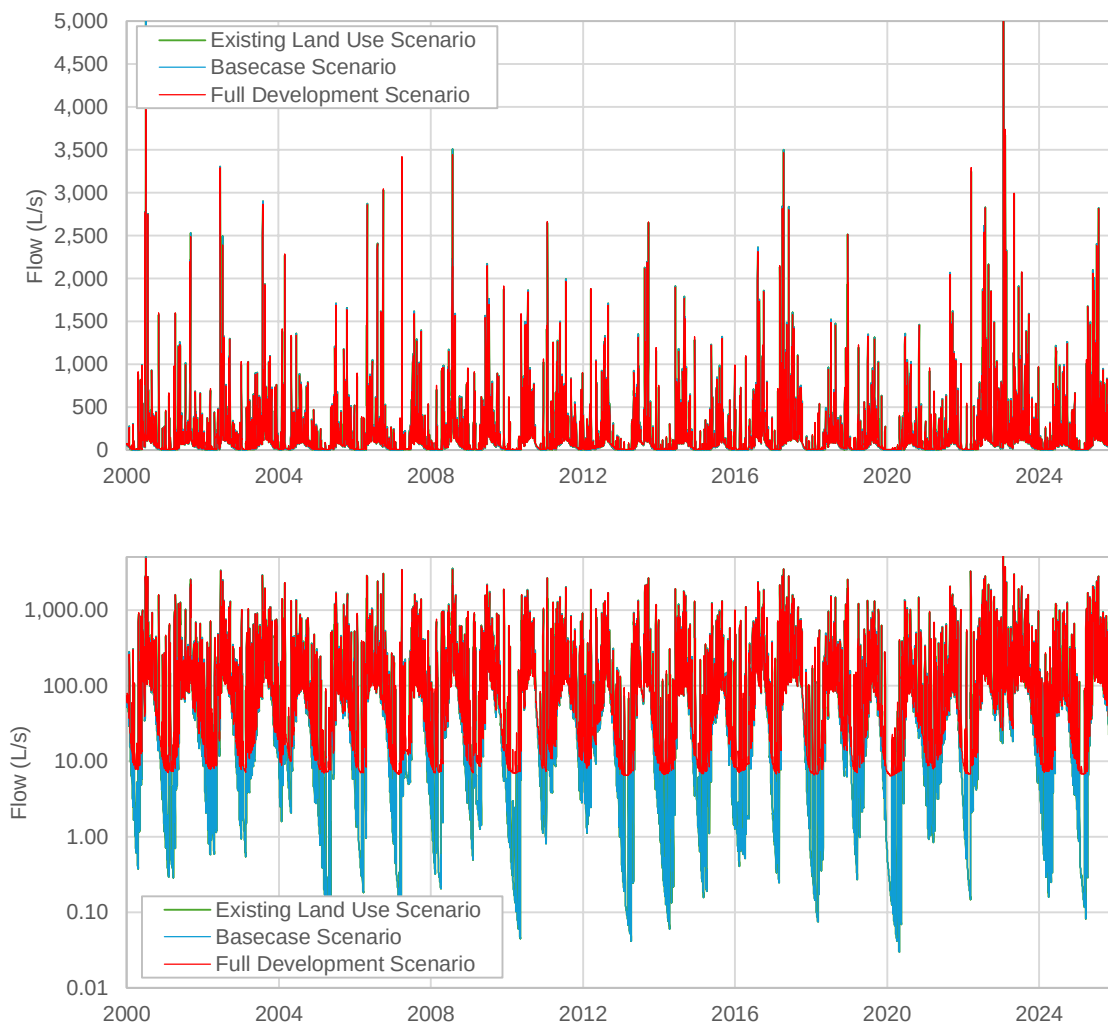


Figure 13. Comparison of simulated flow hydrographs – Site B (Orewa River at Kowhai Ave).

Site C is located downstream of Site B, at the confluence of Waterloo Creek and the Orewa River. The Waterloo Creek tributary adds additional flow. Similar to Site B, an increase in baseflow conditions were simulated resulting from the proposed treated wastewater discharge.



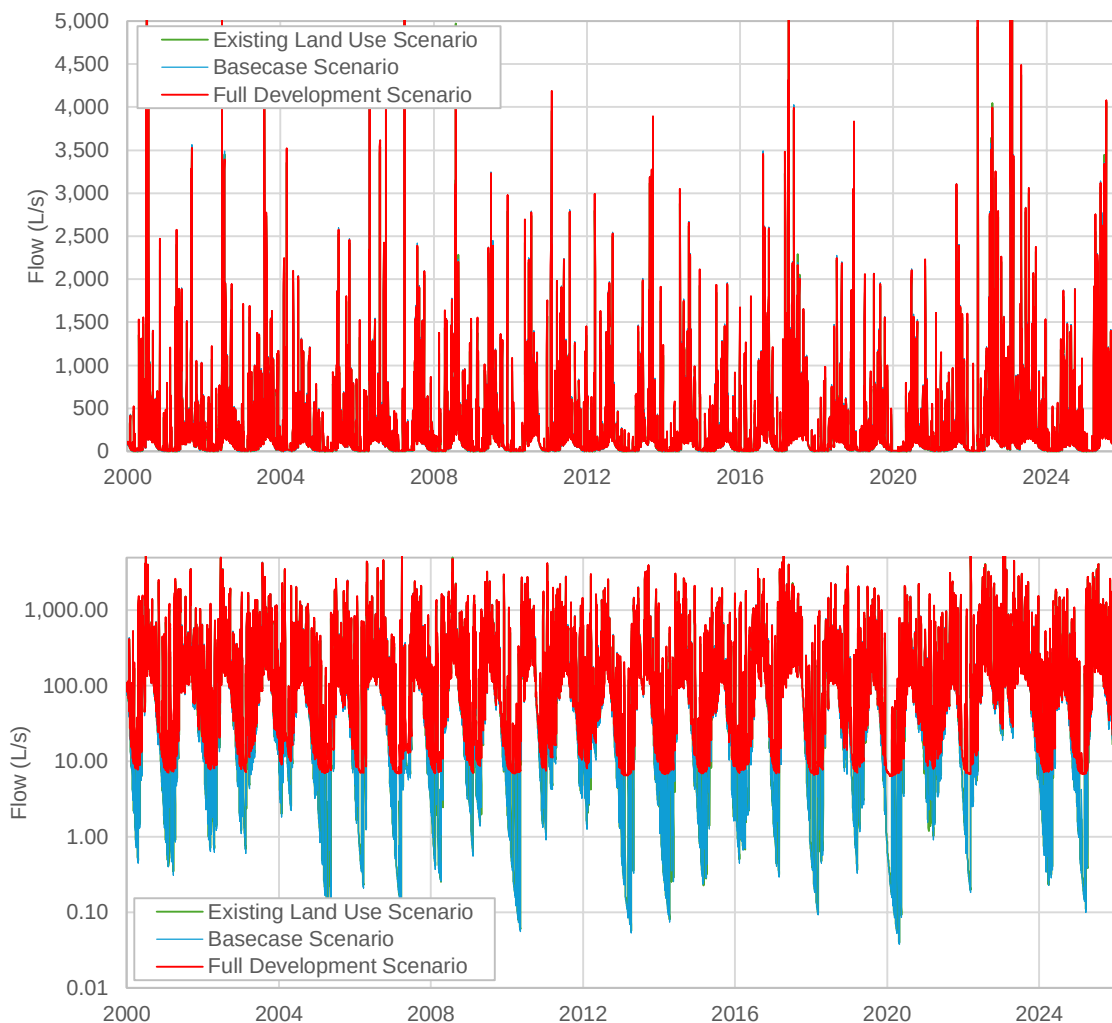


Figure 14. Comparison of simulated flow hydrographs – Site C (Orewa River d/s Confluence with Waterloo Creek).

Site D is located at the downstream extent of the Unnamed Tributary of the catchment that the constructed wastewater wetland will be located within. Due to the proximity to the wastewater wetland, Site D shows the largest difference between Basecase and Full Development Scenarios (**Figure 15**).

Low flows show the greatest increase between scenarios, increasing from 0.1 L/s to 7.3 L/s for the Basecase and Full Development scenarios, respectively. It is noted the increase to 7.3 L/s is equivalent to approximately 630 m<sup>3</sup>/day. This is less than constant treated effluent discharge rate of 660 m<sup>3</sup>/day due to evaporative losses and infiltration to groundwater in the treatment wetland.



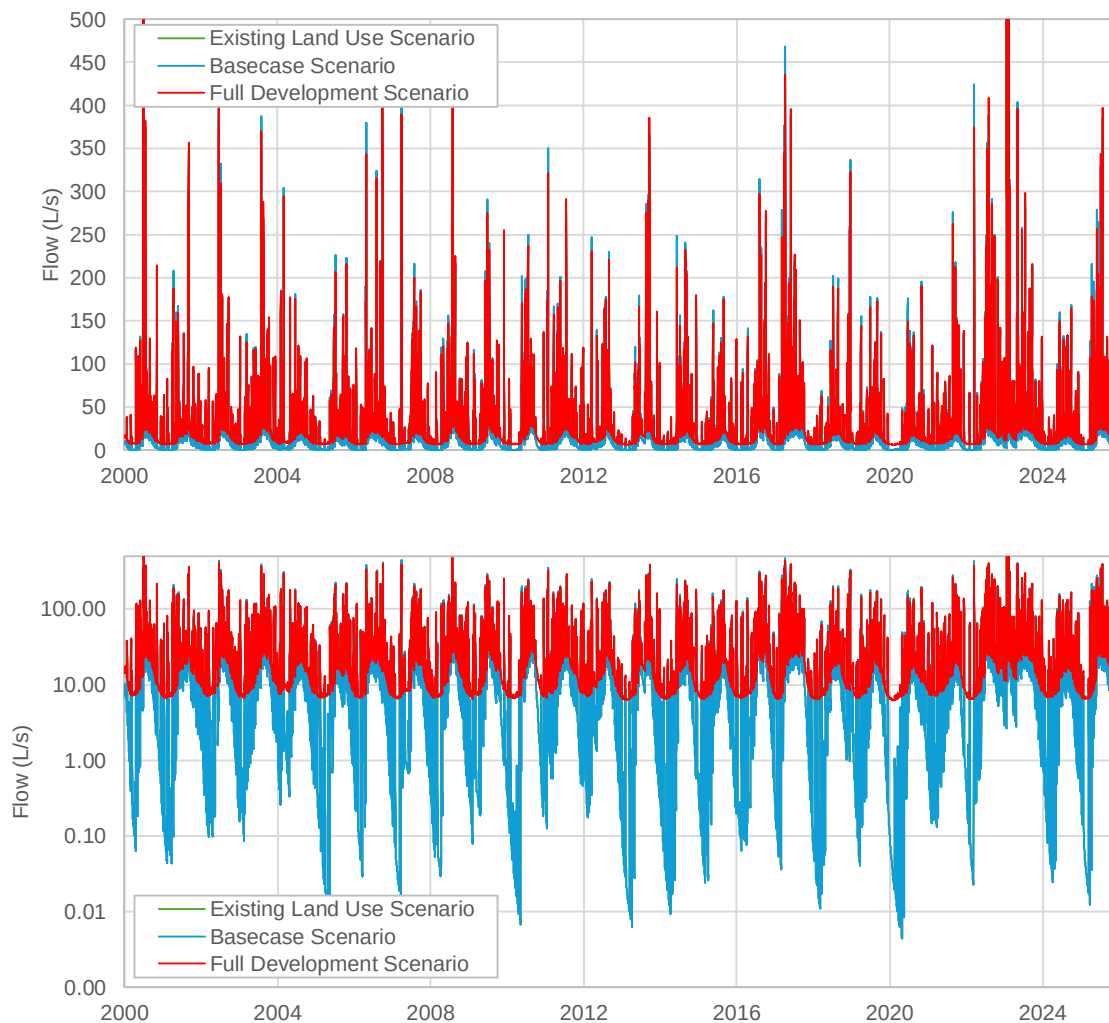


Figure 15. Comparison of simulated flow hydrographs – Site D (Unnamed Tributary).

Table 4. Comparison of simulated flow summary statistics.

| Statistic                                 | Existing Land Use<br>(L/s) | Basecase<br>(L/s) | Full Development<br>(L/s) |
|-------------------------------------------|----------------------------|-------------------|---------------------------|
| <b>Site A – d/s of Take Site</b>          |                            |                   |                           |
| Minimum                                   | 0.0                        | 0.0               | 0.0                       |
| MALF                                      | 0.3                        | 0.3               | 0.3                       |
| 25 <sup>th</sup> Percentile               | 3.9                        | 3.9               | 3.9                       |
| Median                                    | 34.3                       | 34.3              | 34.3                      |
| Mean                                      | 107.0                      | 107.2             | 98.6                      |
| 75 <sup>th</sup> Percentile               | 116.9                      | 117.5             | 92.6                      |
| Maximum                                   | 5,037.6                    | 5,026.4           | 5,001.4                   |
| FRE3                                      | 24                         | 24                | 23                        |
| <b>Site B – Orewa River at Kowhai Ave</b> |                            |                   |                           |



| Statistic                                                         | Existing Land Use<br>(L/s) | Basecase<br>(L/s) | Full Development<br>(L/s) |
|-------------------------------------------------------------------|----------------------------|-------------------|---------------------------|
| Minimum                                                           | 0.0                        | 0.0               | 6.3                       |
| MALF                                                              | 0.5                        | 0.5               | 7.3                       |
| 25 <sup>th</sup> Percentile                                       | 6.9                        | 6.9               | 14.9                      |
| Median                                                            | 60.8                       | 60.8              | 67.7                      |
| Mean                                                              | 189.7                      | 189.7             | 188.7                     |
| 75 <sup>th</sup> Percentile                                       | 207.6                      | 207.6             | 189.4                     |
| Maximum                                                           | 8,922.5                    | 8,922.5           | 8,947.6                   |
| FRE3                                                              | 24                         | 24                | 23                        |
| <b>Site C – Orewa River d/s of Confluence with Waterloo Creek</b> |                            |                   |                           |
| Minimum                                                           | 0.0                        | 0.0               | 6.4                       |
| MALF                                                              | 0.7                        | 0.6               | 7.4                       |
| 25 <sup>th</sup> Percentile                                       | 10.2                       | 11.0              | 19.1                      |
| Median                                                            | 87.7                       | 87.1              | 93.2                      |
| Mean                                                              | 278.2                      | 285.3             | 285.4                     |
| 75 <sup>th</sup> Percentile                                       | 307.1                      | 316.2             | 298.1                     |
| Maximum                                                           | 12,961.9                   | 13,109.9          | 13,157.8                  |
| FRE3                                                              | 24                         | 25                | 24                        |
| <b>Site D – Unnamed Tributary</b>                                 |                            |                   |                           |
| Minimum                                                           | 0.0                        | 0.0               | 6.2                       |
| MALF                                                              | 0.1                        | 0.1               | 6.8                       |
| 25 <sup>th</sup> Percentile                                       | 1.0                        | 1.0               | 8.4                       |
| Median                                                            | 8.2                        | 8.2               | 15.6                      |
| Mean                                                              | 25.3                       | 25.3              | 30.9                      |
| 75 <sup>th</sup> Percentile                                       | 27.3                       | 27.3              | 31.7                      |
| Maximum                                                           | 1,211.0                    | 1,211.0           | 1,201.8                   |
| FRE3                                                              | 24                         | 24                | 19                        |

### 5.1.1 Comparison to Flows Simulated for the Surface Water Take Report

As noted in **Section 2.1**, the model utilised for this assessment differs in structure and functionality compared to the hydrology model used for the Surface Water Take for Community Water Supply assessment. Whilst both models are underpinned by the Soil Moisture Water Balance (SMWBM) rainfall runoff model, the Surface Water Take for Community Water Supply assessment utilised a lumped model (i.e., one set of model parameters to represent the entire catchment). Conversely, this assessment was based on a semi-distributed, sub-catchment based implementation, with key model parameters adjusted to reflect the dominant land uses within each sub-catchment (and across the various land use change scenarios).

The reason for the above differing modelling methodologies was that the details of the surface water abstraction (i.e., location, rate, and minimum flow criterion) and size of the reservoir were required early on during the project development – in order to inform and confirm the number of lots that could be supported, and the location of the reservoir and ancillary infrastructure etc. Whereas the Catchment Hydrology and Water Quality assessment (i.e., this report) could only be progressed once the proposed development plans were further progressed.



A comparison of the simulated flows from the two models for scenarios where the proposed surface water take of 25 L/s when flows are above 36 L/s are presented in **Table 5**, for the location immediately downstream of the proposed take site. This comparison shows both implementations of the model simulate very similar flow regime, and both are considered appropriate for the purposes on which they have been used.

For the purposes of the surface water take consent application, the median flow is specified as 36.6 L/s as this is the more conservative value of the two (i.e., slightly higher value, so flows need to increase higher before abstractions can start).

Table 5. Comparison of simulated flows.

| Statistic                   | Surface Water Take Assessment Model (L/s) | Catchment Hydrology and Water Quality Model (L/s) |
|-----------------------------|-------------------------------------------|---------------------------------------------------|
| Minimum                     | 0.02                                      | 0.0                                               |
| 7-Day MALF                  | 0.36                                      | 0.30                                              |
| 25 <sup>th</sup> Percentile | 6.68                                      | 3.86                                              |
| Median                      | 36.61                                     | 34.29                                             |
| Mean                        | 114.5                                     | 98.61                                             |
| 75 <sup>th</sup> Percentile | 76.13                                     | 92.57                                             |
| Maximum                     | 5,121                                     | 5,001.4                                           |
| FRE3                        | 21                                        | 23                                                |

## 5.2 Catchment Water Quality

This section presents the simulated changes in catchment water quality across the three land use scenarios (**Section 4**), at three (Sites B, C, and D) representative assessment locations (**Section 5**). Site A has been excluded from this section as Site A is located upstream of the majority of the Milldale Stages 14-17 development and wastewater discharge site and hence water quality is not anticipated to change materially at Site A.

Simulated timeseries of Total Nitrogen (TN) concentrations are provided in **Figure 16** to **Figure 18**, and tabular results presented in **Table 6**.

Simulated timeseries of Total Phosphorus (TP) concentrations are provided in **Figure 19** to **Figure 21**, and tabular results presented in **Table 7**.

### 5.2.1 Nitrogen

A time series of TN concentrations at Site B is presented in **Figure 16**. The maximum TN concentrations under the Full Development Scenario are lower than the Basecase scenario, and the lower concentrations are more variable (i.e., exhibit a greater temporal fluctuation compared to the Basecase). The lower peak concentrations are the result of retiring the large area of pastoral land in the northern area of the Milldale Stages 14-17 site to wetlands, riparian planting, and native planting mix. The higher low flow TN concentrations during summer are a result of the treated effluent discharge during periods where upstream catchment inflows are low, and hence low dilution potential.



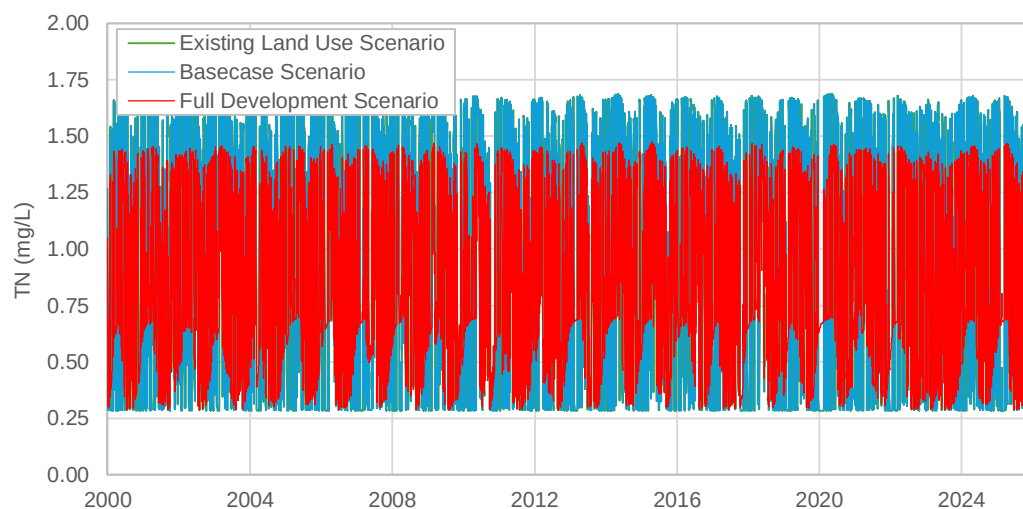


Figure 16. Comparison of simulated TN – Site B (Orewa River @ Kowhai Ave).

A time series of TN concentrations at Site C is presented in **Figure 17**. Similar to Site B, the maximum TN concentrations under the Full Development Scenario are lower than the Basecase Scenario, and the lower concentrations are more variable. This is due to the same reasons as described for Site B.

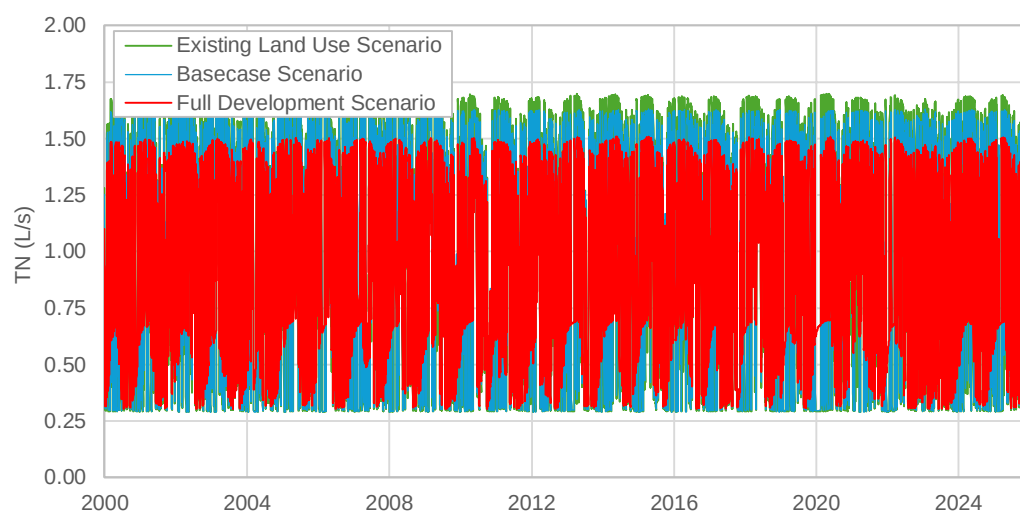


Figure 17. Comparison of simulated TN – Site C (Orewa River d/s Confluence with Waterloo Creek).

A time series of TN concentrations at Site D is presented in **Figure 18**. As this site is located in close proximity to the wastewater treatment wetland it shows the greatest change compared to the Basecase Scenario. The reduction in concentrations is a result of the widespread retiring the large area of pastoral land in the northern area of the Milldale Stages 14-17 site to wetlands, riparian planting, and native planting mix in this sub-catchment.



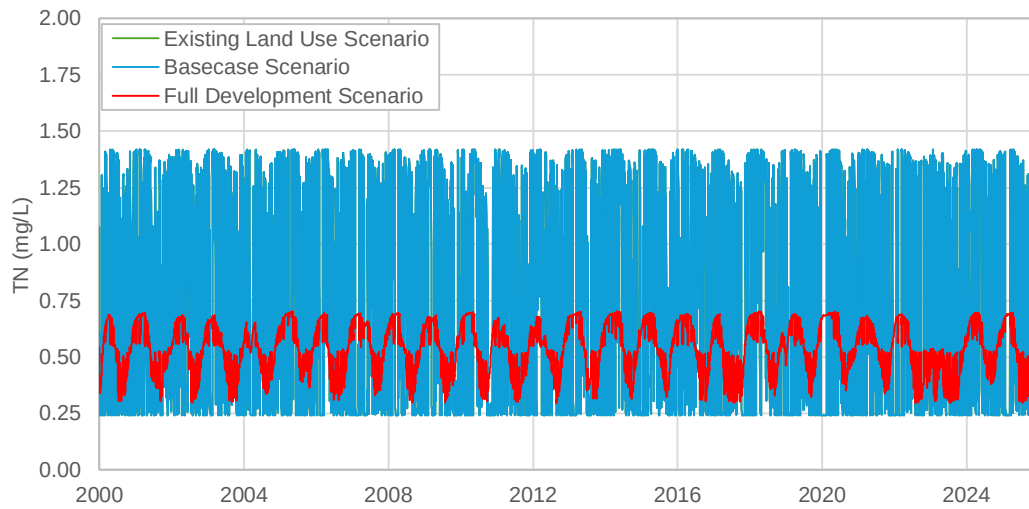


Figure 18. Comparison of simulated TN – Site D (Unnamed Tributary).

Table 6. Comparison of simulated TN summary statistics.

| Statistic                                                         | Existing Land Use<br>(mg/L) | Basecase<br>(mg/L) | Full Development<br>(mg/L) |
|-------------------------------------------------------------------|-----------------------------|--------------------|----------------------------|
| <b>Site B – Orewa River at Kowhai Ave</b>                         |                             |                    |                            |
| Minimum                                                           | 0.28                        | 0.28               | 0.29                       |
| 25 <sup>th</sup> Percentile                                       | 0.31                        | 0.31               | 0.55                       |
| Median                                                            | 0.95                        | 0.95               | 0.79                       |
| Mean                                                              | 0.94                        | 0.94               | 0.87                       |
| 75 <sup>th</sup> Percentile                                       | 1.53                        | 1.53               | 1.27                       |
| Maximum                                                           | 1.69                        | 1.69               | 1.48                       |
| <b>Site C – Orewa River d/s of Confluence with Waterloo Creek</b> |                             |                    |                            |
| Minimum                                                           | 0.29                        | 0.29               | 0.30                       |
| 25 <sup>th</sup> Percentile                                       | 0.34                        | 0.36               | 0.59                       |
| Median                                                            | 1.05                        | 1.10               | 0.94                       |
| Mean                                                              | 0.98                        | 0.99               | 0.94                       |
| 75 <sup>th</sup> Percentile                                       | 1.56                        | 1.53               | 1.36                       |
| Maximum                                                           | 1.70                        | 1.63               | 1.51                       |
| <b>Site D – Unnamed Tributary</b>                                 |                             |                    |                            |
| Minimum                                                           | 0.24                        | 0.24               | 0.29                       |
| 25 <sup>th</sup> Percentile                                       | 0.26                        | 0.26               | 0.46                       |
| Median                                                            | 0.75                        | 0.75               | 0.54                       |
| Mean                                                              | 0.78                        | 0.78               | 0.54                       |
| 75 <sup>th</sup> Percentile                                       | 1.29                        | 1.29               | 0.64                       |
| Maximum                                                           | 1.42                        | 1.42               | 0.70                       |



### 5.2.2 Phosphorus

A time series of simulated TP concentrations at Site B is presented in **Figure 19**. The change in TP concentrations follow a similar pattern to the change in TN concentrations, with lower maximums and more variable lower concentrations. The lower peak concentrations is a result of the retirement of pastoral land in the northern extents of the site.

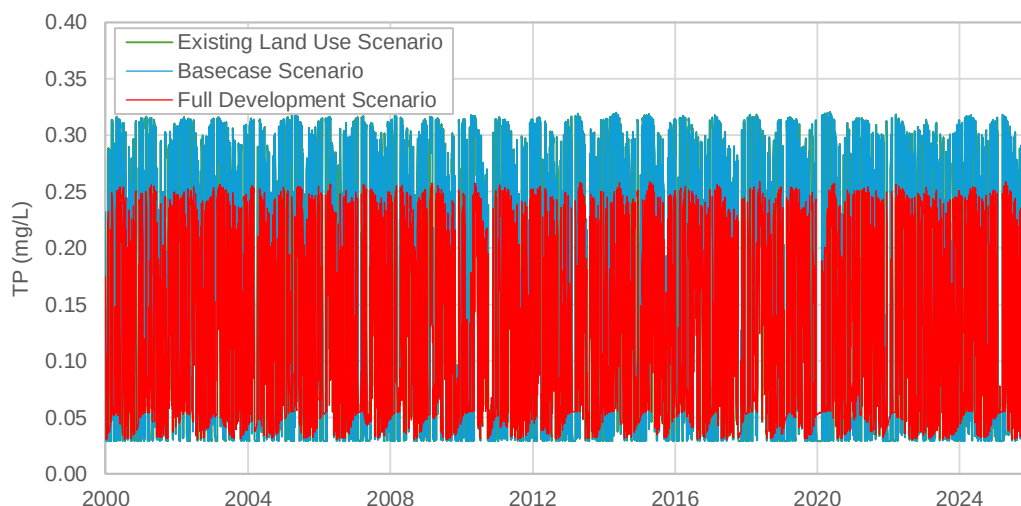


Figure 19. Comparison of simulated TP – Site B (Orewa River @ Kowhai Ave)

A time series of TP concentrations at Site C is presented in **Figure 20**. The pattern of changes in TP concentrations is similar to that at Site B.

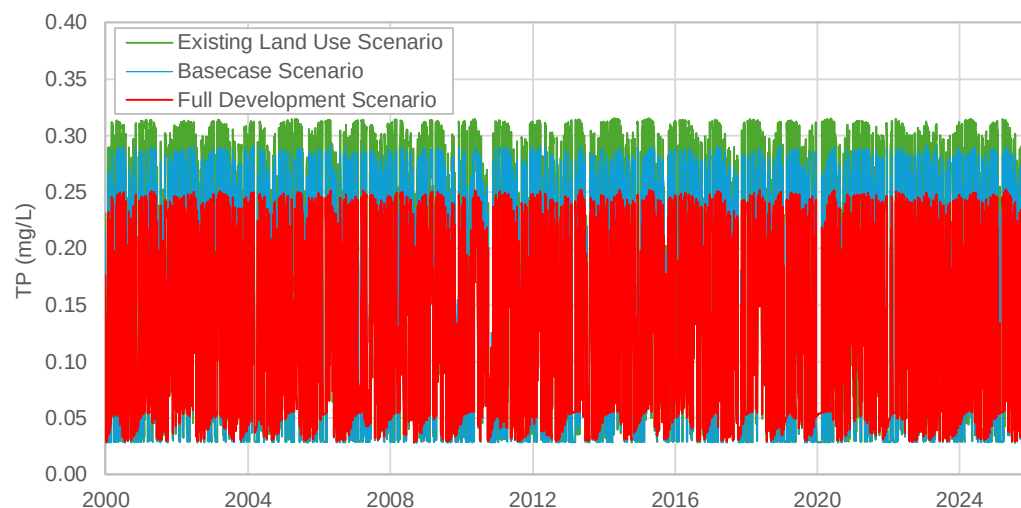


Figure 20. Comparison of simulated TP – Site C (Orewa River d/s Confluence with Waterloo Creek).

A time series of TP concentrations at Site D is presented in **Figure 21**. Maximum TP concentrations are significantly reduced in the Full Development Scenario compared to the Basecase Scenario. This is a result of the land use change in the sub-catchment upstream (i.e. retirement of pastoral land to wetlands, riparian planting, and native planting mix).



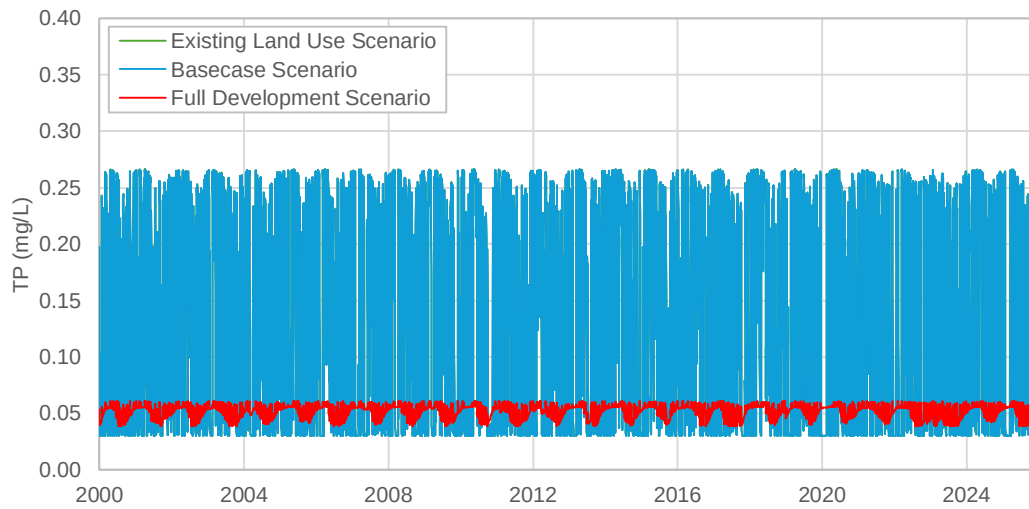


Figure 21. Comparison of simulated TP – Site D (Unnamed Tributary).

Table 7. Comparison of simulated TP summary statistics.

| Statistic                                                         | Existing Land Use<br>(mg/L) | Basecase<br>(mg/L) | Full Development<br>(mg/L) |
|-------------------------------------------------------------------|-----------------------------|--------------------|----------------------------|
| <b>Site B – Orewa River at Kowhai Ave</b>                         |                             |                    |                            |
| Minimum                                                           | 0.03                        | 0.03               | 0.03                       |
| 25 <sup>th</sup> Percentile                                       | 0.04                        | 0.03               | 0.05                       |
| Median                                                            | 0.17                        | 0.17               | 0.11                       |
| Mean                                                              | 0.16                        | 0.16               | 0.13                       |
| 75 <sup>th</sup> Percentile                                       | 0.29                        | 0.29               | 0.22                       |
| Maximum                                                           | 0.32                        | 0.32               | 0.26                       |
| <b>Site C – Orewa River d/s of Confluence with Waterloo Creek</b> |                             |                    |                            |
| Minimum                                                           | 0.03                        | 0.03               | 0.03                       |
| 25 <sup>th</sup> Percentile                                       | 0.04                        | 0.04               | 0.05                       |
| Median                                                            | 0.18                        | 0.18               | 0.14                       |
| Mean                                                              | 0.17                        | 0.16               | 0.14                       |
| 75 <sup>th</sup> Percentile                                       | 0.29                        | 0.27               | 0.22                       |
| Maximum                                                           | 0.32                        | 0.29               | 0.25                       |
| <b>Site D – Unnamed Tributary</b>                                 |                             |                    |                            |
| Minimum                                                           | 0.03                        | 0.03               | 0.04                       |
| 25 <sup>th</sup> Percentile                                       | 0.03                        | 0.03               | 0.05                       |
| Median                                                            | 0.13                        | 0.13               | 0.05                       |
| Mean                                                              | 0.14                        | 0.14               | 0.05                       |
| 75 <sup>th</sup> Percentile                                       | 0.24                        | 0.24               | 0.06                       |
| Maximum                                                           | 0.27                        | 0.27               | 0.06                       |



## 6. Assessment of Effects

This section details the actual effects of the proposed Milldale North Stages 14-17 development on catchment hydrology and water quality in the Orewa River, downstream of the proposed development.

Potential effects on the environment associated with the development from a hydrology and water quality perspective include:

- Downstream flow effects;
- Effects on downstream water users; and
- Water quality effects with particular focus on limiting nutrients Nitrogen and Phosphorus.

The actual effects identified are assessed and summarised in the sub-sections below.

### 6.1 Hydrology

To assess the effects on the streamflow regime, the Basecase and Full Development Scenarios were compared in **Section 5**. **Sections 6.1.1** and **6.1.2** discuss the comparisons and effects on stream flows and downstream consent users.

#### 6.1.1 Effects on Downstream Flows

As the take from the stream is a high-flow take, water will not be abstracted during times of below median flow. Therefore, flows immediately downstream of the point of take, below the median will not be impacted. High flows will be reduced by a maximum of 25 L/s immediately downstream of the point of take. As only 30% of the flow above median (up to 25 L/s) will be abstracted, the effect on flushing flows is negligible – with a reduction in the annual average FRE3 from 24 to 23 events.

Further downstream, at the Kowhai Ave site, low flows increase due to the treated effluent discharges, with the MALF increasing from approximately 0.5 L/s to 7.3 L/s. This is considered a positive effect as low flows are increased. The effect of high-flow abstractions is reduced as a proportion of total flow due to the additional tributaries and catchment inflows that occur between the abstraction site and Kowhai Ave.

#### 6.1.2 Effects on Downstream Water Users

There are no known consented water takes on the main stem of the Orewa River downstream of the proposed take site. Therefore, there are no effects on downstream consented water takes.

As the proposed take is a high-flow take, all flows below the median will remain in-stream and available for any permitted activity takes within the Orewa River downstream of the take site. Therefore, the potential effects on downstream permitted activity water takes are considered less than minor.

### 6.2 Water Quality

This section describes the assessment of effects of land use change, surface water abstractions and treated wastewater discharges on water quality of the Orewa River.

#### 6.2.1 Nitrogen

The largest reduction in TN was simulated at Site D (unnamed tributary). This was due to the widespread retirement of pastoral land and conversion to wetland, riparian planting and native planting mix within this sub-catchment. While treated wastewater effluent is discharged via the treatment wetland in this sub-catchment, concentrations of surface runoff TN flowing from the bottom of the treatment wetland (i.e., the outlet) are anticipated to be lower than that of typical agricultural land use surface water runoff. Concentrations of TN in baseflow (groundwater) flow from the bottom of the treatment wetland are anticipated to be even lower, hence provide further reduction.



The reduction in TN concentration as a percentage reduction from the Baseline Scenario decreases with increasing distance downstream (i.e., at Sites B and C). This is because these sites include runoff from the entire Orewa River catchment upstream, including large areas outside of the Milldale North Stages 14-17 Site which remain unchanged. In addition, TN runoff from urban areas (i.e., the proposed development) will be lower than the current pastoral. However, both sites do show a modest reduction in peak concentrations during higher flow periods, and a modest increase in summer / dryer period low end concentrations – resulting from the constant treated effluent surface water runoff / outflow from the wetland.

Guideline values for various water quality parameters are provided in Table 5 of the Assessment of Surface Water Quality Effects report – Milldale North Water Takes and Discharges prepared by Viridis. This reports a TN trigger value of 0.292 mg/L based on the Australia and New Zealand Default Guideline Values (ANZ DGV). Simulated median TN concentrations exceed this value for all three representative locations and all three land use scenarios. All but one of Auckland Council's monitoring samples (**Figure 4**) exceed this value. However, we note the median TN concentration at all three assessment locations was simulated to decrease slightly under the Full Development land use scenario and hence is still considered an improvement.

Table 5 of the Viridis report also outlines the National Policy Statement – Freshwater Management (NPS-FM) attribute band values for Nitrate nitrogen. While the model presented here only simulated TN, Nitrate nitrogen is a component of TN (along with Organic nitrogen, Ammonia, and Nitrite nitrogen) and hence Nitrate nitrogen must best equal to or less than the TN concentrations simulated here. The simulated TN concentrations for the Full Development scenario at all three representative assessment locations would fall within Attribute Band A (i.e., the highest/best quality)

### 6.2.2 Phosphorus

The spatial changes in TP concentrations simulated are largely the same as those observed and described for TN, with the largest reductions occurring at Site D, and smaller reductions at Sites B and C. This is due to the same land use change reasons as described for TN.

The model presented here only simulated TP (i.e., the sum of all forms of phosphorus). It was noted in the Treated Wastewater Wetland<sup>11</sup> report that dissolved reactive phosphorus (DRP - which is a component to TP) tends to be 8.5 times less than TP (in other words DRP tends to be approximately 12% of TP) based on Auckland Council's monitoring data from the Orewa River at Kowhai Ave. On this basis, DRP concentrations at Representative Assessment locations A and B, for the Full Development scenario would fall within Attribute B and C, while location C would fall with Attribute B and B, respectively.

<sup>11</sup> WWLA. 2026. Treated Wastewater Cascading Wetland – Milldale Stages 14-17 Fast Track. Report prepared for Fulton Hogan Land Development Ltd. Rev 1.



## 7. Recommendations

A resource consent duration of 35-years is recommended for the proposed surface water abstraction for municipal supply in order to provided certainty of supply to the proposed development. A duration of 35-years is considered appropriate given the no more than minor effects on hydrology (flows) and existing water users.

The following consent conditions relating to the proposed surface water high-flow take are recommended:

- Stream flow is continuously monitored at a location near to the surface water take as a means to assess the allowable high-flow take rate. Flow monitoring should be aligned with industry best practice, including but not limited to, site location, routine check and maintenance of site and equipment, and when necessary, flow gaugings to establish rating curve(s), as much as practicable.
- The high-flow take is not permitted until the measured stream flow at the surface water take site exceeds the median stream flow. The median stream flow at the proposed water take location is set at 36.6 L/s at the time of this consent approval.
- A water meter is required on the water take to ensure the consented maximum take rate does not exceed 25 L/s, or 30% of the flow in the stream above median at the time of abstraction. The water meter and associated infrastructure must be appropriately maintained to provide reasonable confidence in data and minimal adverse effects on the stream bed and banks.
- The Applicant must analyse the measured stream flow data and high-flow take rate and report to Auckland Council on an annual basis, the following:
  - Compliance to the high-flow take rate, clearly comparing the monitored stream flow to the measured water take; and
  - Analysis of the hydrological flow regime, clearly identifying the minimum, median, mean and maximum stream flows.



## 8. Summary and Key Conclusions

### Model Development

A continuous simulation catchment hydrology and water quality assessment of the Orewa River catchment was undertaken to quantify the potential effects of the proposed Milldale Stages 14-17 development, comprising land use change, a high-flow surface water take for municipal supply, and treated wastewater discharge via a constructed wetland.

The model was calibrated to measured flow at Auckland Council's Orewa River at Kowhai Ave site and to available instream nutrient concentrations, and achieved a level of calibration appropriate for catchment-scale assessment of relative land use change.

Three scenarios were compared — Existing Land Use, Basecase (existing land use plus the already consented Milldale stages), and Full Development — with effects assessed as the change between the Basecase and Full Development scenarios at four representative locations.

### Surface Water Flow Impacts

The proposed surface water take operates only when flows exceed the median at the point of take and is limited to no more than 30% of the instantaneous flow above median, up to a maximum of 25 L/s. Consequently, no change to low flows will occur downstream of the point of take. Mid-range and high flows immediately downstream of the take are reduced by up to 25 L/s, and the frequency of flushing flows (FRE3) reduced from 24 to 23 events per year.

Further downstream, the effect of abstraction diminishes as a proportion of total flow through the contribution of intervening tributaries, and is partially offset by the treated wastewater discharge. At the Orewa River at Kowhai Ave Site (Site B), the MALF is projected to increase from approximately 0.5 L/s to 7.3 L/s under the Full Development Scenario. Hence the Orewa River is anticipated to flow continuously year-round rather than ceasing to flow during dry summer periods as currently occurs.

There are no existing consented surface water takes on the main stem of the Orewa River downstream of the point of take and hence no effect on existing consented water takes. As all flows below the median remain instream and available for any permitted activity takes, the effects on permitted activity takes are considered no more than minor.

### Surface Water Quality Impacts

Simulated Total Nitrogen and Total Phosphorus concentrations were predicted to reduce under the Full Development scenario at all three water quality assessment locations, principally through retirement of pastoral land in the northern part of the site and its conversion to wetland, riparian and native planting.

The greatest improvement is predicted to occur at Site D in the unnamed tributary, where mean TN reduced from 0.78 to 0.54 mg/L and mean TP from 0.14 to 0.05 mg/L. Improvements were progressively smaller downstream at the Orewa River at Kowhai Ave Site and downstream of the confluence with Waterloo Creek, where flow and nutrient contributions from the wider unchanged catchment dominate.

Peak concentrations during high flow periods reduce at all sites, while low-flow concentrations were predicted to show a modest increase during summer, reflecting the constant treated wastewater contribution during periods when upstream dilution is limited.

### Key Conclusions

Key conclusions are summarised as follows:

- The high-flow take has no effect on low flows or MALF downstream of the point of take, and reduces flushing flow frequency by one event per year on average.



- Mid-range and high flows immediately downstream of the take will decrease by up to 25 L/s, diminishing progressively downstream.
- The treated wastewater discharge increases low flows such that the Orewa River is anticipated to flow continuously year-round.
- There are no consented takes on the main stem downstream of the point of take and thus there are no effects on existing consented water takes. Effects on permitted activity takes are considered to be less than minor.
- Land use change will result in lower mean (average) and peak TN and TP concentrations at all assessment locations.
- Summer low-flow nutrient concentrations may increase under limited dilution, while remaining within the anticipated range for the receiving environment.
- Overall, actual and potential effects on catchment hydrology and water quality are considered no more than minor, with net improvements in nutrient concentrations and low-flow reliability.

## Appendix A. Soil Moisture Water Balance Model

The Soil Moisture Water Balance Model (SMWBM) is a semi-deterministic rainfall-runoff model. Model functionality includes an infiltration function, surface ponding function, evaporation functions for differing land cover.

The SMWBM was developed into a plugin specific for use as the rainfall runoff model within the SOURCE framework. Within SOURCE, the SMWBM plugin allows catchment parameters to be set for each of the model sub-catchments, transforming the SMWBM from a semi-deterministic lumped parameter model into a powerful conceptual distributed model.

The model utilises daily rainfall and monthly evaporation input data to calculate the soil moisture conditions under natural rainfall conditions, and under different irrigation schemes. The model operates on a daily time step during dry days, however when rain days occur, a finer hourly calculation step is implemented to enable peak flows to be assessed more accurately than a daily time step model.

Table 8. SMWBM parameters.

| Parameter    | Name                                                               | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|--------------|--------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ST (mm)      | Maximum soil water content                                         | ST defines the size of the soil moisture store in terms of a depth of water                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| SL (mm)      | Soil moisture content where drainage ceases.                       | Soil moisture storage capacity below which sub-soil drainage ceases due to soil moisture retention.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| FT (mm/day)  | Sub-soil drainage rate from soil moisture storage at full capacity | Together with POW, FT (mm/day) controls the rate of percolation to the underlying aquifer system from the soil moisture storage zone. FT is the maximum rate of percolation through the soil zone.                                                                                                                                                                                                                                                                                                                                                                                  |
| ZMAX (mm/hr) | Maximum infiltration rate                                          | ZMAX and ZMIN are nominal maximum and minimum infiltration rates in mm/hr used by the model to calculate the actual infiltration rate ZACT. ZMAX and ZMIN regulate the volume of water entering soil moisture storage and the resulting surface runoff. ZACT may be greater than ZMAX at the start of a rainfall event. ZACT is usually nearest to ZMAX when soil moisture is nearing maximum capacity.                                                                                                                                                                             |
| ZMIN (mm/hr) | Minimum infiltration rate                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| POW (>0)     | Power of the soil moisture-percolation equation                    | POW determines the rate at which sub-soil drainage diminishes as the soil moisture content is decreased. POW therefore has significant effect on the seasonal distribution and reliability of drainage and hence baseflow, as well as the total yield from a catchment.                                                                                                                                                                                                                                                                                                             |
| PI (mm)      | Interception storage capacity                                      | PI defines the storage capacity of rainfall that that is intercepted by the overhead canopy or vegetation and does not reach the soil zone.                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| AI (-)       | Impervious portion of catchment                                    | AI represents the proportion of the catchment that is impervious and directly linked to drainage pathways.                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| R (0,1)      | Evaporation – soil moisture relationship                           | Together with the soil moisture storage parameters ST and SL, R governs the evaporative process within the model. Two different relationships are available. The rate of evapotranspiration is estimated using either a linear (0) or power-curve (1) relationship relating evaporation to the soil moisture status of the soil. As the soil moisture capacity approaches, full, evaporation occurs at a near maximum rate based on the mean monthly pan evaporation rate, and as the soil moisture capacity decreases, evaporation decreases according to the predefined function. |
| DIV (-)      | Fraction of excess rainfall allocated directly to pond storage     | DIV has values between 0 and 1 and defines the proportion of excess rainfall ponded at the surface due to saturation of the soil zone or rainfall exceeding the soils infiltration capacity to eventually infiltrate the soil, with the remainder (and typically majority) as direct runoff.                                                                                                                                                                                                                                                                                        |
| TL (days)    | Routing coefficient for surface runoff                             | TL defines the lag of surface water runoff.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |



|             |                                           |                                                                                                                                        |
|-------------|-------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|
| GL (days)   | Groundwater recession parameter           | GL governs the lag in groundwater discharge or baseflow from a catchment.                                                              |
| QOBS (m³/s) | Initial observed streamflow               | QOBS defines the initial volume of water in the stream at the model start period and is used to precondition the soil moisture status. |
| AA, BB      | Coefficients for rainfall disaggregation. | Used to determine the rainfall event duration and pattern. Default values usually suffice.                                             |

A conceptual diagram of the key components of SMWBM model structure and functionality is shown in **Figure 22**.

The key model parameters for differing land covers are detailed in **Table 9**.

Table 9. Key SMWBM parameters for differing land covers.

| Land Use | ST  | FT   | Zmax | PI  | DIV | AI   |
|----------|-----|------|------|-----|-----|------|
| Pasture  | 200 | 1.25 | 3    | 2   | 0.2 | 0    |
| Forest   | 300 | 1.25 | 4    | 4   | 0.1 | 0    |
| Urban    | 100 | 1.25 | 0.1  | 1.5 | 0.5 | 0.65 |

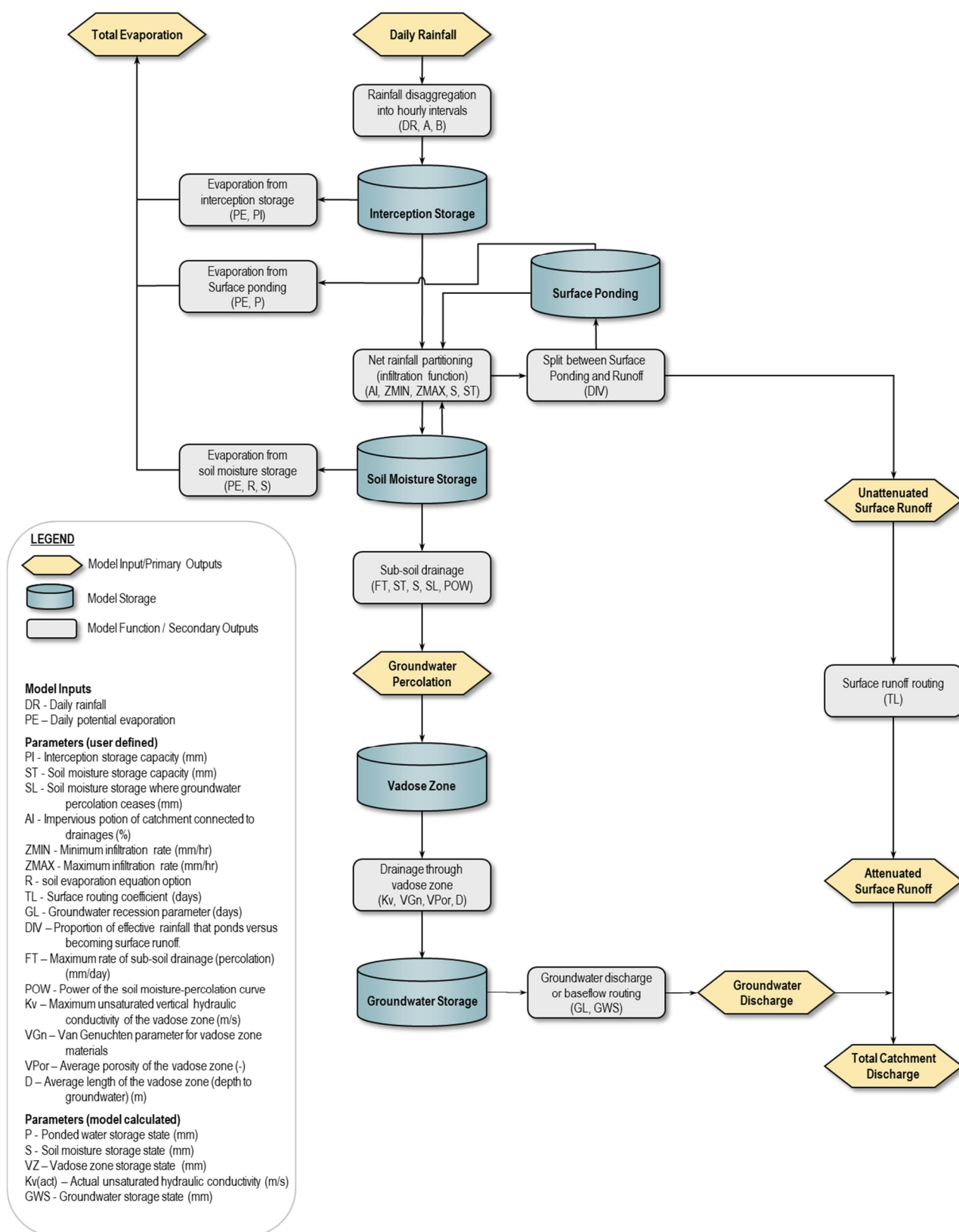


Figure 22. Flow diagram of the SMWBM structure and parameters.