FRESHWATER MANAGEMENT TOOL
Tauranga City Council
WaterNZ SW Conference 2023

Overview - TCC Waters Planning

Understand	Inform	Influence
Watercourse Assessments Flood Modelling & Assessments Freshwater Management Tool Infrastructure Assessments Local & Topic-Specific Investigations	30 Year Infrastructure & Assets Management Plan	Capital works programme
	Catchment Management Plans & Consents	Regulatory provisions Non-regulatory initiatives / Community actions

Tauranga's FWMT

Working to understand the natural water cycle and how best to protect the health of water and meet the city's needs

Purpose of the FWMT

- Continuous process-based simulation of flow, water quality and interventions.
- Representation of hydrogeology for baseflow/ water supply consideration
- Linking freshwater outcomes to infrastructure and policy intervention options for local government
- Connected to the wider system
  - Local and regional governance processes
  - Community capital, TCC team, catchment and city
  - The Ora (health) of Wai (water) both ecosystem and mauri.

TC FWMT Wider Connections

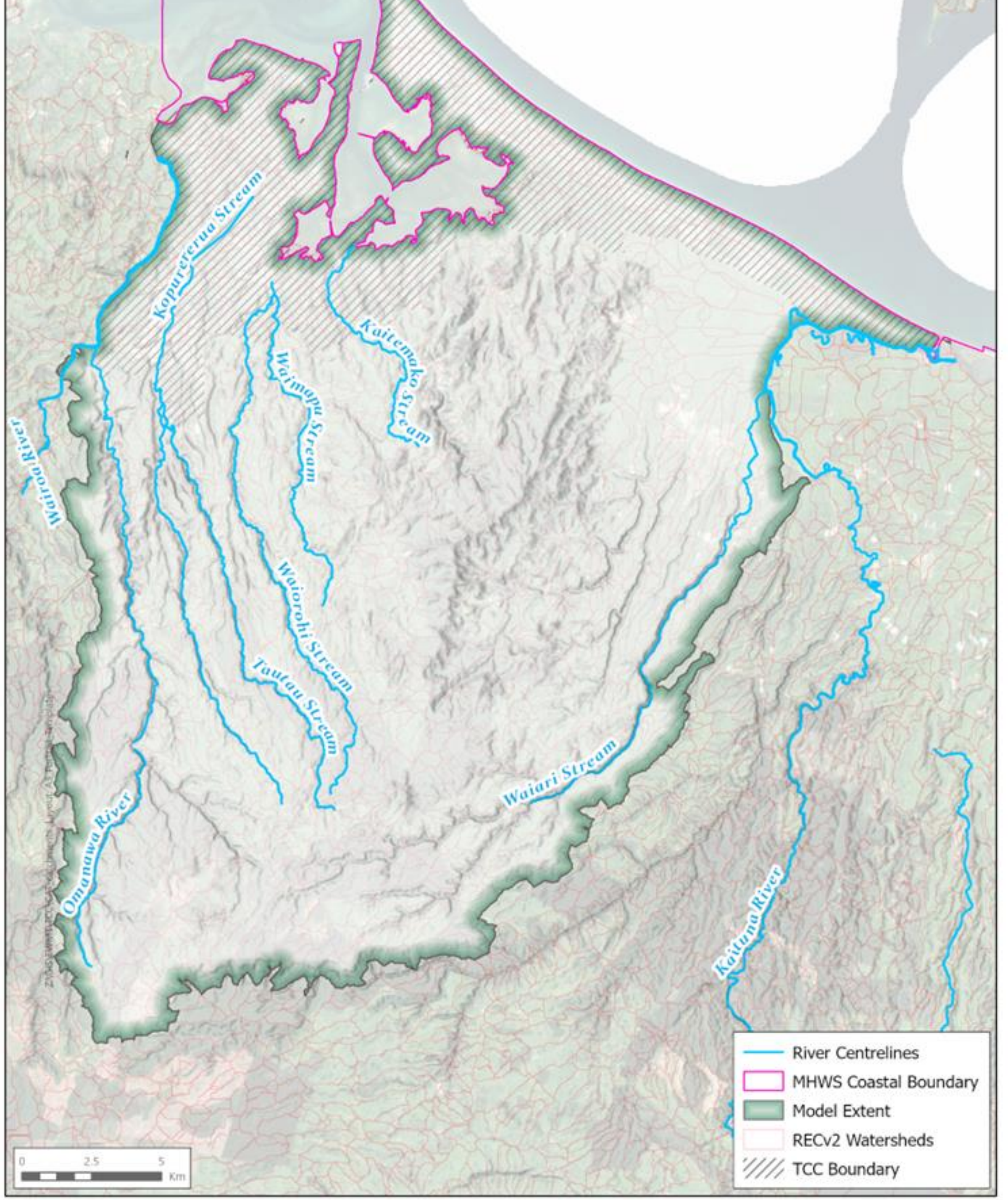
- Te Rangapū Mana Whenua o Tauranga Moana
- Bay of Plenty Regional Council BoP RC
- Inform wider stakeholders
- Peer Review Committee, engaging early and deeply to embed wider perspective and opportunity to improve along the way.
    - Nic Conland (Taiao Natural Resource Management)
    - Dr Hellen Rutter (Landcare Research)
    - Dr Annette Semedina-Davies (NIWA)
    - Dr Kēpā Morgan (Mahi Maioro Professionals) (More recently - Te Rangapū nominated)

Mana Whenua TC FWMT Connection

- Te Rangapū Mana Whenua o Tauranga Moana
- Long deep history of kaitiakitanga, mātauranga, maramataka observation - ways of knowing.
- Introductions have been made to FWMT but need for long term relationship building ahead.
- Challenging to see value in a digital twin of the water cycle - with its shortcomings in time / space and simplification
- Work ahead to clarify how underpinning assumptions align to the Aotearoa NZ context which must include Te Mana o Te Wai.
- Potential Mauri Model Decision Making Framework (DMF) parallel to modelling.

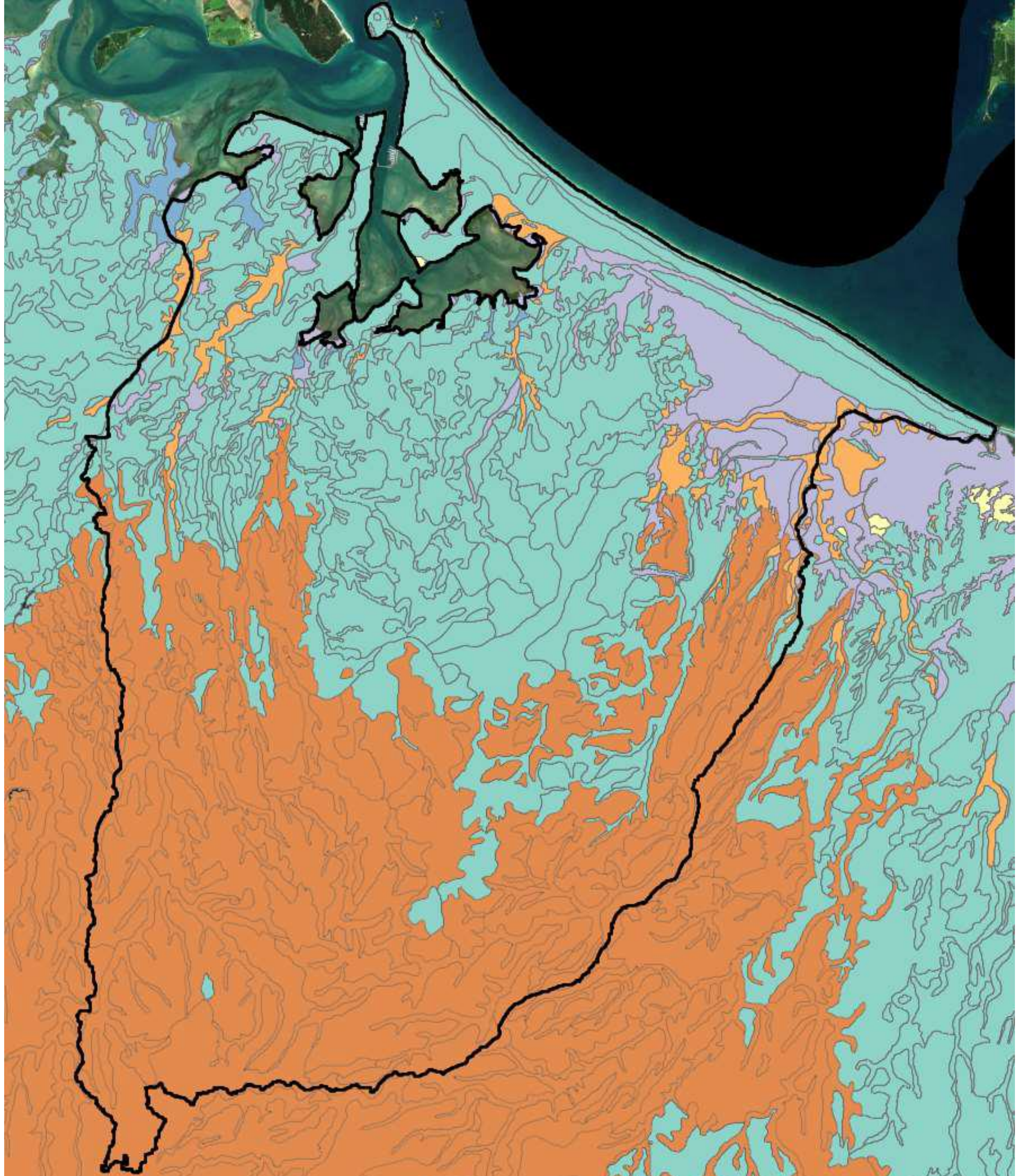
Ki uta ki tai
Mountains to Sea

- Tauranga as a downstream city
- WBoPDC upstream
- BoP RC managing catchments and rural activities
- BoP RC NPS FW program



Class A / A+ Soils

- High Permeability Catchments
- Upper Catchment –Pumice soils with sands and gravel (A+ HSG Orange)
- Lower Catchment – Alophanic soils with silt and sands (A HSG Green)
- Remainder Alluvial HSG B or HSG D Soils



Land Cover/ Land Activity

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Input data sets

TCC Impervious surfaces, BoP land uses, traffic, roof material, district plan, reticulated properties

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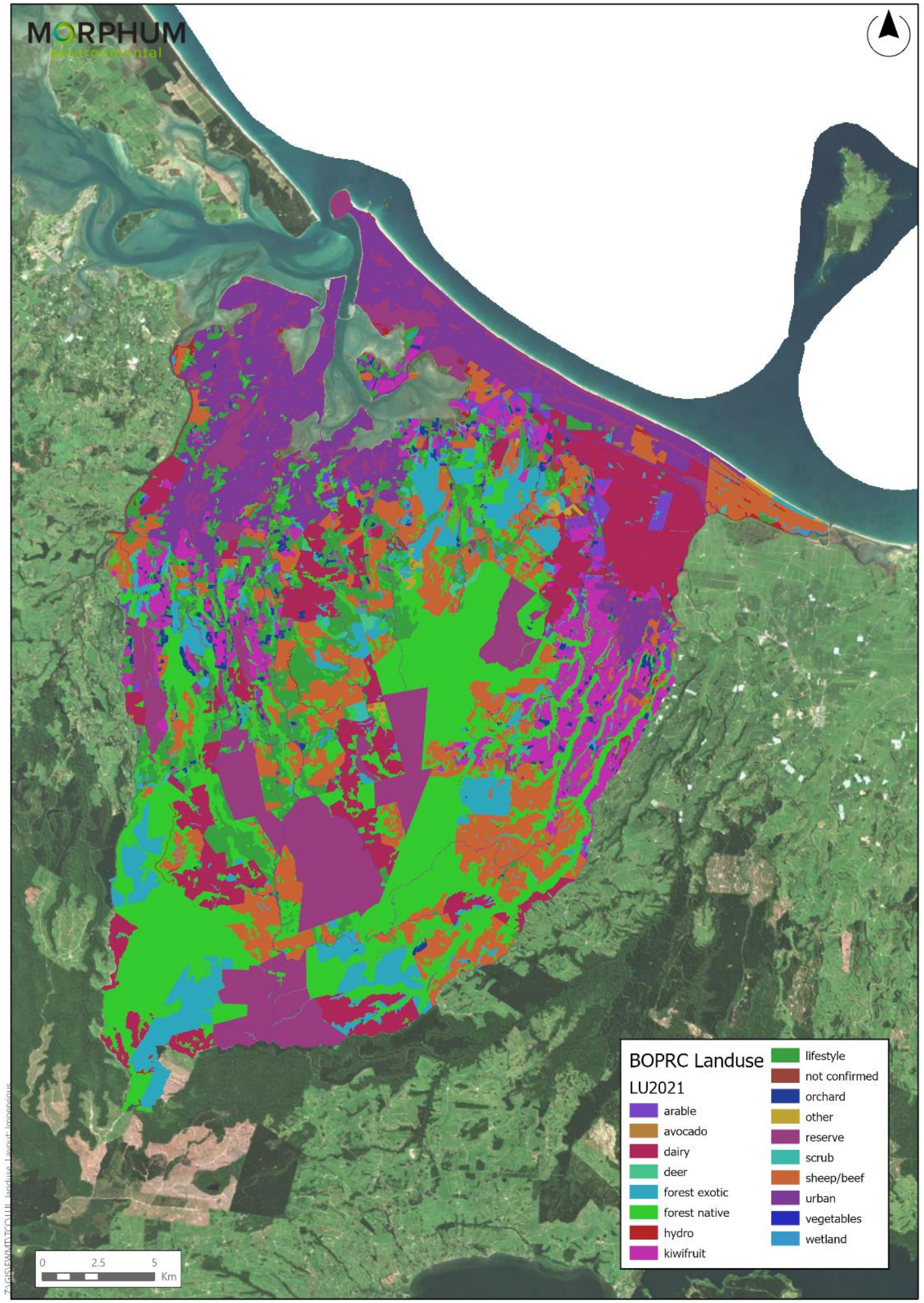
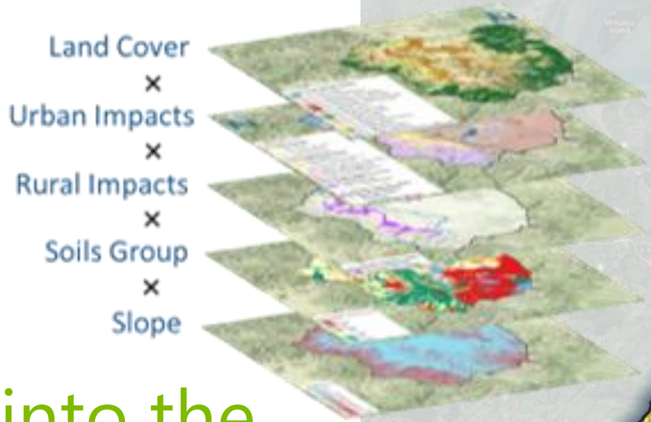
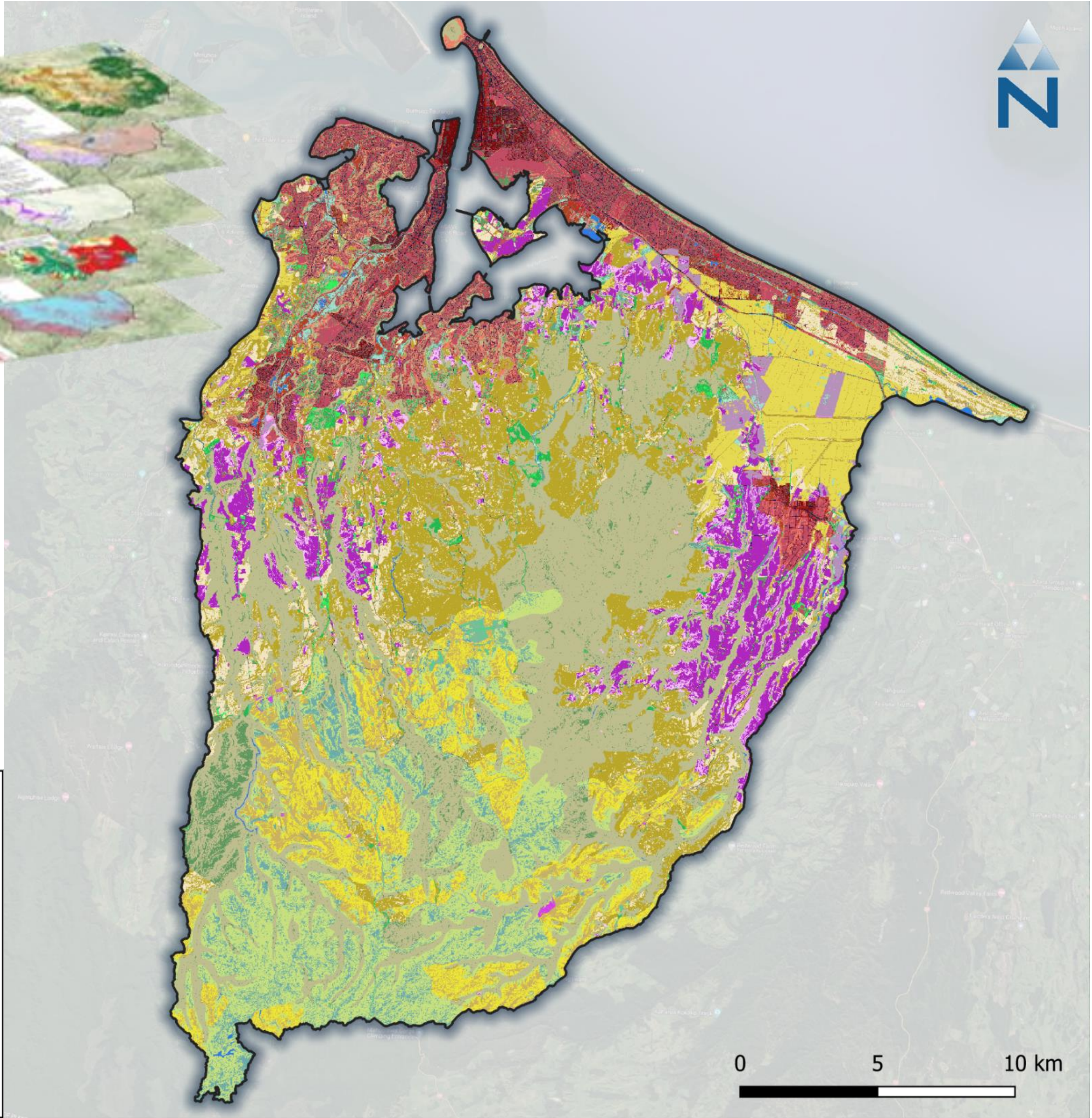
Distinct land cover and impact classes for HRU config



Final Hydrological Response Units



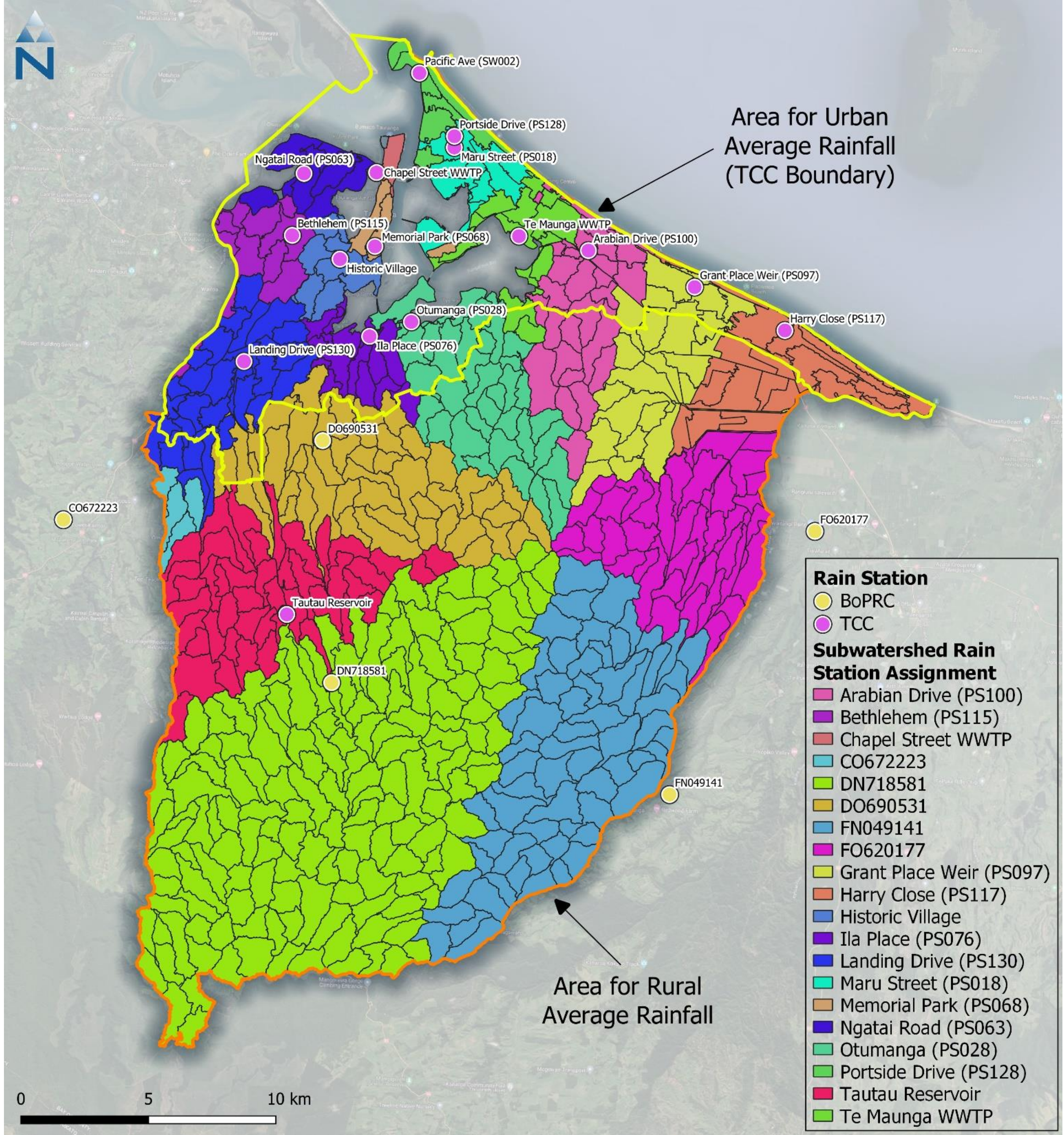
- 87 Final HRUs
- Impacts “peppered” into the final HRU raster:
  - Effective Imperviousness (DCIA)
  - Roof material impacts (Coated/Uncoated)
  - Road traffic impact (VPD)
  - Horticulture/Forest/Pasture impacts
  - On-site wastewater impacts



Rainfall Gauges

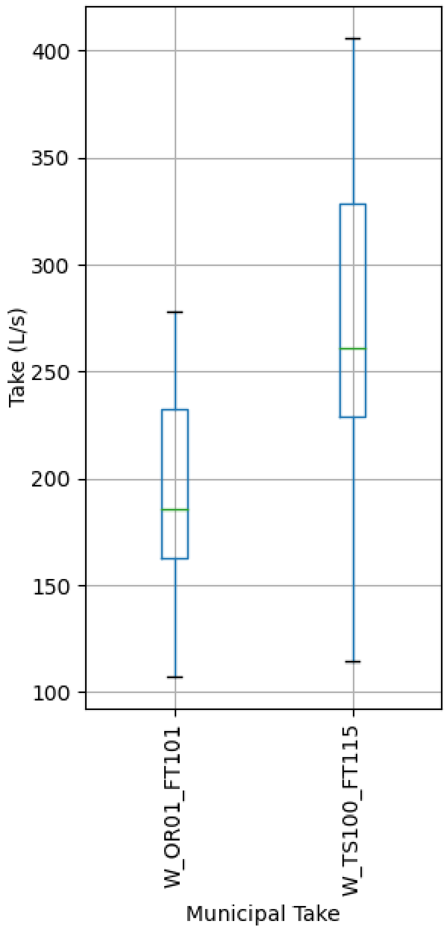
Gauges assigned to sub-catchments by proximity using the Thiessen Polygon Method Quality Control

- Missing intervals were patched with rainfall from nearby gauges using the Normal Ratio Method
- Unflagged gaps in the observed data (defined as a 14-day interval with zero rainfall) were flagged as "missing" for NRM consideration
- Evapotranspiration and Temperature

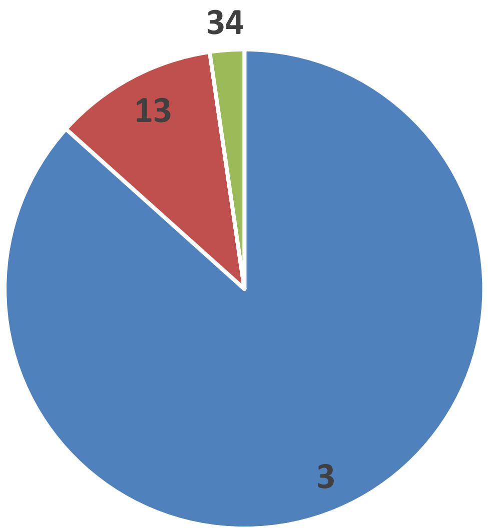


Surface Water Takes

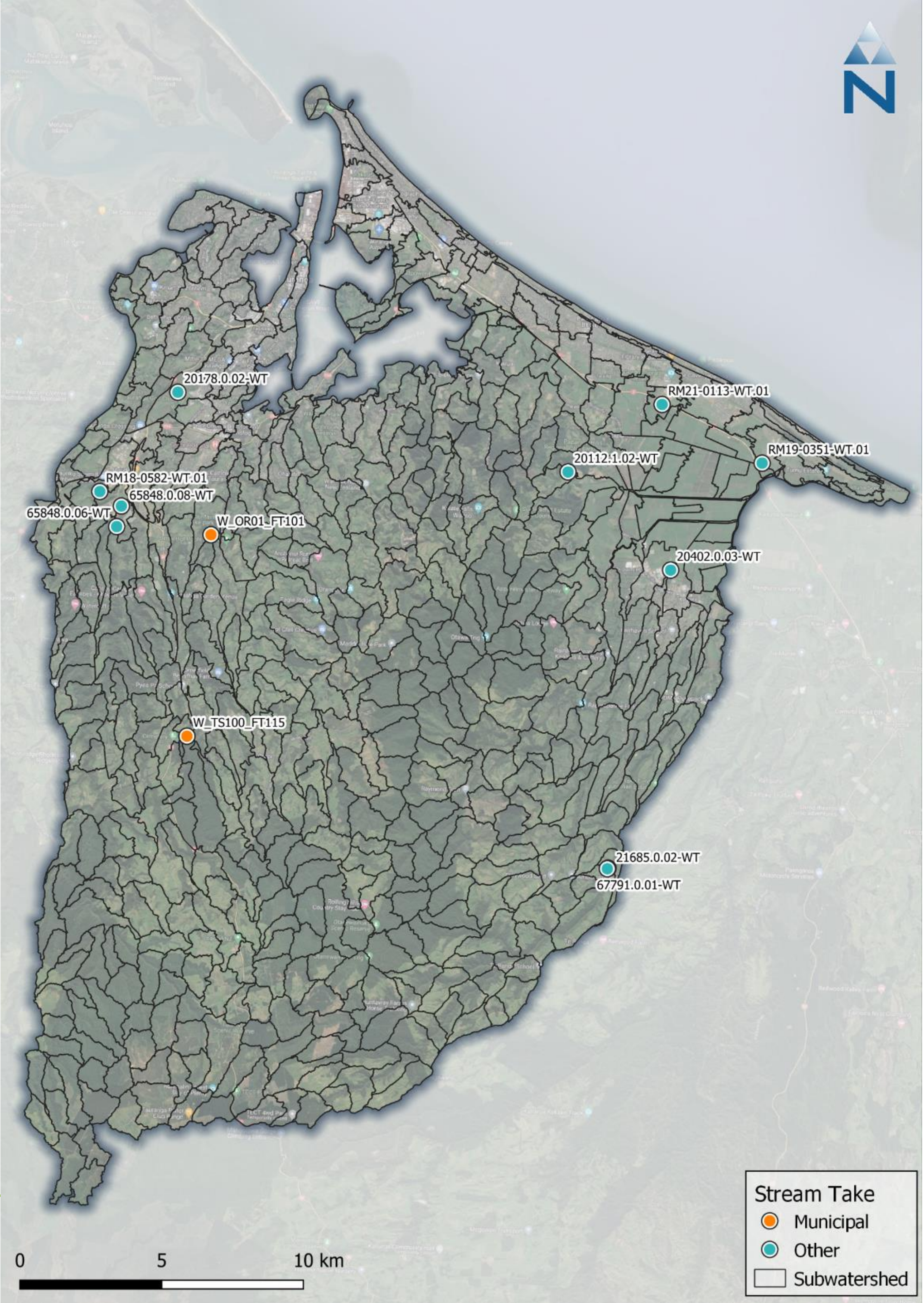
(Data Summary)



TCC FWMT Domain: Number of Consented Takes vs Max Volume - 64,000 ML/A

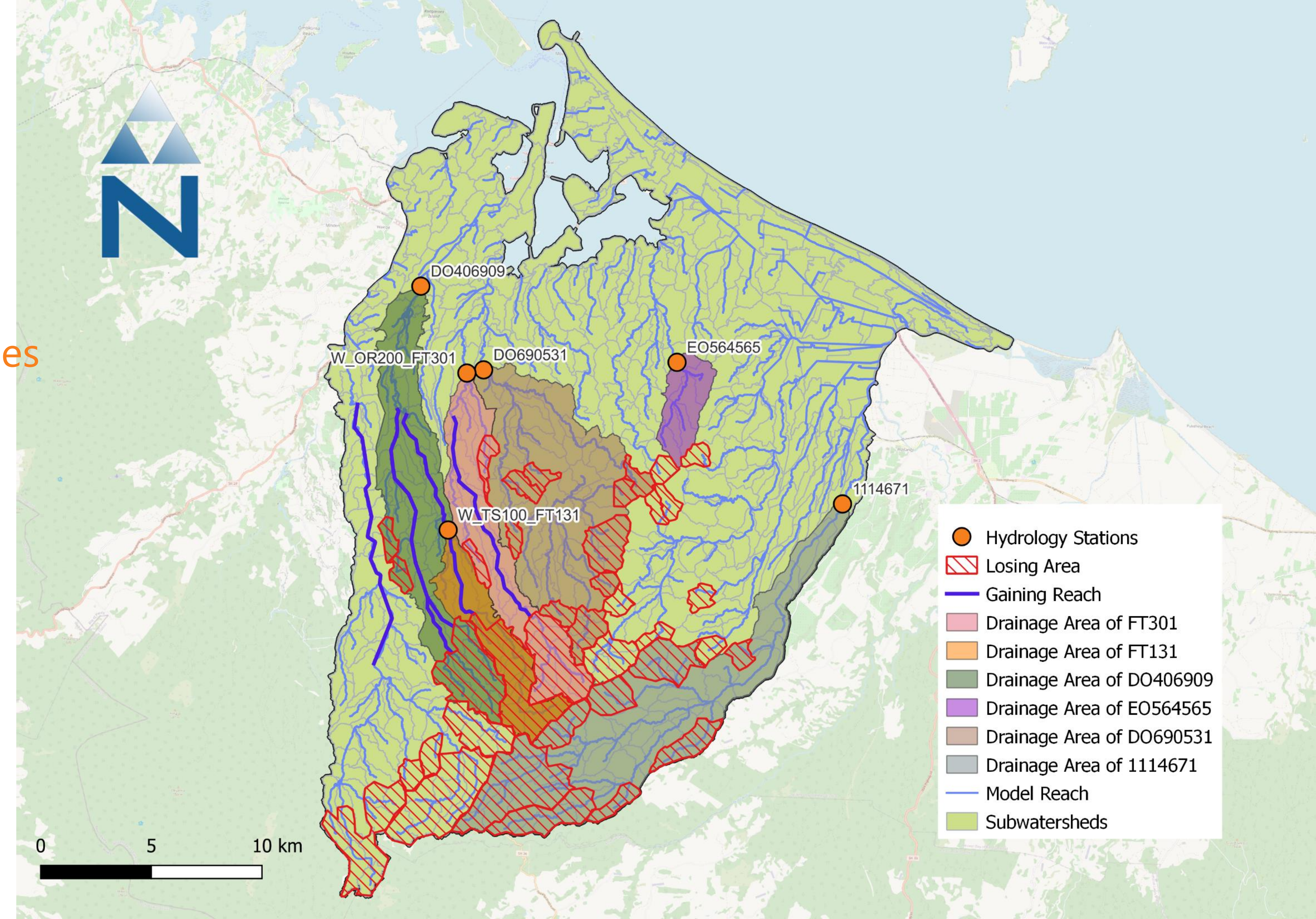


- TCC Takes (87%)
- Others over 10 L/s Average (11%)* Excl Frost Only
- Others under 10 l/s (2%)



Hydro-geology

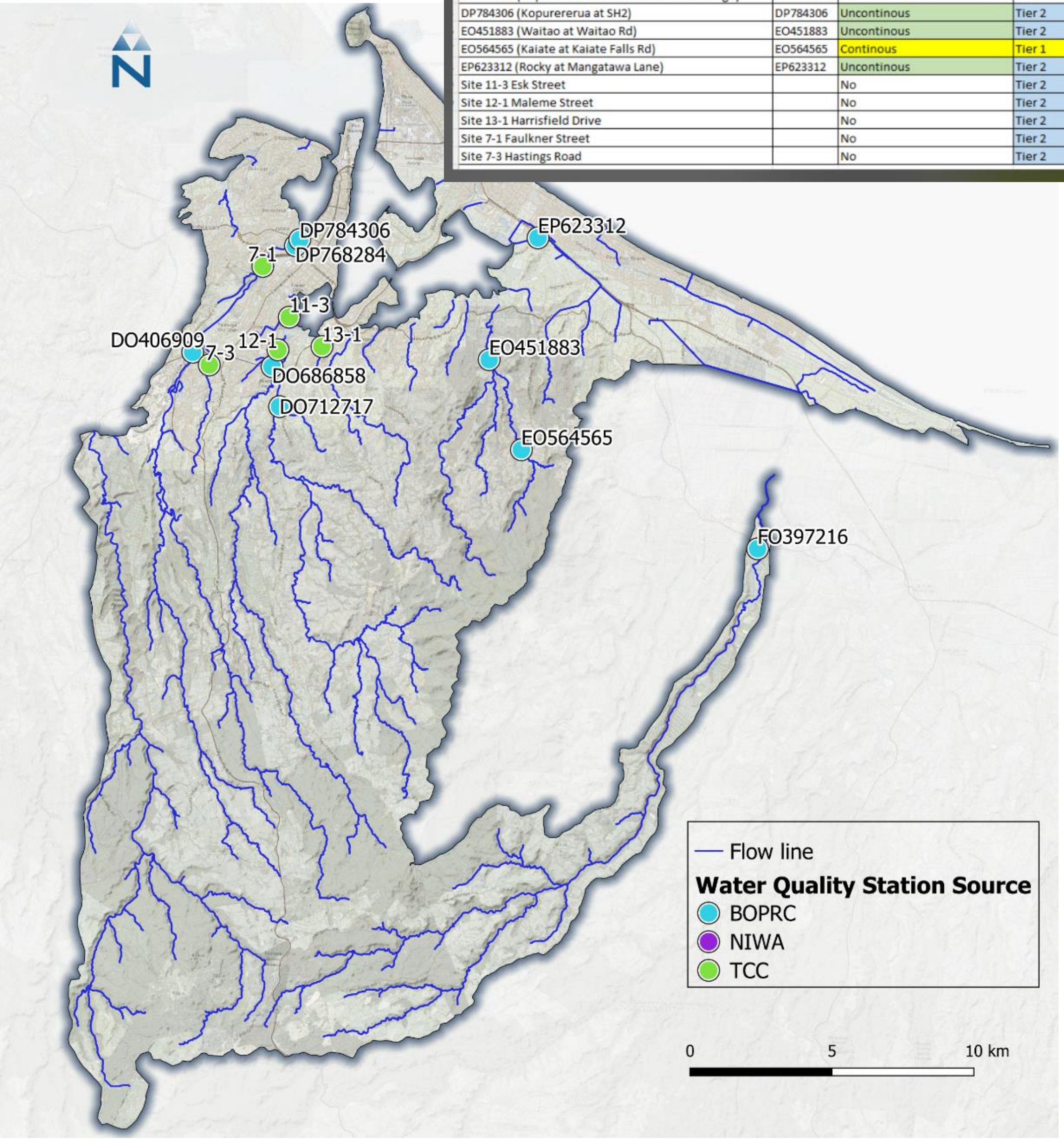
Calibration Gauges
Gaining Streams
Losing Streams



Water Quality Data Inventory

STANAME	Flow Gage	Flow_Note	Tier
DN390630 (Kopurererua at Taumata Bridge)		No	Tier 3
DN517858 (Tautau at Pyes Pa Rd)	W-TS100-FT	Continous	Tier 1
DN732387 (Tautau at Oropi Road Bridge)		No	Tier 3
DO279543 (Kopurererua at U/S Clear Springs Orchard)		No	Tier 3
DO301351 (Tautau 1300m u/s Kopurererua confluence)		No	Tier 3
DO318701 (Kopurererua at Paraone Koikoi Dr)		No	Tier 3
DO332334 (Kopurererua 1300m u/s Tautau confluence)		No	Tier 3
DO406909 (Kopurererua at SH29)	DO406909	Continous	Tier 1
DO446932 (Nanakau 500m u/s Kopurererua)		No	Tier 2
DO686858 (Waimapu 100m d/s SH29)	DO686858	Uncontinous	Tier 2
DO712717 (Waimapu at Pukemapu Rd)	DO712717	Uncontinous	Tier 2
DP562094 (Kopurererua at Wylie St Footbridge)		No	Tier 3
DP631185 (Kopurererua Old Channel at Old Bridge)		No	Tier 3
DP784306 (Kopurererua at SH2)	DP784306	Uncontinous	Tier 2
EO451883 (Waitao at Waitao Rd)	EO451883	Uncontinous	Tier 2
EO564565 (Kaiate at Kaiate Falls Rd)	EO564565	Continous	Tier 1
EP623312 (Rocky at Mangatawa Lane)	EP623312	Uncontinous	Tier 2
Site 11-3 Esk Street		No	Tier 2
Site 12-1 Maleme Street		No	Tier 2
Site 13-1 Harrisfield Drive		No	Tier 2
Site 7-1 Faulkner Street		No	Tier 2
Site 7-3 Hastings Road		No	Tier 2

Station ID	TAM	NO2	NO3	DO	SED	TEMP	TCU	TZN	PO4	TN	NOX	TP	ECOLI
DN390630	15	0	0	15	14	15	0	0	15	15	15	15	15
DN517858	14	0	0	14	13	15	0	0	14	14	14	14	14
DN732387	15	0	0	15	12	15	0	0	15	15	15	15	15
DO279543	10	0	0	10	9	10	0	0	10	10	10	10	10
DO301351	14	0	0	12	14	14	10	10	14	14	14	14	14
DO318701	15	0	0	15	14	15	15	15	15	15	15	15	15
DO332334	14	0	0	14	14	14	5	5	14	14	14	14	14
DO406909	207	0	0	197	388	198	15	15	206	170	207	208	208
DO446932	15	0	0	15	14	15	14	14	15	15	15	15	15
DO686858	167	0	0	169	166	170	0	0	166	145	169	170	168
DO712717	137	0	0	136	136	137	0	0	131	101	133	137	148
DP562094	15	0	0	15	14	15	15	15	15	15	15	15	15
DP631185	15	0	0	14	14	15	15	15	15	14	15	14	15
DP784306	199	0	0	198	195	200	14	14	199	159	200	202	201
EO451883	158	0	0	156	156	158	0	0	155	142	156	158	157
EO564565	10	0	0	82	10	83	0	0	10	10	9	10	483
EP623312	155	0	0	151	156	153	0	0	154	104	157	158	156
Site 11-3 Esk Street	5	5	5	5	2	5	4	5	0	0	0	0	0
Site 12-1 Maleme Street	26	28	28	28	28	28	20	28	0	0	0	0	8
Site 13-1 Harrisfield Drive	25	28	28	28	24	28	18	27	0	0	0	0	7
Site 15-2 Hammond St.	0	0	0	0	0	0	0	0	0	0	0	0	0
Site 6-3 Birch Ave (NEW)	0	0	0	0	0	0	0	0	0	0	0	0	0
Site 7-1 Faulkner Street	23	27	28	27	27	28	16	28	0	0	0	0	6
Site 7-2 Chadwick Road	1	2	2	2	2	2	2	2	0	0	0	0	0
Site 7-3 Hastings Road	9	9	9	9	9	9	3	9	0	0	0	0	0
Site 7-4 Kennedy Road	0	0	0	0	0	0	0	0	0	0	0	0	0
Site 8-1 Taniwha Place	21	20	29	29	29	29	7	26	0	0	0	0	7
Site 8-2 Miles Lane	27	28	29	29	26	29	13	28	0	0	0	0	8
Total	1312	147	158	1385	1486	1400	186	256	1163	972	1173	1184	1699



Model Approach

- FWMT leverages similar programmes in Aotearoa
  - Auckland FWMT
  - Tātaki Wai: Kaipara Moana
- Continuous simulation timeseries 15-year, 15-minute time step
- Process driven hydrology and contaminant
- Simplified groundwater representation

The FWMT

Process-based, Open Sourced, Peer-Reviewed, and Tested in Regulatory Processes

Input

- Climate / Rain
- Land Use / Soils
- Slope / Imperviousness
- Aquifer/spring interactions
- Point sources / takes
- And much more

Output

- Continuous simulation time series of flow & contaminants for each land use, subwatershed and waterbody

LSPC Watershed Model

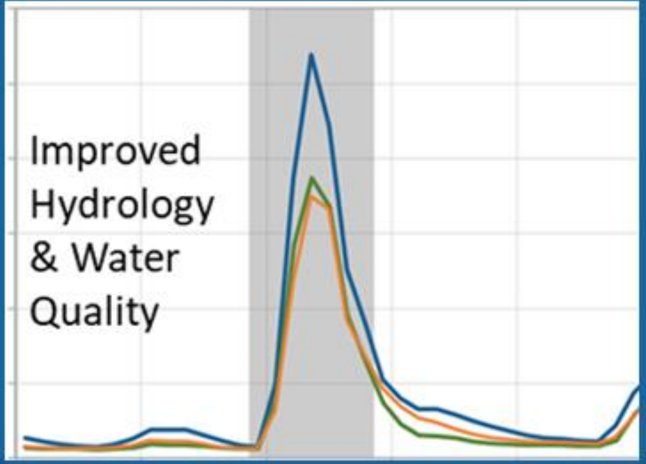
Current State Model

TCC Study Area

SUSTAIN

Future State Model

- Time series after optimised implementation of source control and infrastructure

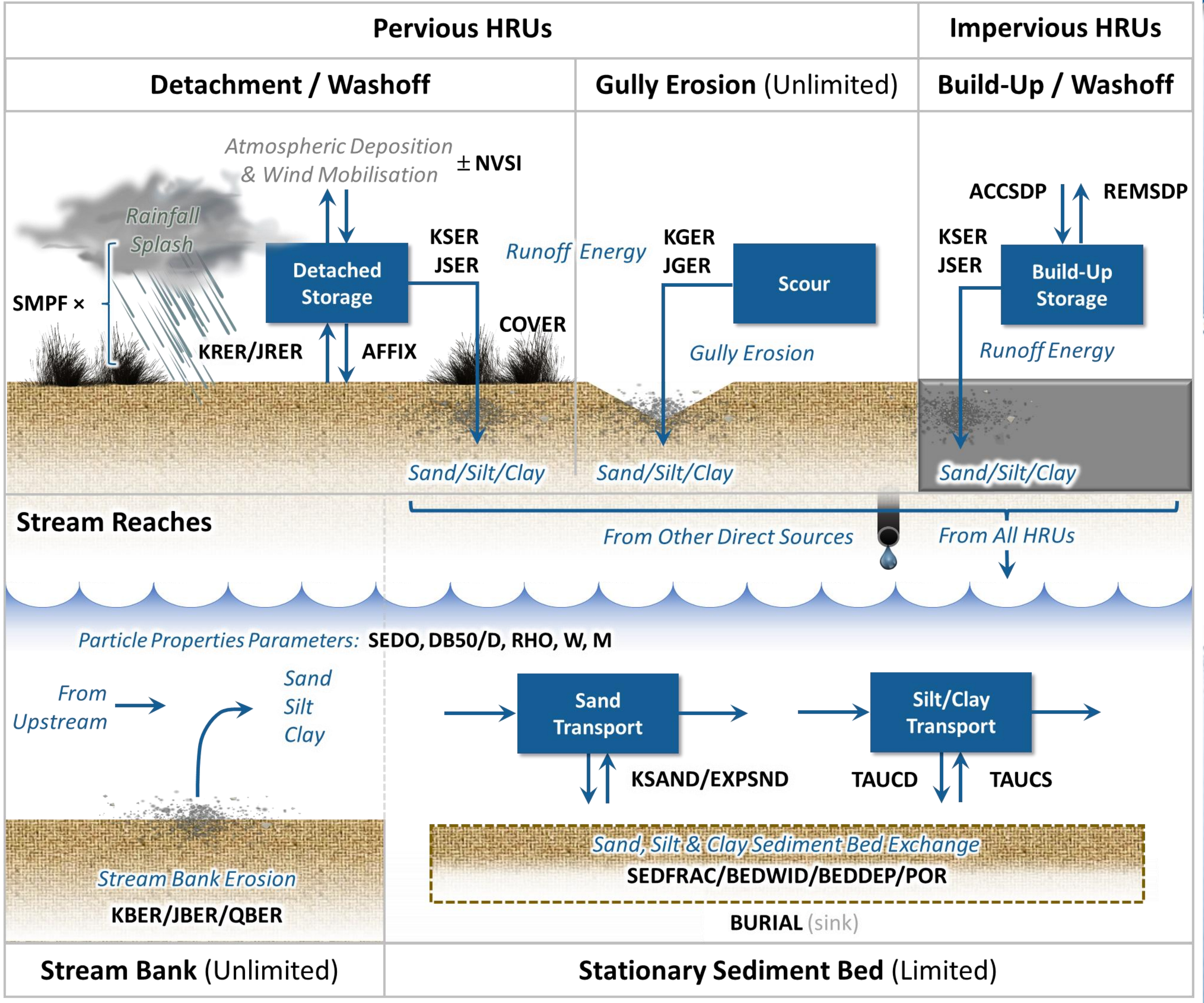


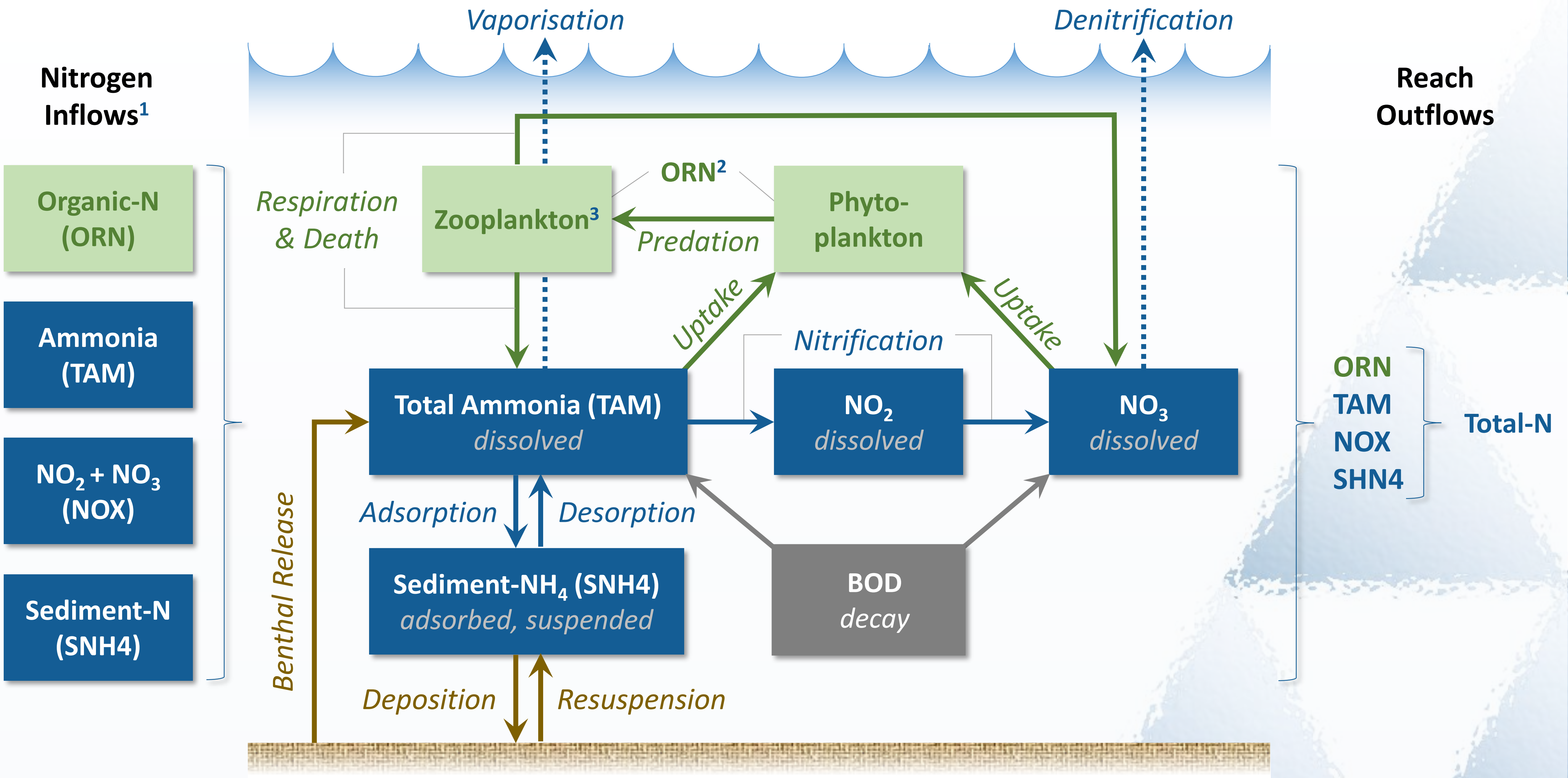
HRU Distribution (LULC-Impact × Soil Group × Slope)

109 Potential HRUs (if stratified by ALL soil and ALL slope combinations)

LUID	Land Use/LandCover and Impact (LULC)	Percent Area	Effective Impervious	Soil Group						Slope		
				All	A+	A	B	C	D	All	Low	High
				0	1	2	3	4	5	0	1	2
1000	Dev_Commercial	0.2%	69.3%	-	-	86.3%	-	-	13.7%	0.1%	91.6%	8.3%
2000	Dev_Industrial	0.8%	70.3%	-	-	91.0%	-	-	9.0%	0.3%	90.5%	9.2%
3000	Dev_Residential	3.2%	28.8%	-	-	90.5%	0.0%	-	9.5%	0.1%	74.6%	25.3%
4001	Roof_Impact_1	1.5%	31.8%	-	1.2%	93.6%	0.0%	-	5.2%	0.0%	86.7%	13.3%
4002	Roof_Impact_2	0.4%	34.8%	-	1.3%	93.6%	0.0%	-	5.0%	0.0%	83.1%	16.9%
4003	Roof_Impact_3	0.7%	50.1%	-	0.8%	93.6%	0.0%	-	5.6%	0.0%	88.5%	11.5%
5001	Dev_Road_Impact_1	0.8%	45.0%	-	5.7%	88.3%	-	-	6.0%	0.0%	87.0%	13.0%
5002	Dev_Road_Impact_2	0.3%	51.4%	-	0.2%	93.7%	-	-	6.2%	-	93.9%	6.1%
5003	Dev_Road_Impact_3	0.4%	48.9%	-	-	81.5%	-	-	18.5%	0.0%	95.5%	4.5%
5004	Dev_Road_Impact_4	0.1%	54.6%	-	-	99.0%	0.9%	-	0.1%	0.1%	94.1%	5.7%
6000	Dev_Pervious	4.3%	-	-	-	86.1%	0.0%	-	13.8%	0.3%	70.3%	29.4%
7000	OSWW	0.2%	-	-	4.9%	86.3%	0.0%	-	8.8%	0.0%	61.3%	38.7%
8001	Horticulture_Impact_1	1.0%	-	-	6.1%	91.0%	0.0%	-	2.9%	0.0%	56.0%	44.0%
8002	Horticulture_Impact_2	1.1%	-	-	-	41.1%	-	-	58.9%	0.0%	79.9%	20.1%
8003	Horticulture_Impact_3	6.2%	-	-	0.1%	94.1%	0.0%	-	5.7%	0.0%	74.9%	25.1%
9001	Pasture_Impact_1	21.0%	-	-	22.5%	72.5%	0.1%	-	4.9%	0.0%	34.6%	65.4%
9002	Pasture_Impact_2	11.0%	-	-	33.4%	32.5%	-	-	34.1%	0.0%	55.5%	44.4%
10000	Rural_Grassland	2.1%	-	-	18.9%	70.9%	-	-	10.2%	0.1%	44.3%	55.6%
11001	Forest_Impact_1	38.3%	-	-	28.1%	68.9%	0.0%	-	3.0%	0.0%	16.6%	83.3%
11002	Forest_Impact_2	5.7%	-	-	36.2%	63.3%	-	-	0.5%	-	19.9%	80.1%
12001	Unsealed_Road_Impact_1	0.3%	-	-	39.0%	54.3%	-	-	6.7%	-	59.0%	41.0%
14000	Water	0.4%	-	-	6.1%	47.0%	-	-	46.8%	1.4%	66.4%	32.2%
	Watershed Total	**100%**	**3%**	**0%**	**22%**	**69%**	**0%**	**0%**	**9%**	**0%**	**38%**	**61%**

Sediment Model

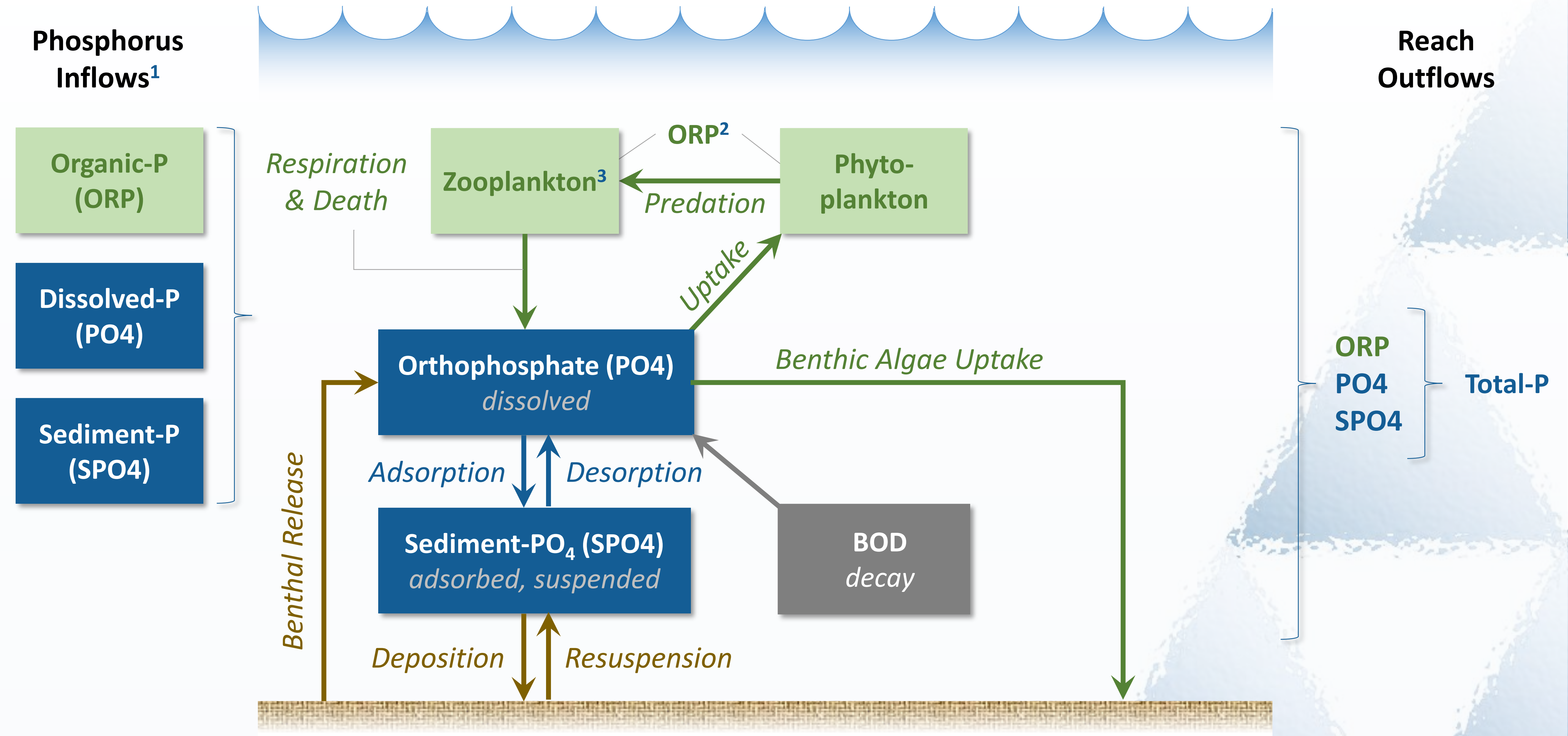




1: Nitrogen inflows vary by HRU type and flow pathway (i.e., surface, interflow, groundwater; point sources & upstream reaches)

2: ORN, Organic-P (ORP), Organic-C (ORC), and BOD are updated with phytoplankton death

3: Zooplankton is not simulated in Freshwater Management Tool



1: *Phosphorus inflows vary by HRU type and flow pathway (i.e., surface, interflow, groundwater; point sources & upstream reaches)*

2: *ORP, Organic-N (ORN), Organic-C (ORC), and BOD are updated with phytoplankton death*

3: *Zooplankton is not simulated in Freshwater Management Tool*

Model Calibration

Weather Data

Ensure quantity + quality of spatial/temporal coverage of forcing data that drive watershed hydrology.

Land Hydrology

Identify influential land use features and factors. Define parameter groups. Check base flow, runoff, seasonal.

Stream Transport

Include special hydraulic features of stream routing network (i.e., reservoirs, point sources, diversions).

Water Quality

1. Sediment
2. Associated Pollutants
3. Other Pollutants
4. Fate and Transport

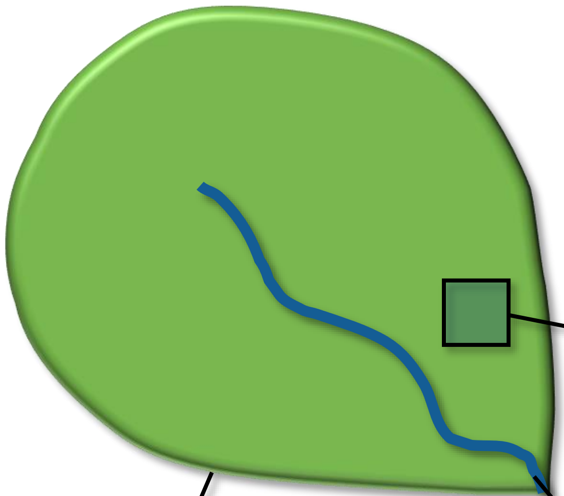
Focus: Weather Data

Focus: Upstream Flow Gages

Focus: Downstream Flow Gages

Focus: Instream Gages

Parallel Objective: *Minimize Uncertainty Propagation*



By HRU × Subatchment (Physical):

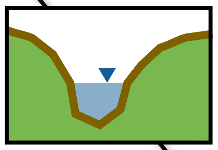
- Slope of HRU
- Length of Overland Flow
- Imperviousness

By Individual HRU (Processes):

- Interception Storage Capacity
- Subsurface Storage Capacity
- All other Hydrological Parameters, Rates, and Constants

By Subcatchment:

- Parameter Group*
- HRU Area Distribution
- Weather Data
- Average Elevation
- Reach or Lake Segment



By Reach/Lake Segment:

- Reach Group *
- Geometry
- Transport Rates and Constants

* Parameter/Reach Groups can be used to differentiate features with distinct characteristics.

Stream Representation

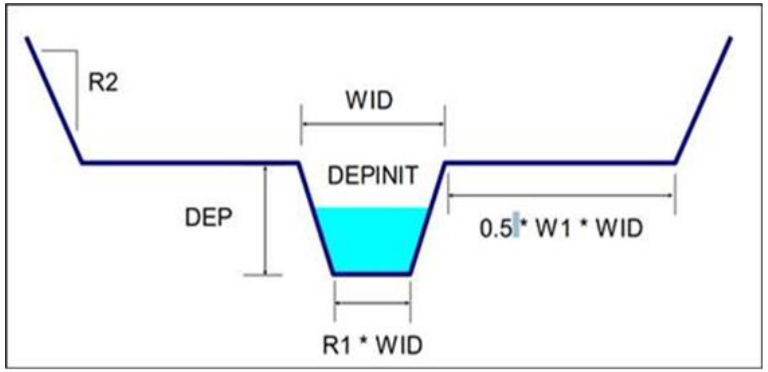
Advanced geospatial analysis to develop representative stream geometries at a **regional scale**

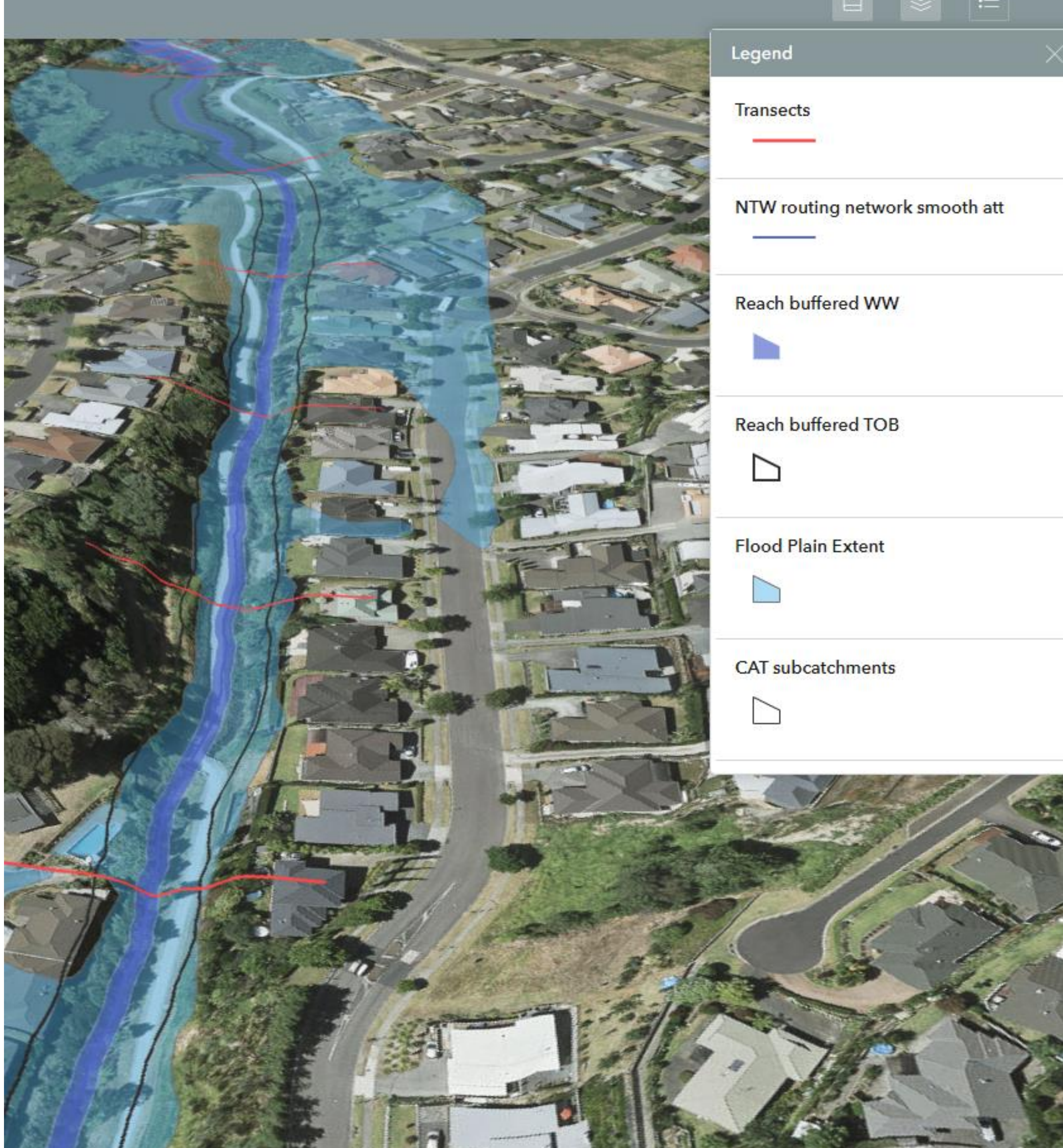
Stream Delineation

- Development of a primary flow network to burn all known pipes into a topographical raster to trace hydrological connection (not flood connection) and define actual water quality event catchments

Stream Channel Geometry

- Extraction of representative cross sections from LiDAR
- Automated workflows in FME to draw average parameters by reach for friction, erosivity, vegetation etc.



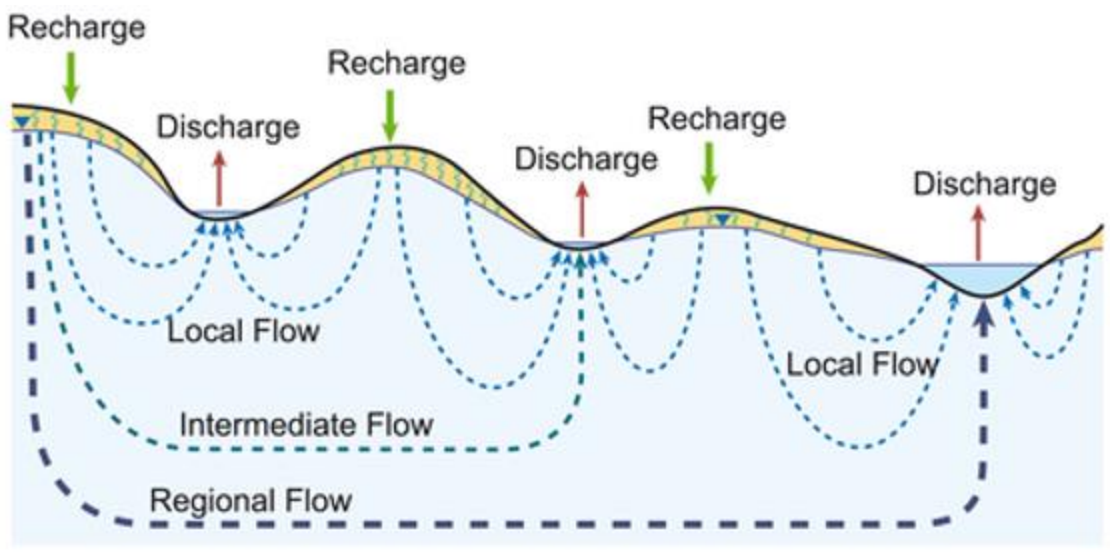


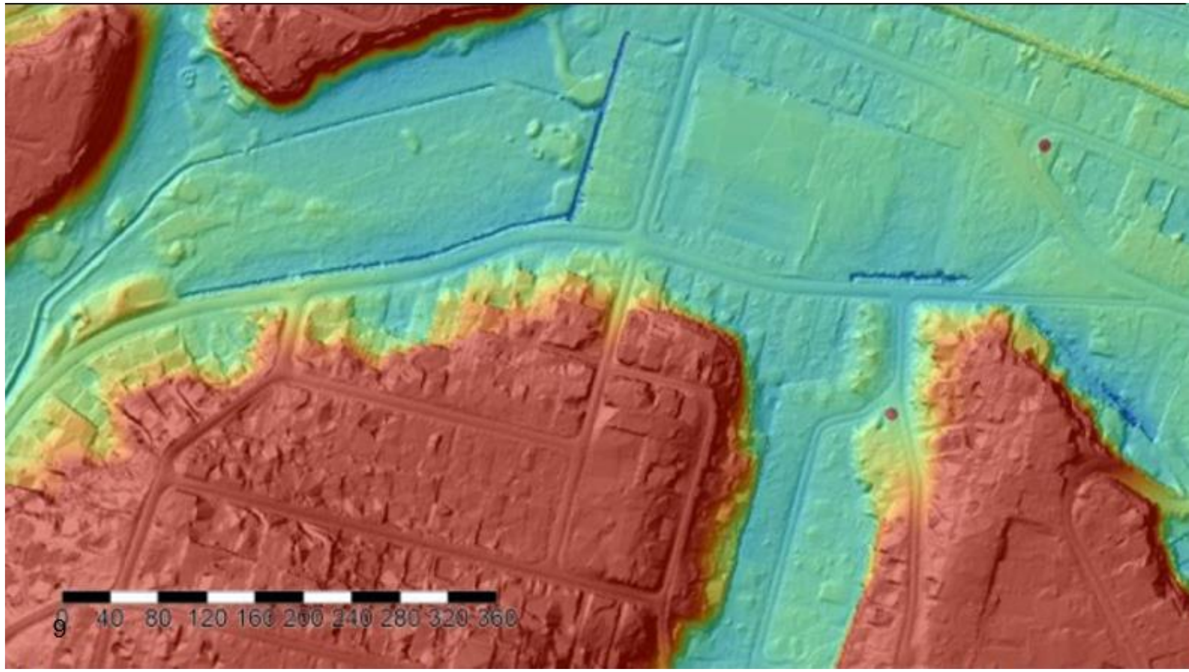
Groundwater Representation

Targeted approaches for different hydrogeological conditions and the purpose of FWMT in different areas

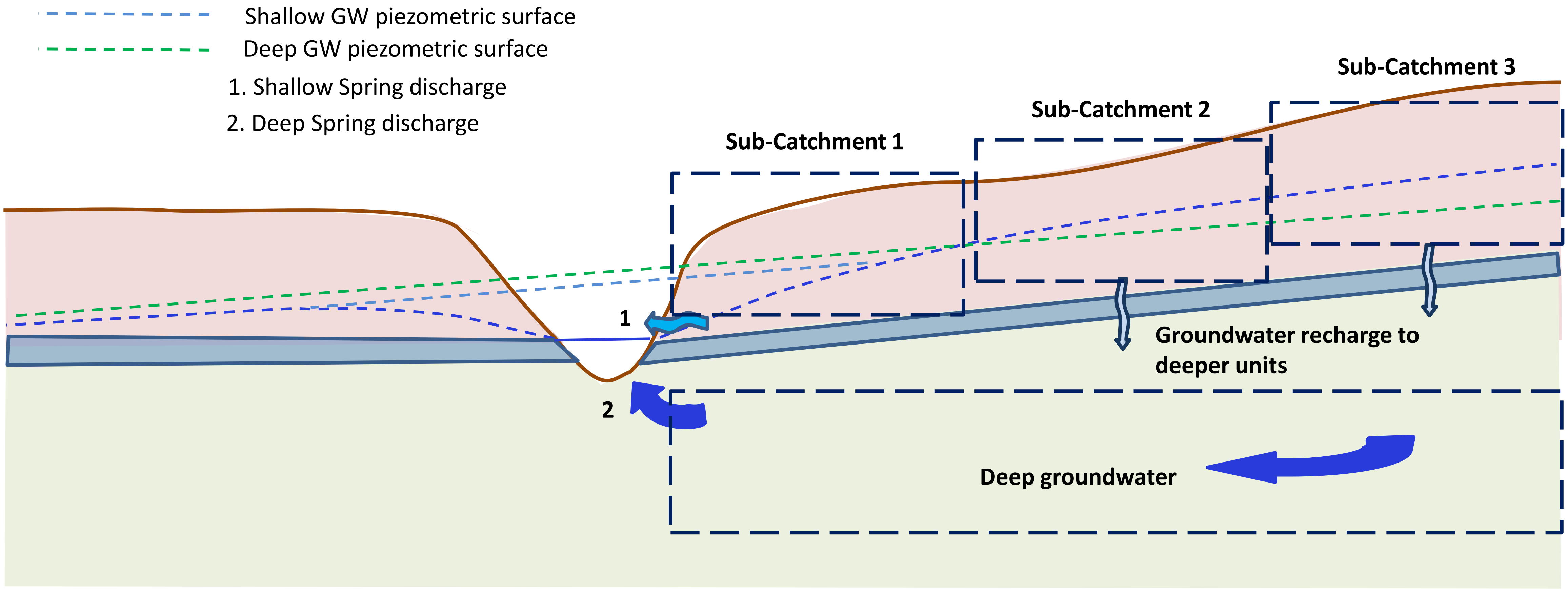
Key points

- Water supply streams show a relationships between stream flow and groundwater recharge at different catchment scales
- Climate is influencing stream flow, with streams recently at record low levels
- Understanding the geological and hydrogeological setting is critical to predicting groundwater flow, stream low-flow and scenario outcomes
- Soil-water balance and climate models provide a scalable approach for predicting groundwater recharge and discharge
- Different approaches and level of detail in different areas, dependent upon FWMT objectives and available information



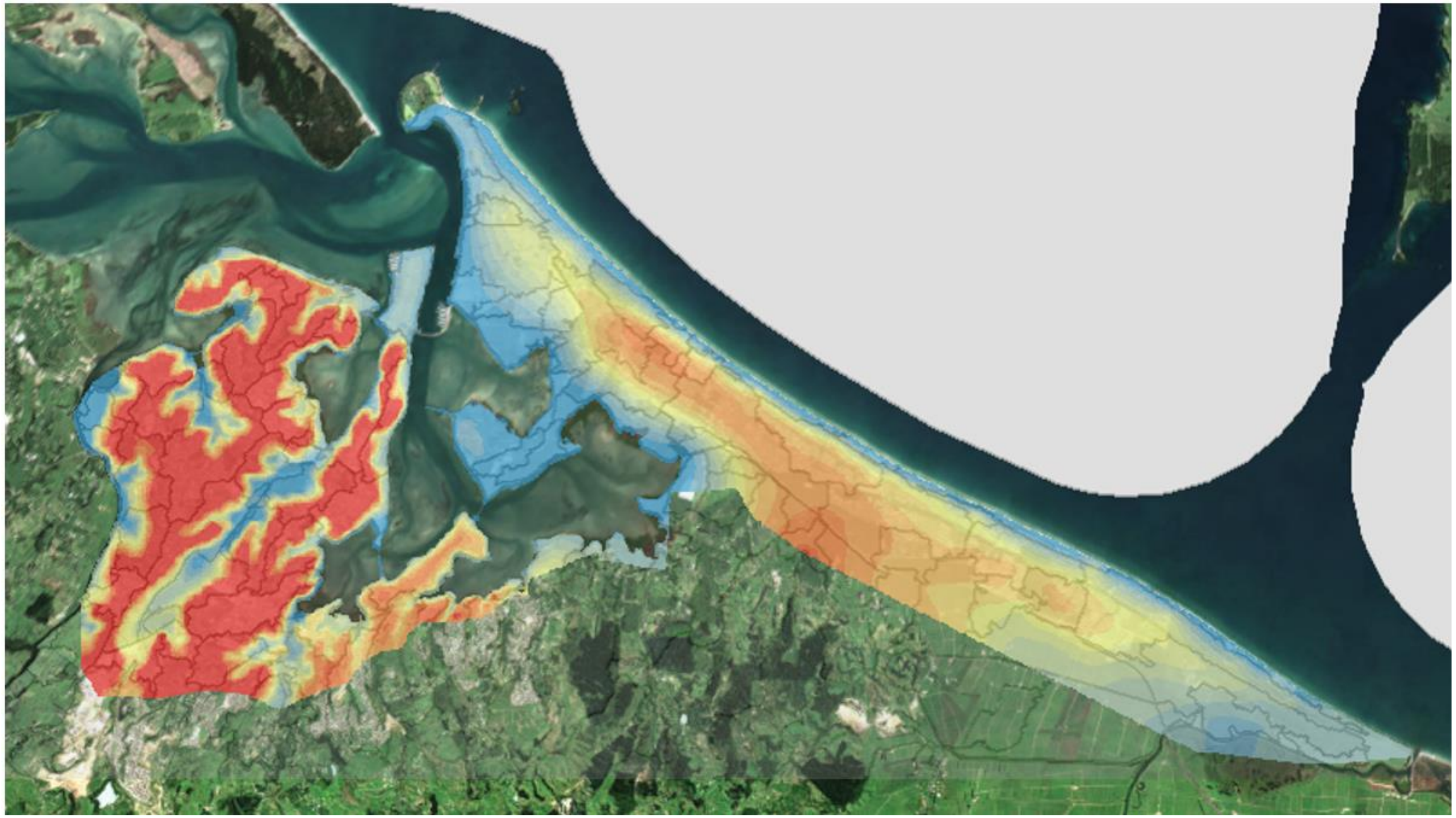


Upper Catchment



Lower Catchment

- Cross-catchment groundwater flow
- Routing of deep groundwater recharge to adjacent sub-catchment active groundwater
- Degree of routing based on estimated groundwater catchment area and groundwater flow estimates



GW Issues and opportunities

Information Gaps

- Groundwater level times series representative of shallow and deep volcanic rock – connectivity, aquifer response and properties
- Groundwater level data in key upper and lower catchment areas – delineation of groundwater catchments
- Detailed geological and hydrogeological understanding near springs – influential lithology and hydraulic properties
- Groundwater recharge in Tauranga catchment
- Water chemistry

Issues

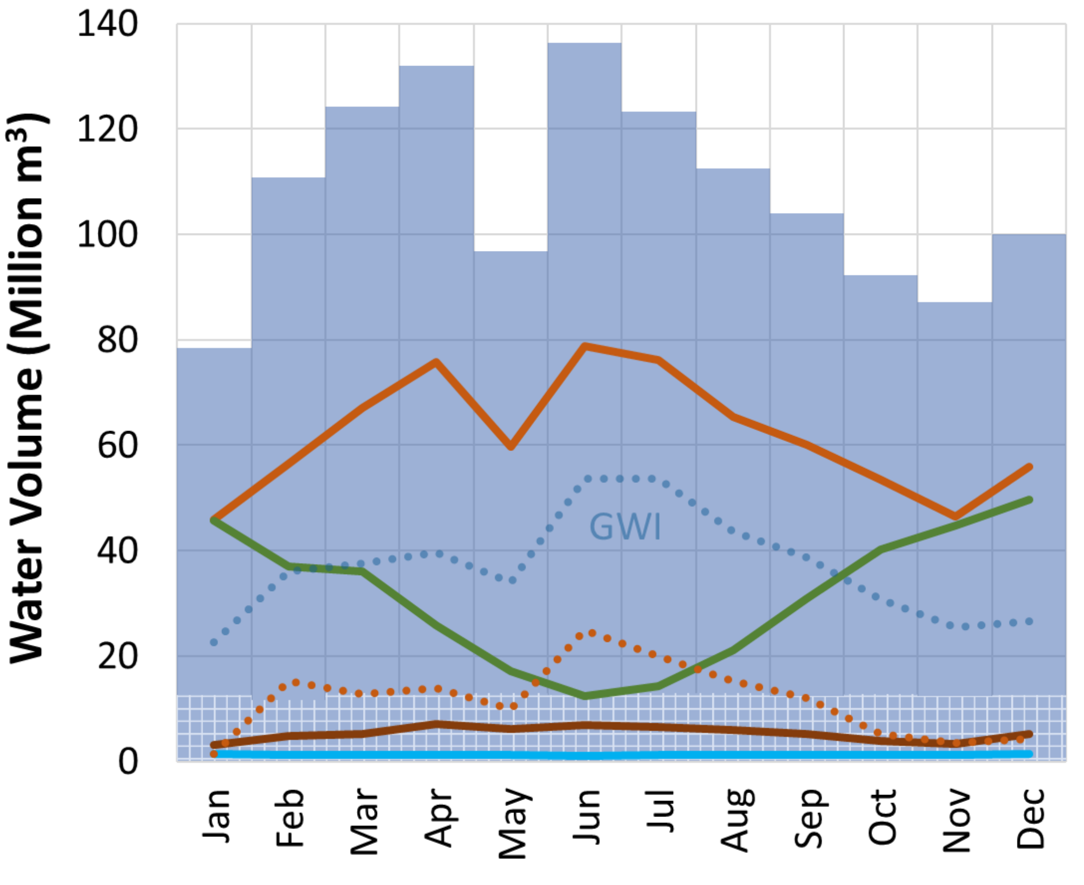
- Differences to BOPRC model and estimates
- Model uncertainty vs parameter uncertainty
- Simplified model not refined for groundwater take allocation

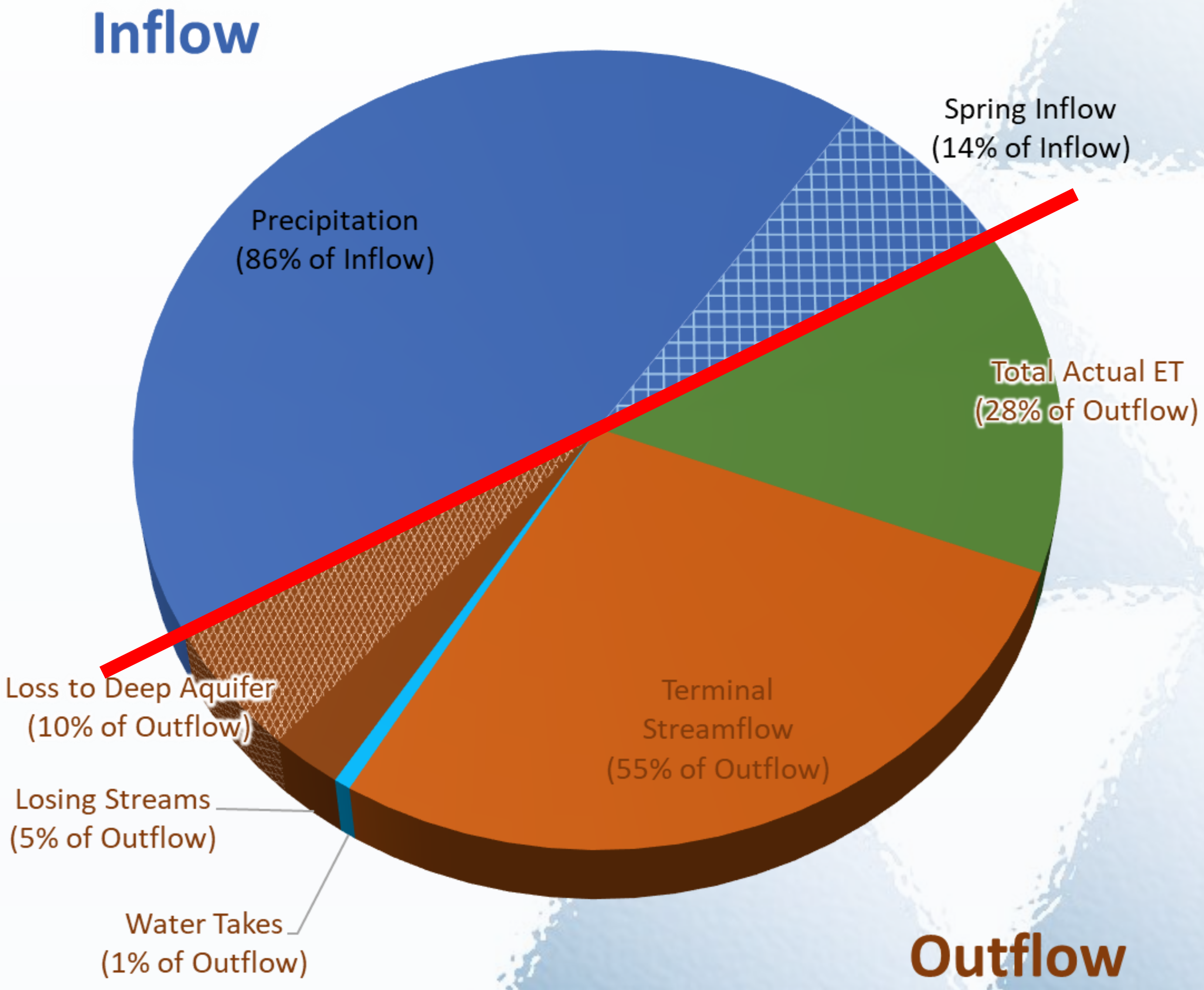
Opportunities

- Refine BOPRC Modflow model for a specific groundwater supply scenario

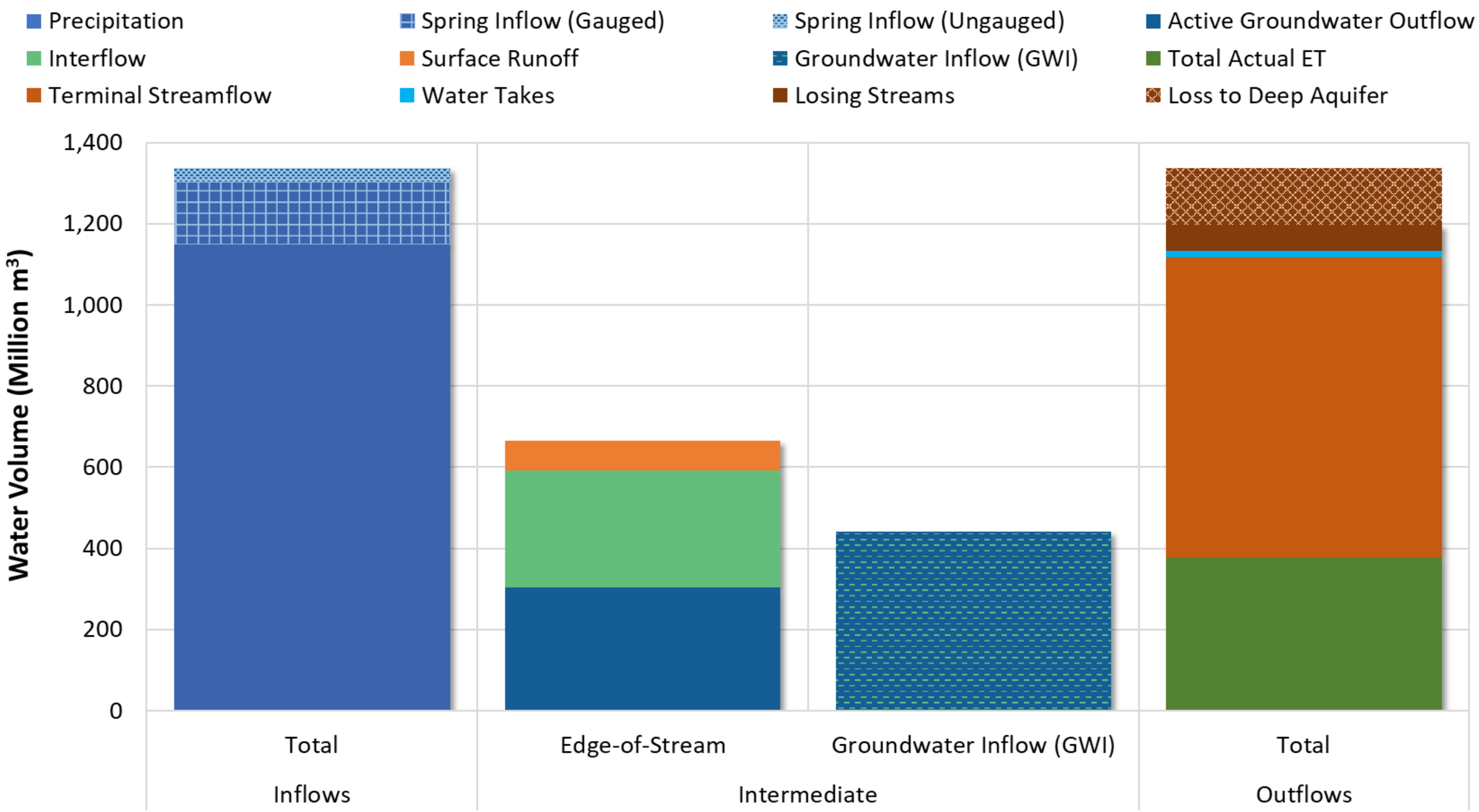
Results

Water Balance Summary





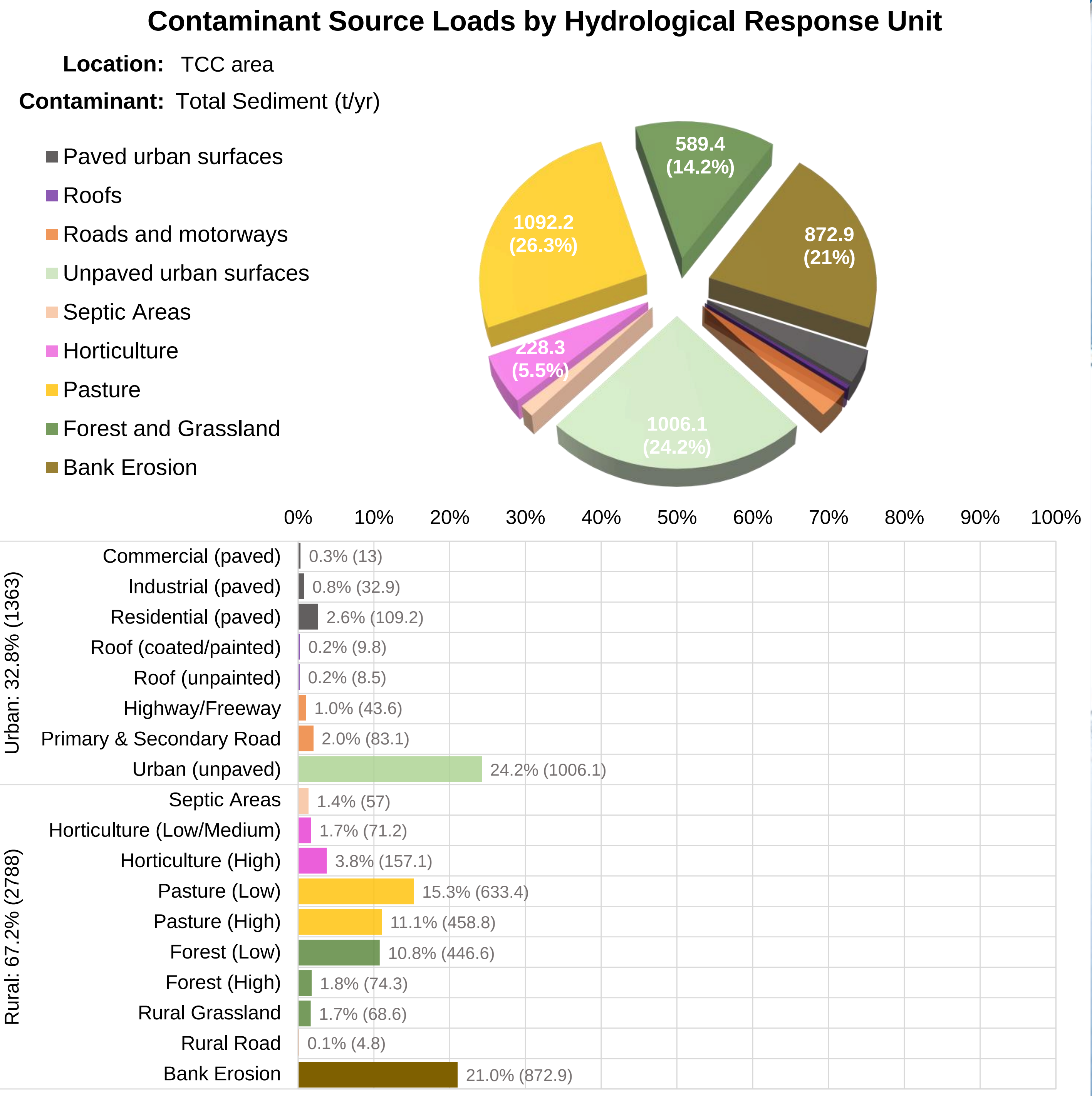
Water Budget Summary

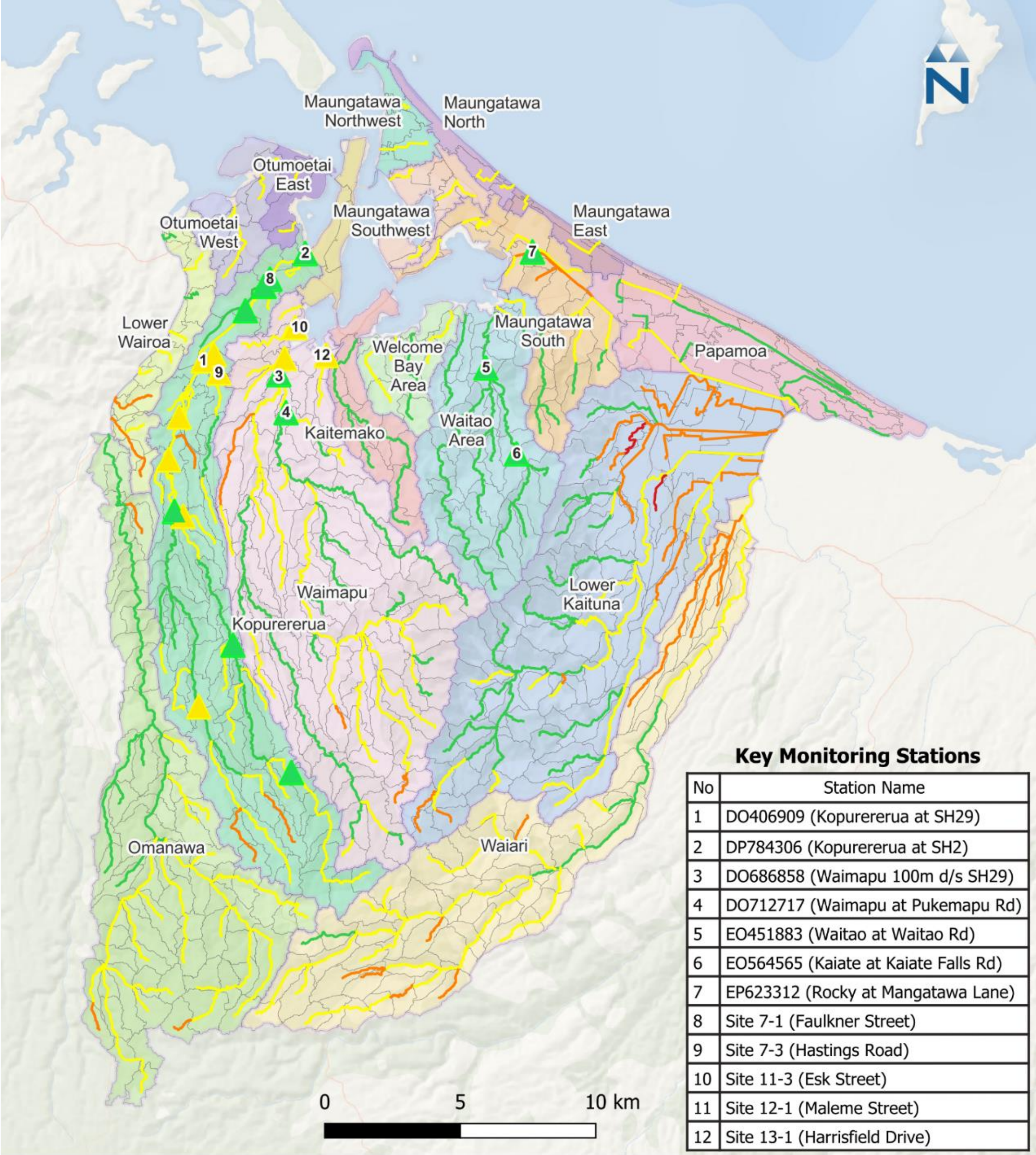


Source Apportionment *

- TCC sources only
- **Delivered** loads to waterbody by source
- Dominant sources:
  - **Pasture** (26.3%)
  - **Urban Unpaved** (24.2%)
  - **Bank Erosion** (21%)
  - **Forest & Grassland** (14%)
  - **Horticulture** (5.5%)

** Sediment load distribution from TCC area sources only*





Key Monitoring Stations

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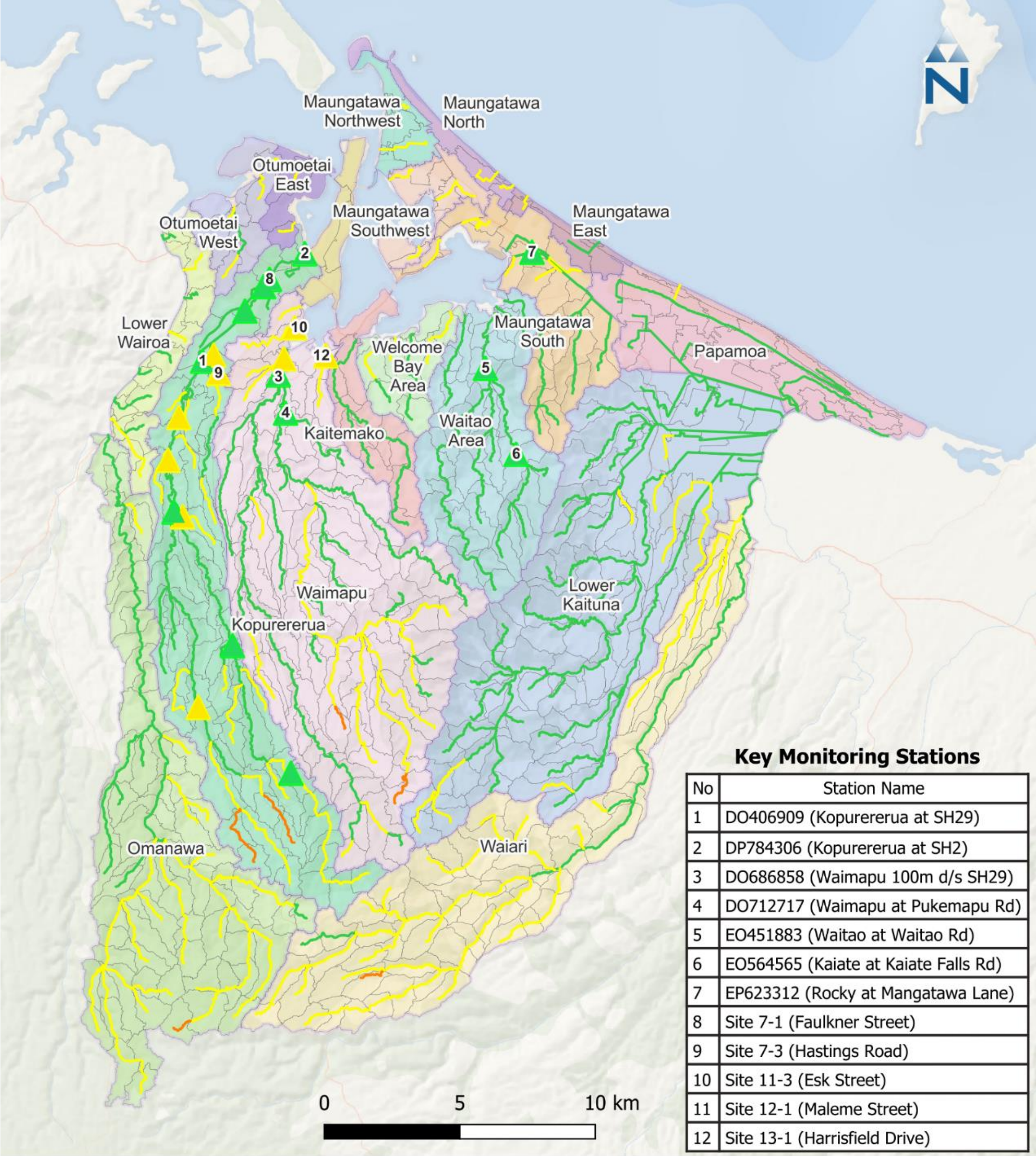
11	Site 12-1 (Maleme Street)
12	Site 13-1 (Harrisfield Drive)

Total Oxidised Nitrogen Predicted Grading

Streams
Subcatchments
Tauranga watersheds

Stream Segment and Predicted Grade
A
B
C
D / E

Observed Grades
A
B
C
D / E



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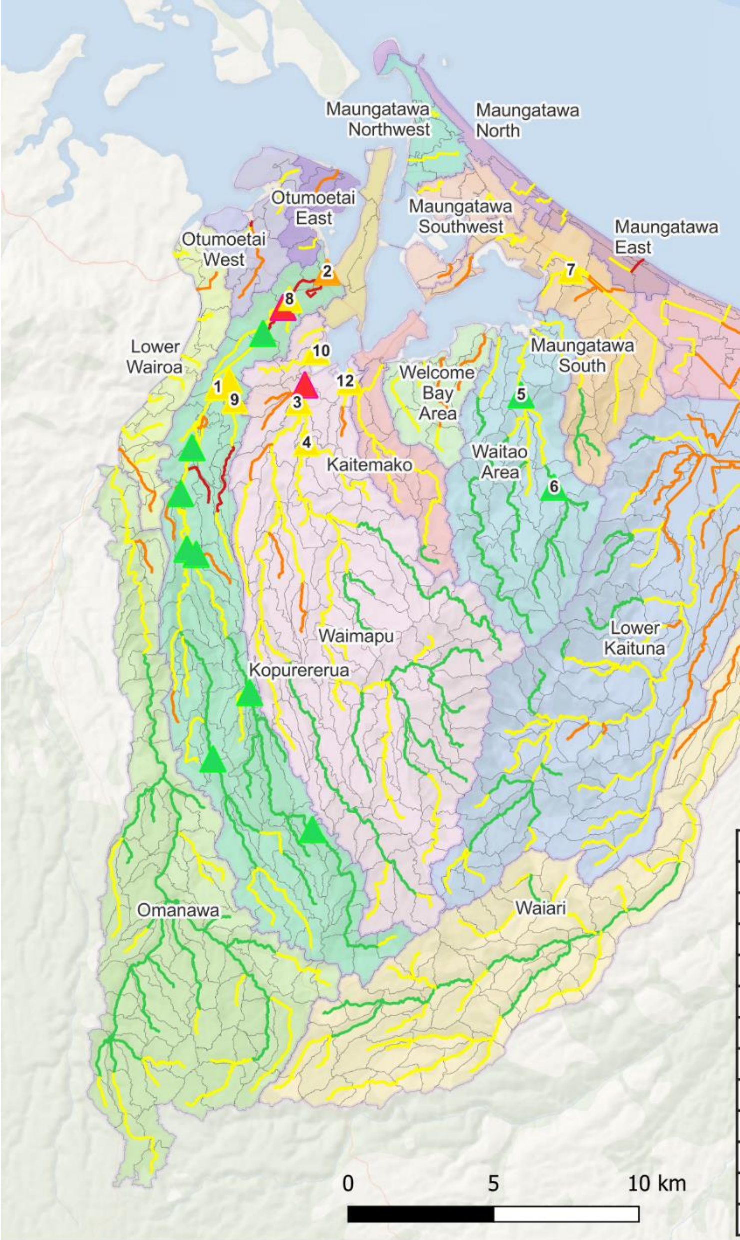
Total Oxidised Nitrogen Predicted Grading (based on Median only)

Streams
Subcatchments
Tauranga watersheds

Stream Segment and Predicted Grade
A
B
C
D / E

Observed Grades
A
B
C
D / E



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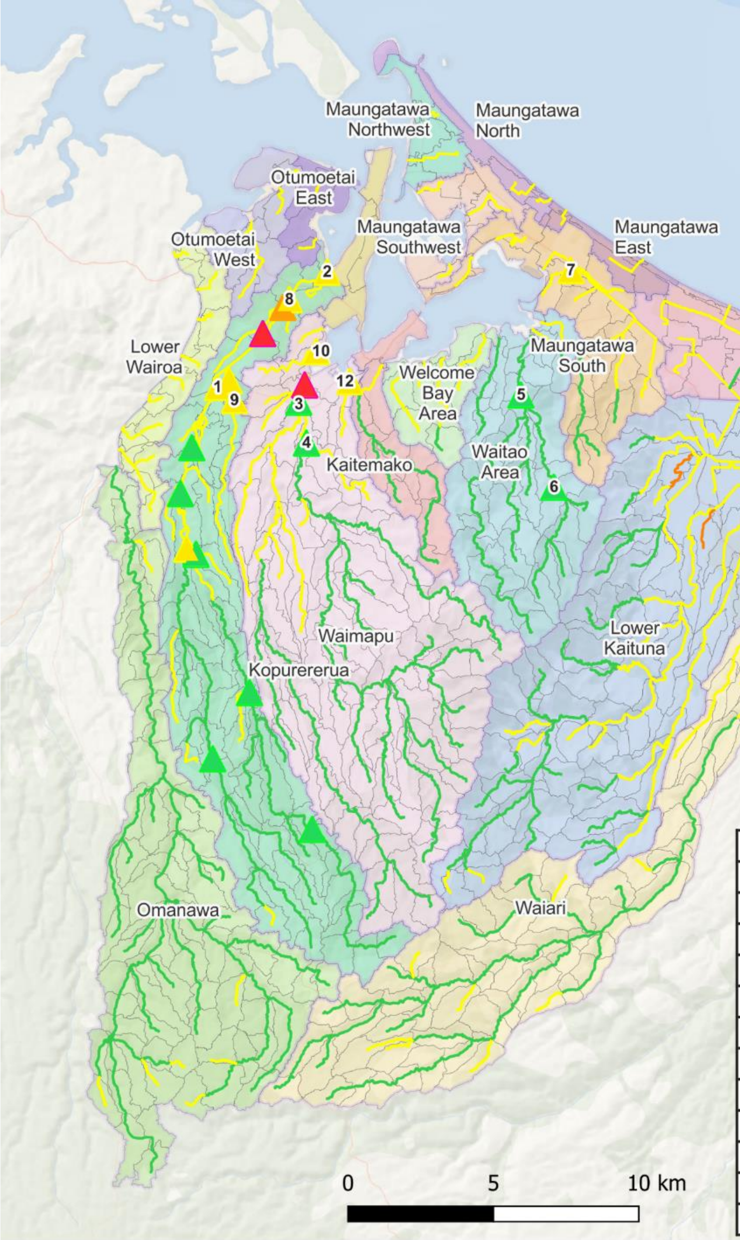
Total Ammoniacal Nitrogen
Predicted Grading
(using maximum)

Streams
Subcatchments
Tauranga watersheds

Stream Segment and Predicted Grade
A
B
C
D / E

Observed Grades
A
B
C
D / E



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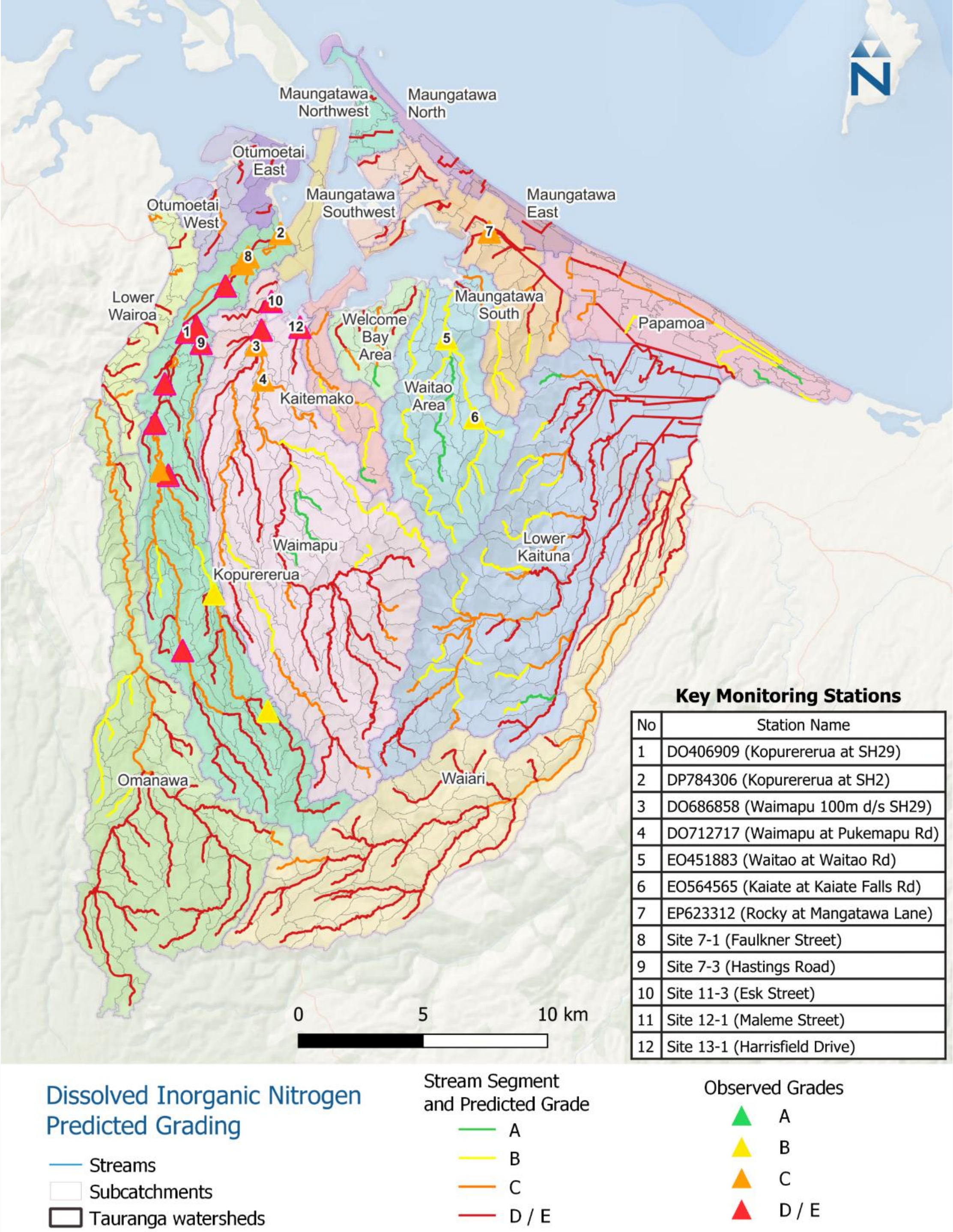
Total Ammoniacal Nitrogen
Predicted Grading
(using 95th percentile)

Streams
Subcatchments
Tauranga watersheds

Stream Segment and Predicted Grade
A
B
C
D / E

Observed Grades
A
B
C
D / E


Maungatawa Northwest
Maungatawa North
Otumoetai East
Otumoetai West
Maungatawa Southwest
Maungatawa East
Lower Wairoa
Welcome Bay Area
Maungatawa South
Papamoa
Kaitemako
Waitao Area
Waimapu
Lower Kaituna
Kopurererua
Omanawa
Wairari
0
5
10 km
Key Monitoring Stations
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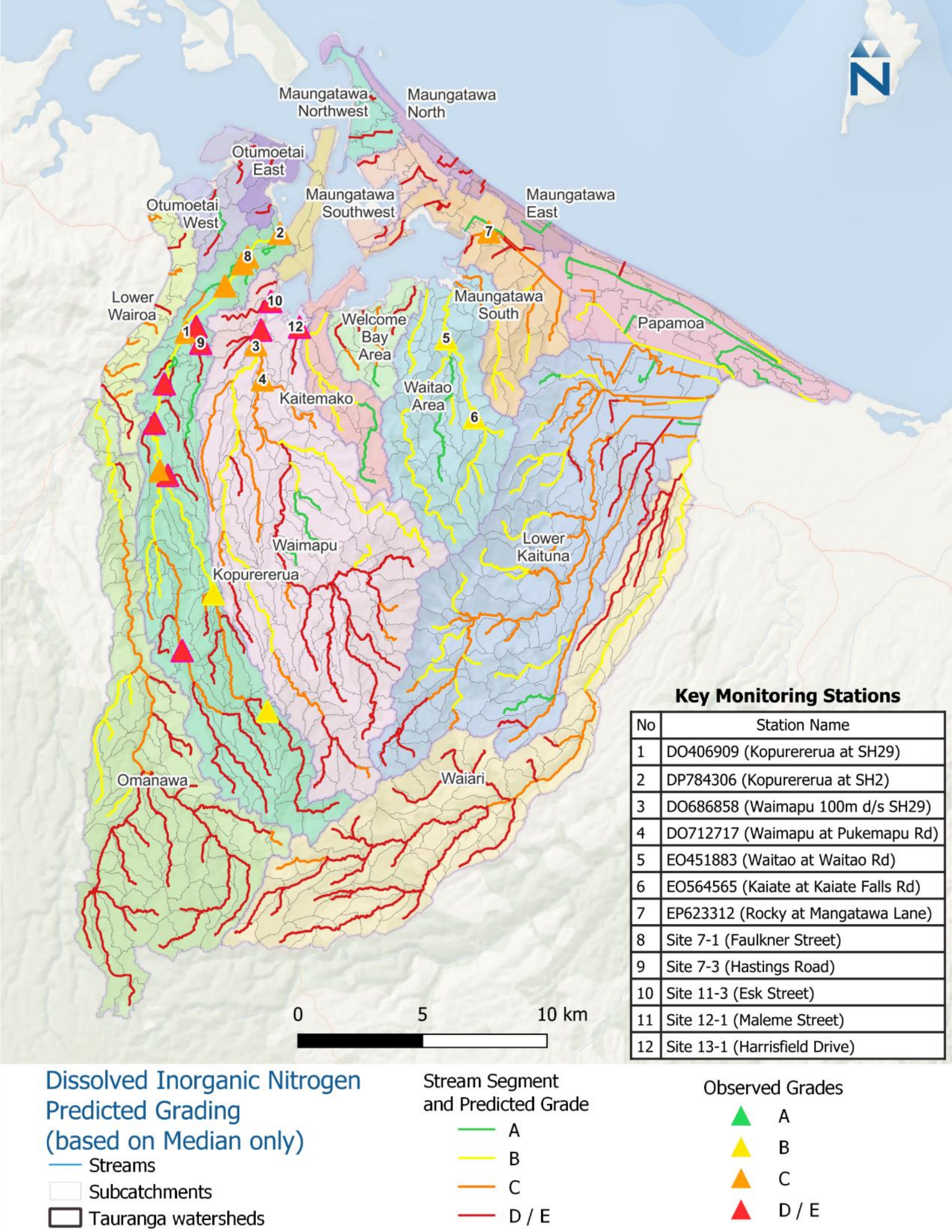
Dissolved Inorganic Nitrogen Predicted Grading
Streams
Subcatchments
Tauranga watersheds
Stream Segment and Predicted Grade
A
B
C
D / E
Observed Grades
A
B
C
D / E


Maungatawa Northwest
Maungatawa North
Otumoetai East
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Maungatawa Southwest
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Lower Wairoa
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Dissolved Inorganic Nitrogen Predicted Grading (based on Median only)
Streams
Subcatchments
Tauranga watersheds
Stream Segment and Predicted Grade
A
B
C
D / E
Observed Grades
A
B
C
D / E

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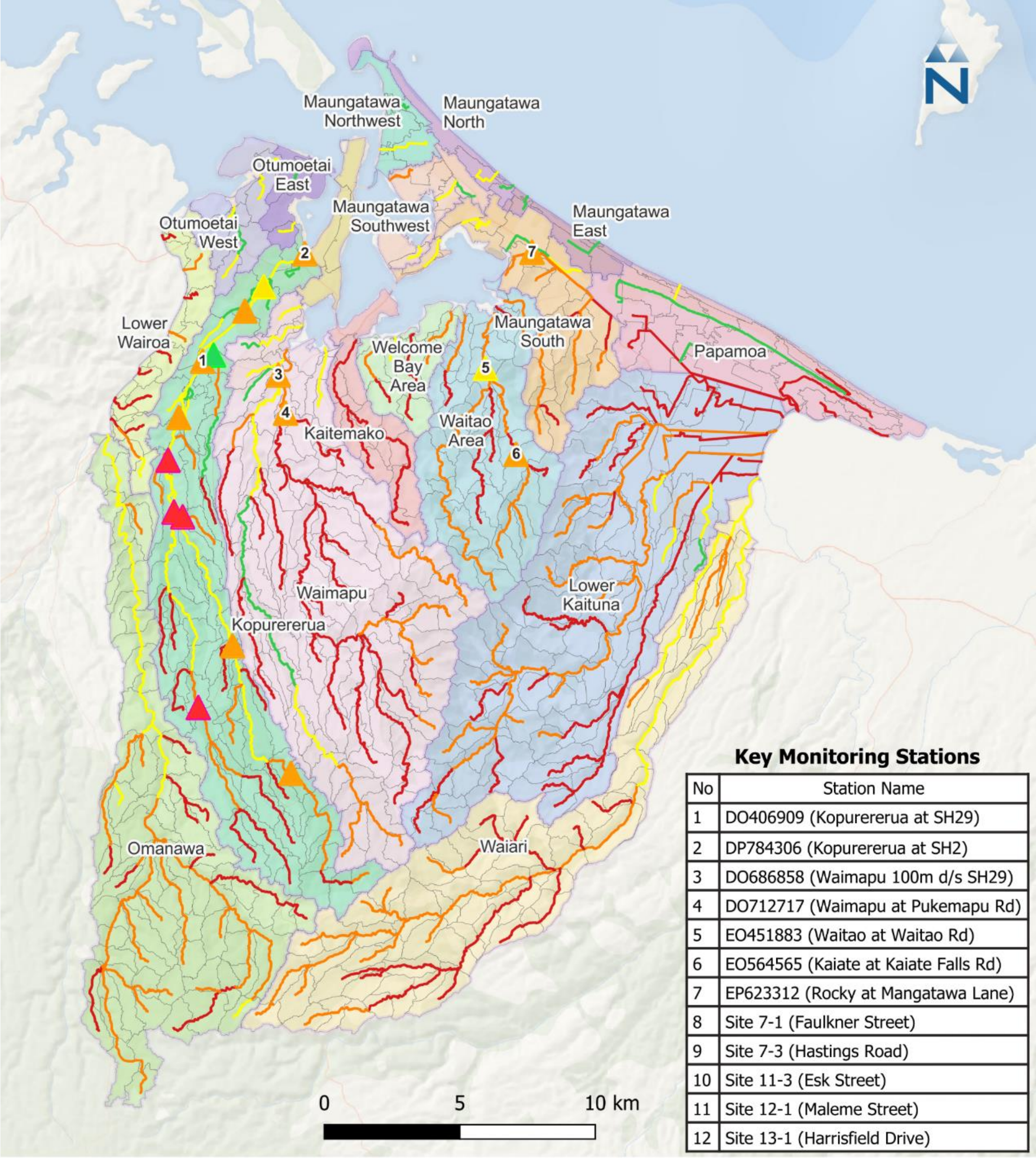
Dissolved Reactive Phosphorous Predicted Grading



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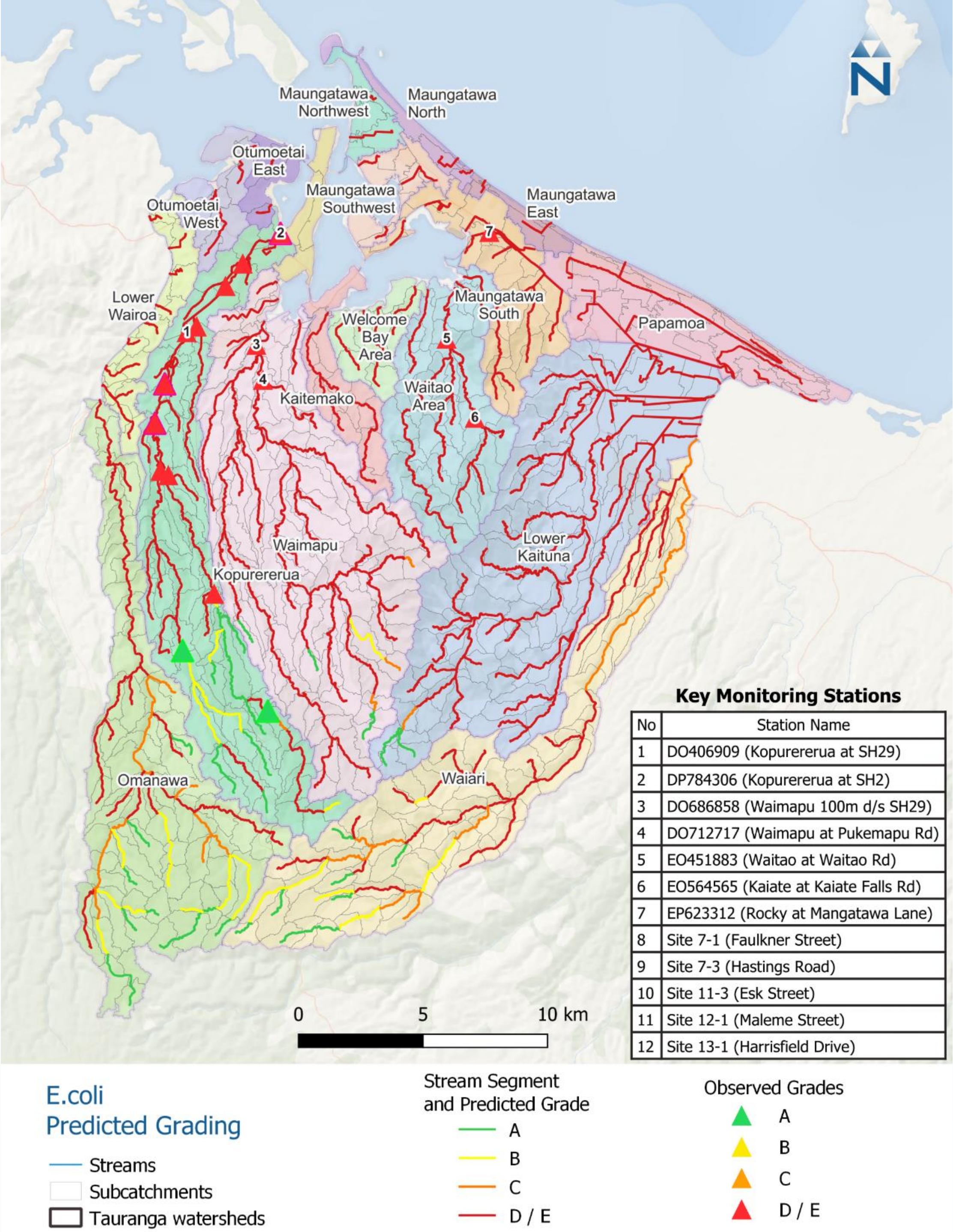
Dissolved Reactive Phosphorous Predicted Grading (based on Median only)



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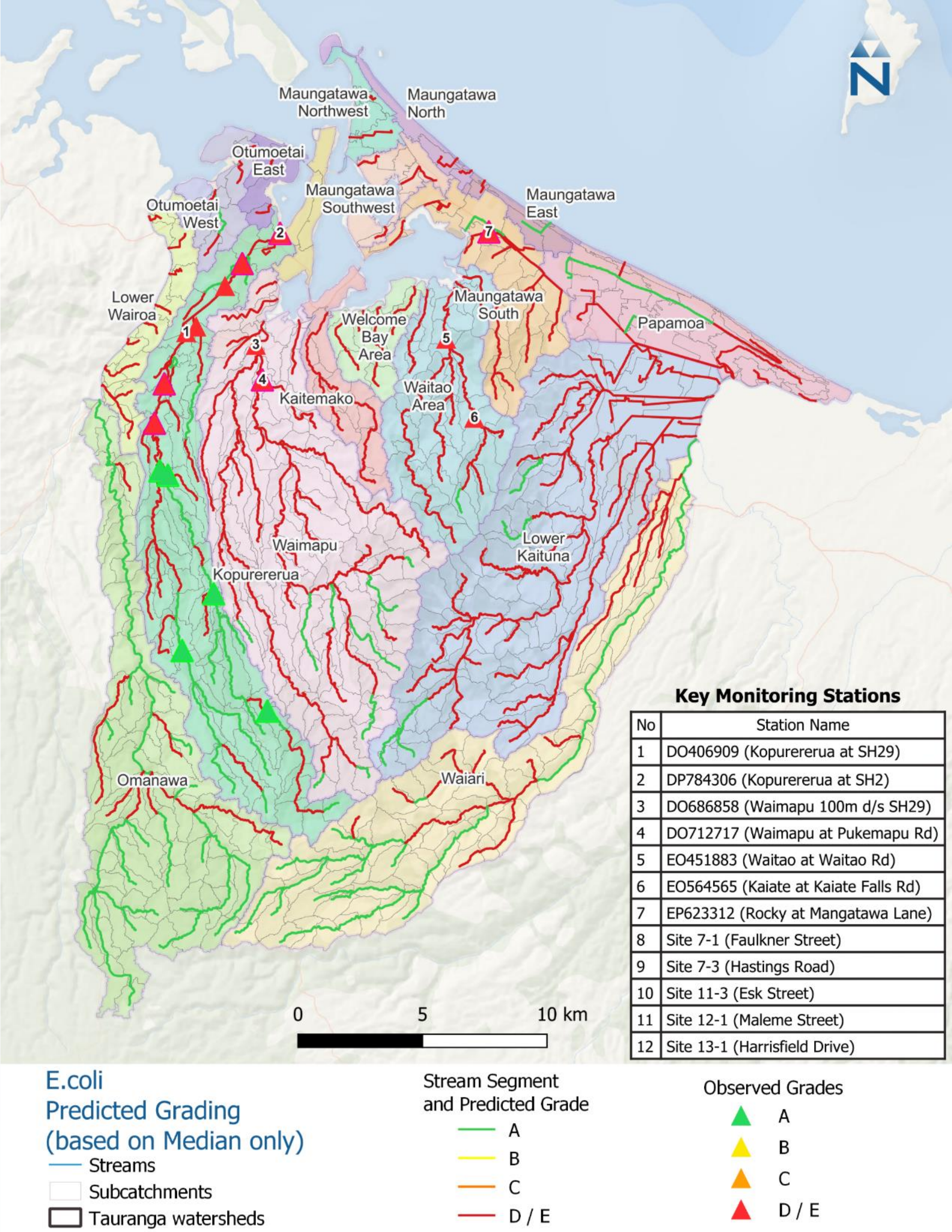

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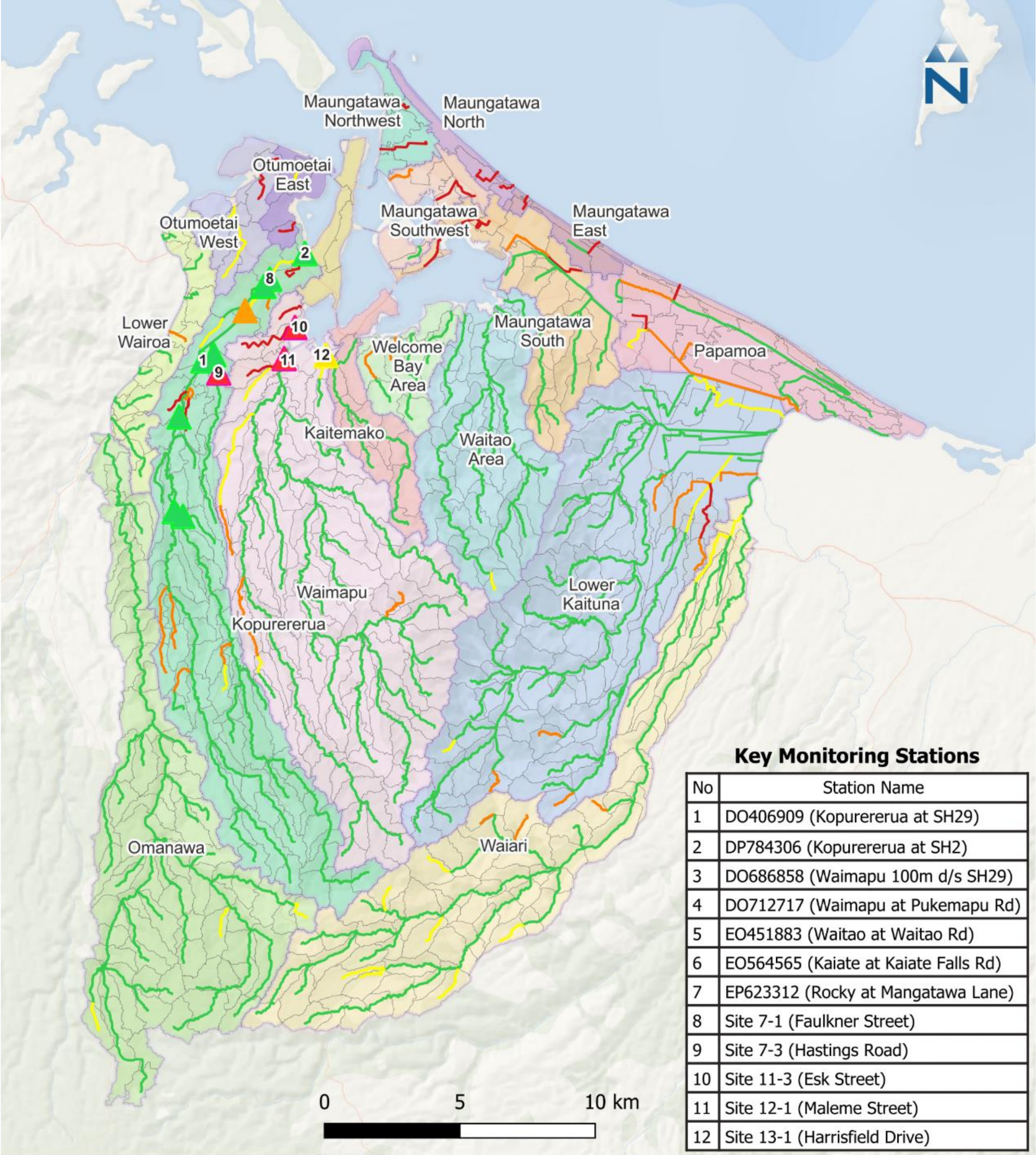

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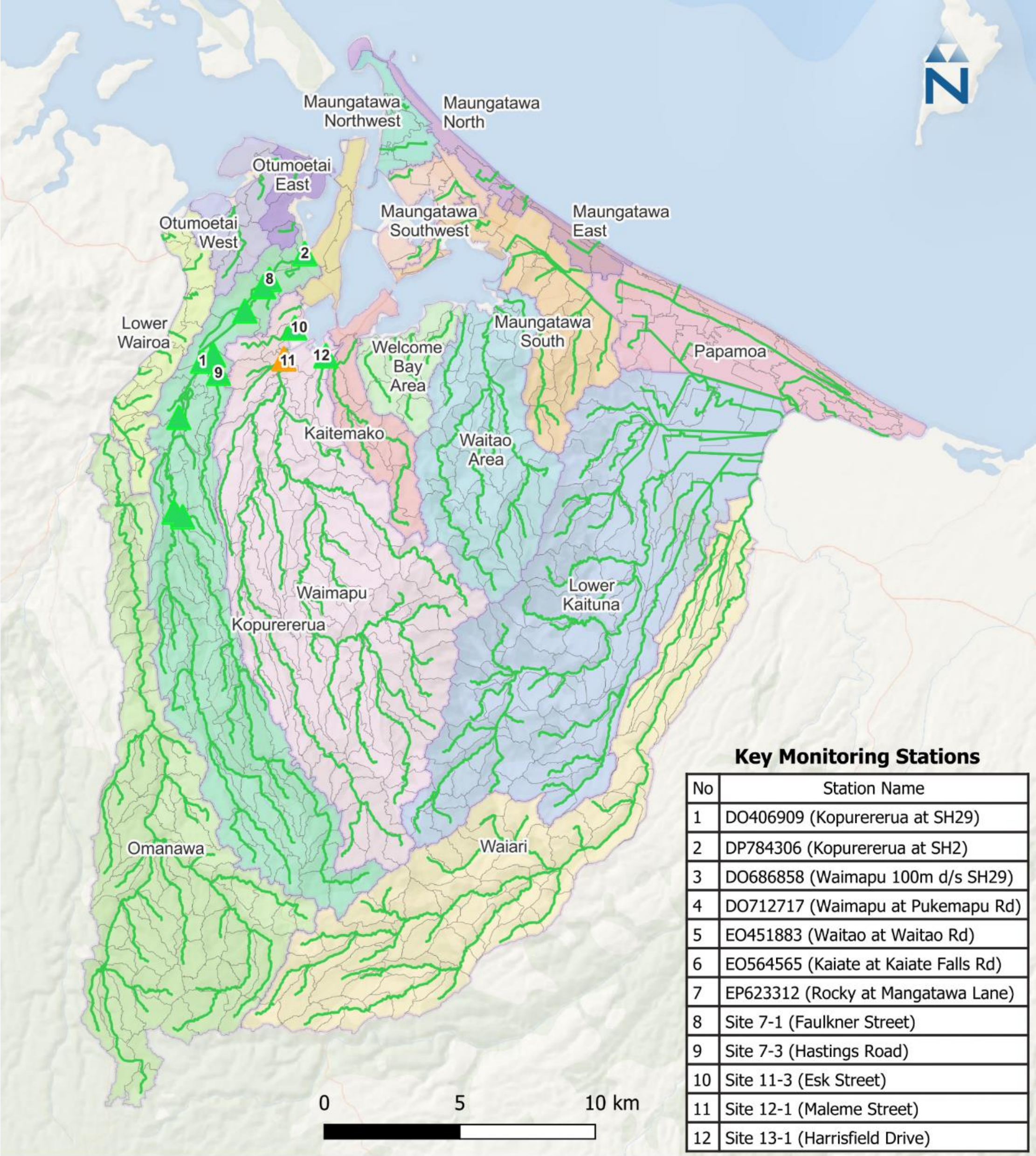
Dissolved Copper Predicted Grading

Streams
Subcatchments
Tauranga watersheds

Stream Segment and Predicted Grade
A
B
C
D / E

Observed Grades
A
B
C
D / E



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Dissolved Copper Predicted Grading (based on Median only)

Streams
Subcatchments
Tauranga watersheds

Stream Segment and Predicted Grade
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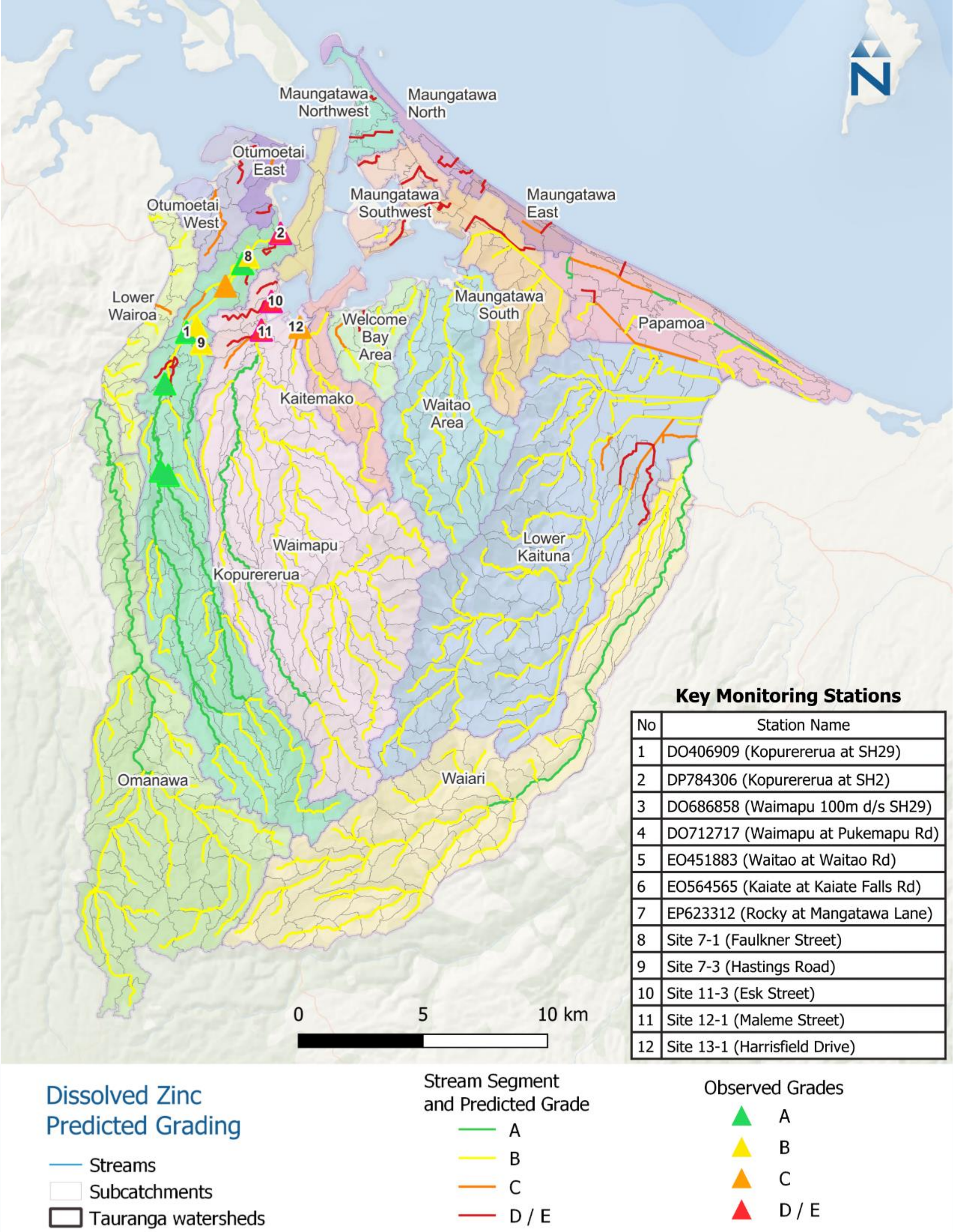

Maungatawa Northwest
Maungatawa North
Otumoetai East
Otumoetai West
Maungatawa Southwest
Maungatawa East
Lower Wairoa
Maungatawa South
Welcome Bay Area
Papamoa
Kaitemako
Waitao Area
Waimapu
Lower Kaituna
Kopurererua
Omanawa
Waiari
0 5 10 km
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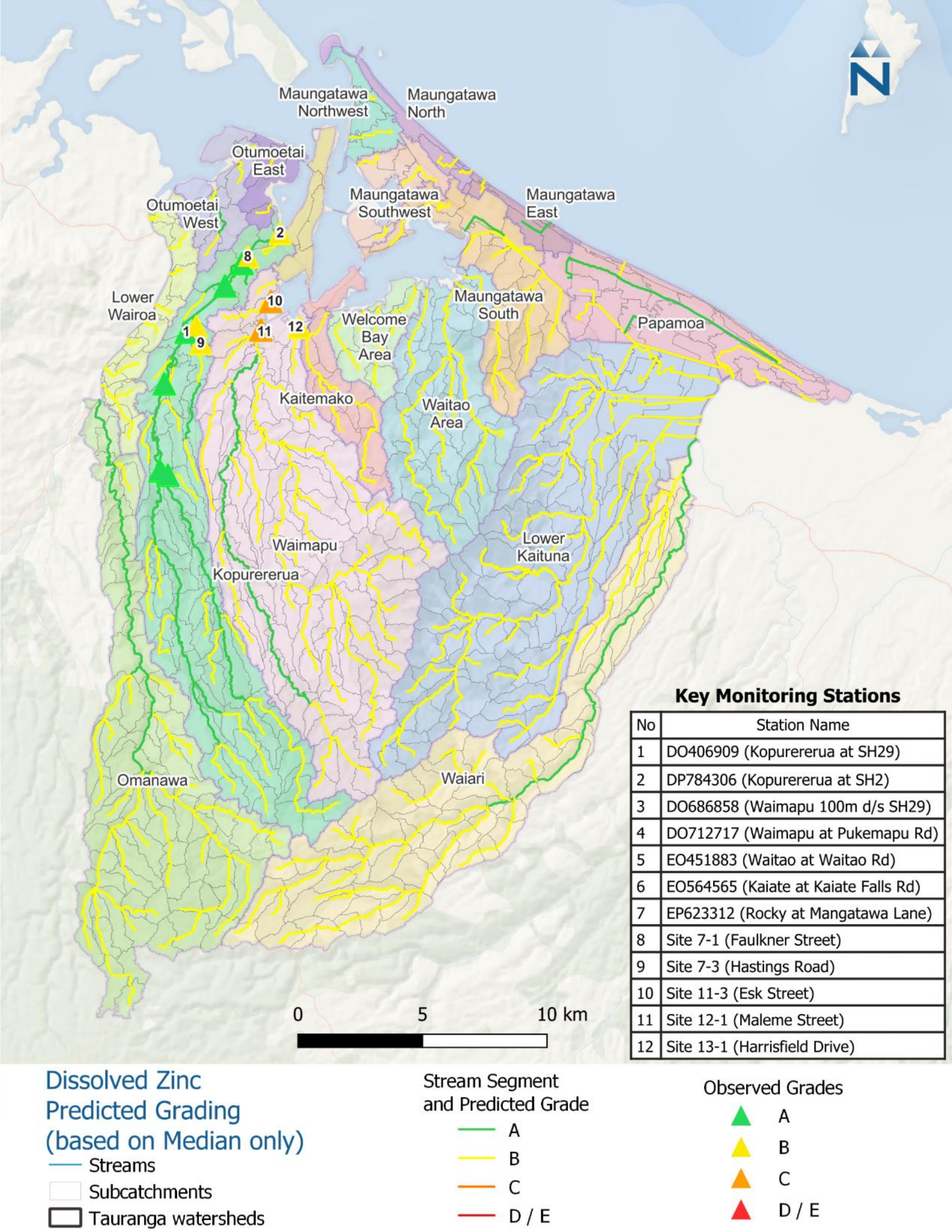
Dissolved Zinc Predicted Grading
Streams
Subcatchments
Tauranga watersheds
Stream Segment and Predicted Grade
A
B
C
D / E
Observed Grades
A
B
C
D / E



Maungatawa Northwest
Maungatawa North
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Otumoetai West
Maungatawa Southwest
Maungatawa East
Lower Wairoa
Maungatawa South
Welcome Bay Area
Papamoa
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Waimapu
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Kopurererua
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Waiari
0 5 10 km
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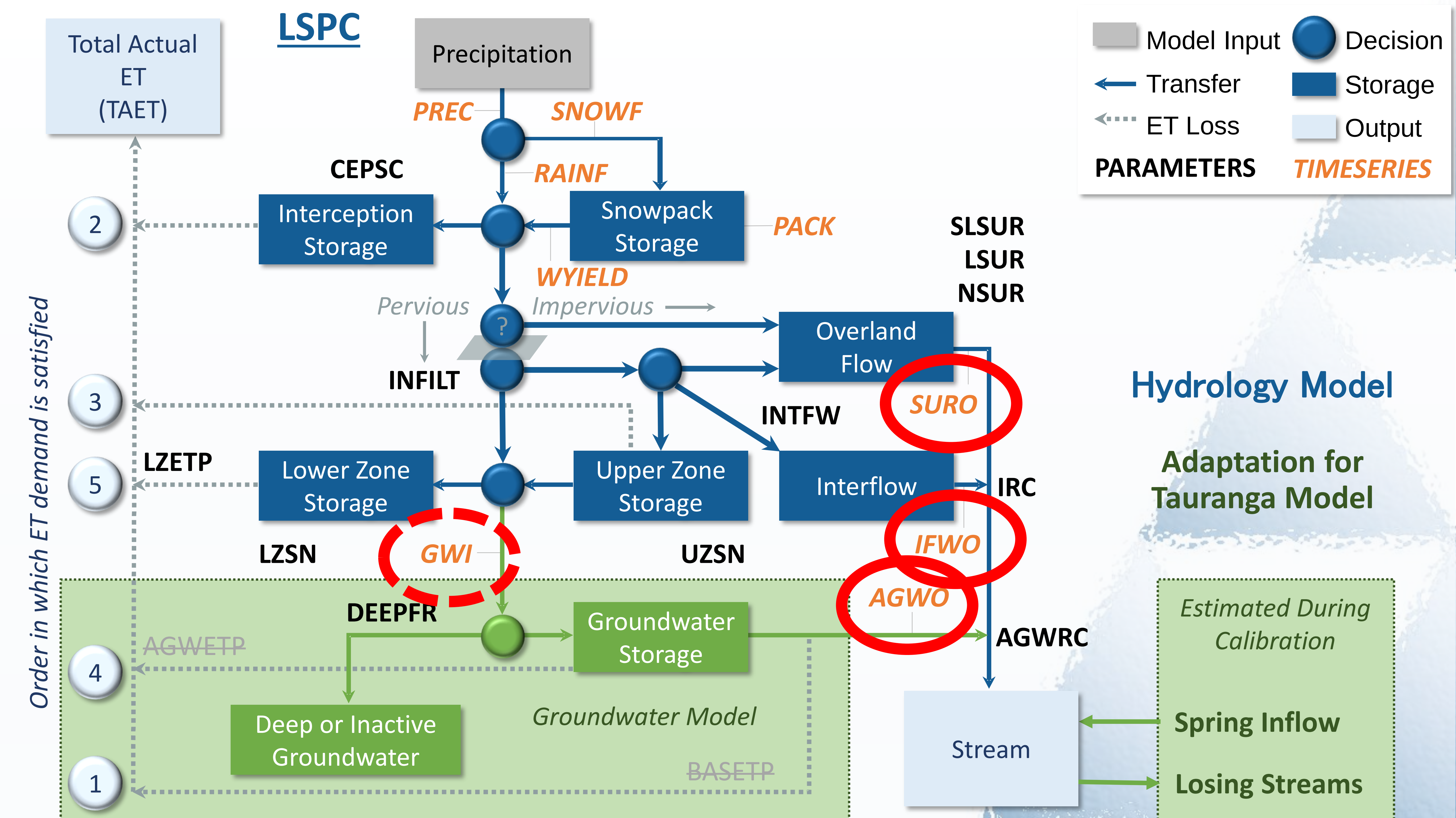
Streams
Subcatchments
Tauranga watersheds
Stream Segment and Predicted Grade
A
B
C
D / E
Observed Grades
A
B
C
D / E



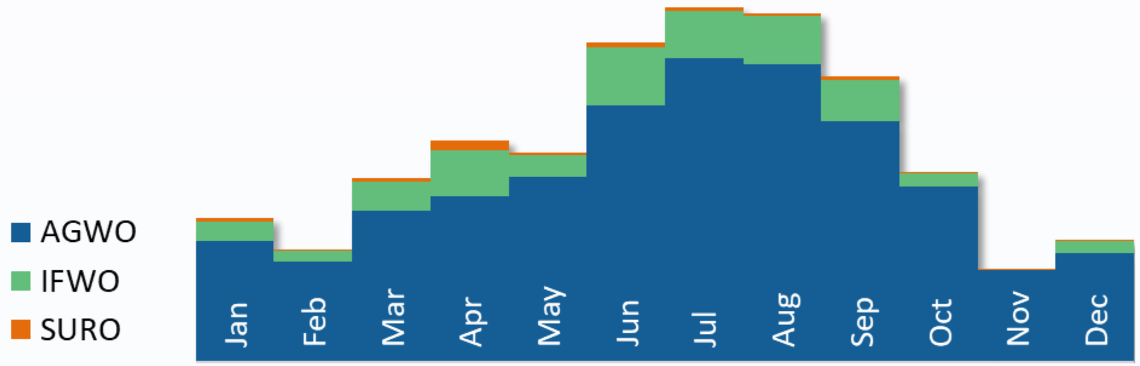
LSPC
Total Actual ET (TAET)
Precipitation
PREC
SNOWF
RAINF
CEPSC
Interception Storage
Snowpack Storage
PACK
WYIELD
Pervious
Impervious
?
INFILT
Overland Flow
SLSUR
LSUR
NSUR
SURO
INTFW
Interflow
IRC
IFWO
Lower Zone Storage
Upper Zone Storage
LZETP
LZSN
UZSN
GWI
DEEPFR
Groundwater Storage
AGWO
AGWRC
~~AGWETP~~
Deep or Inactive Groundwater
Groundwater Model
~~BASETP~~
Stream
Order in which ET demand is satisfied
1
2
3
4
5
Model Input
Decision
Transfer
Storage
ET Loss
Output
PARAMETERS
TIMESERIES
Hydrology Model
Adaptation for Tauranga Model
Estimated During Calibration
Spring Inflow
Losing Streams

Hydrological Impact of A vs. A+ Soils

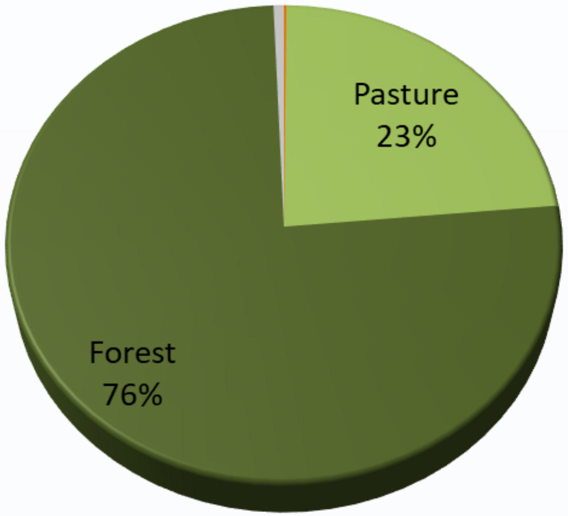
- *Kaiate at Kaiate Falls Rd*

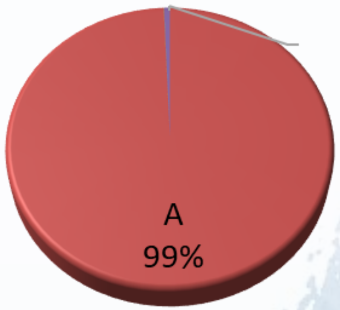
EO564565

Volume:

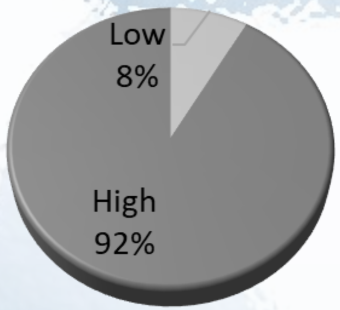


Lanuse Area:

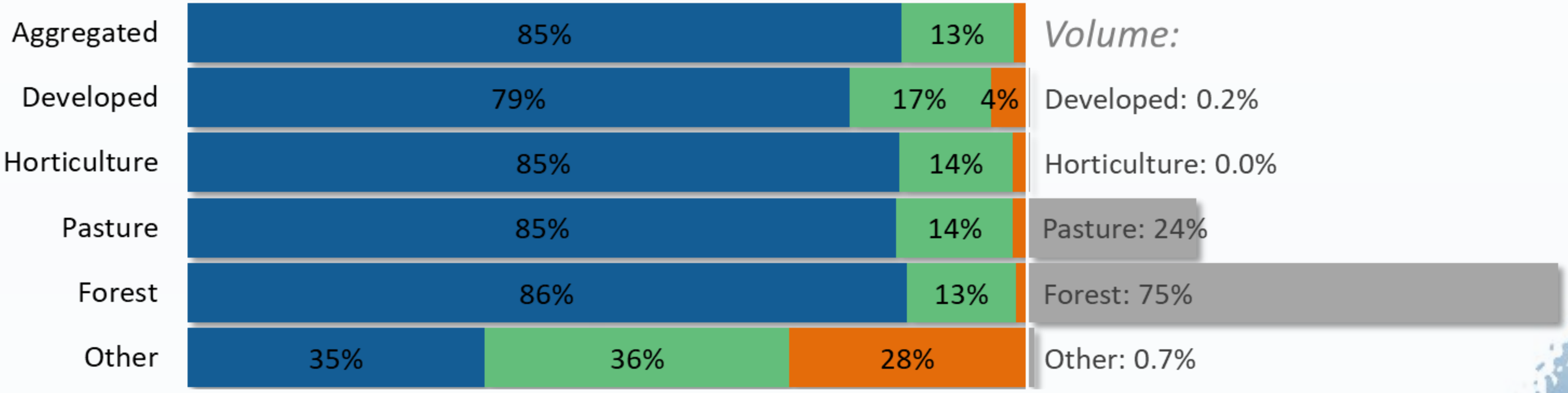




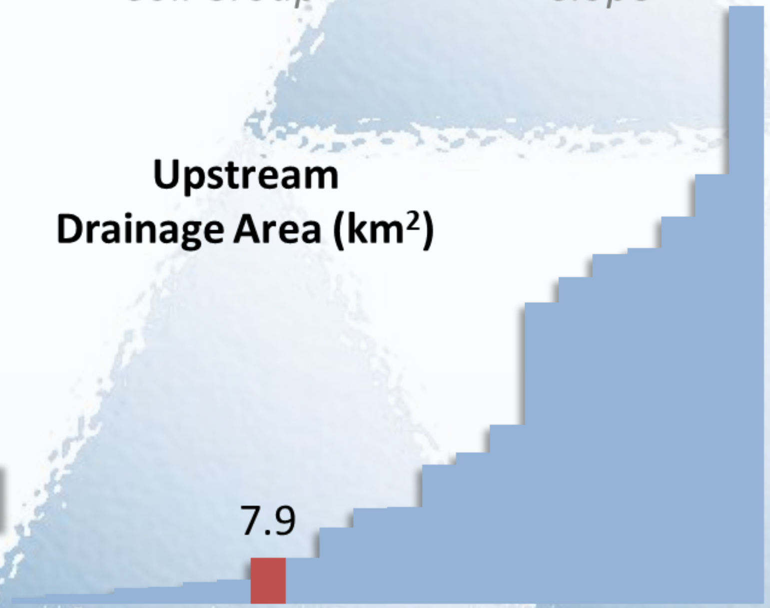
Soil Group



Slope



Upstream Drainage Area (km²)

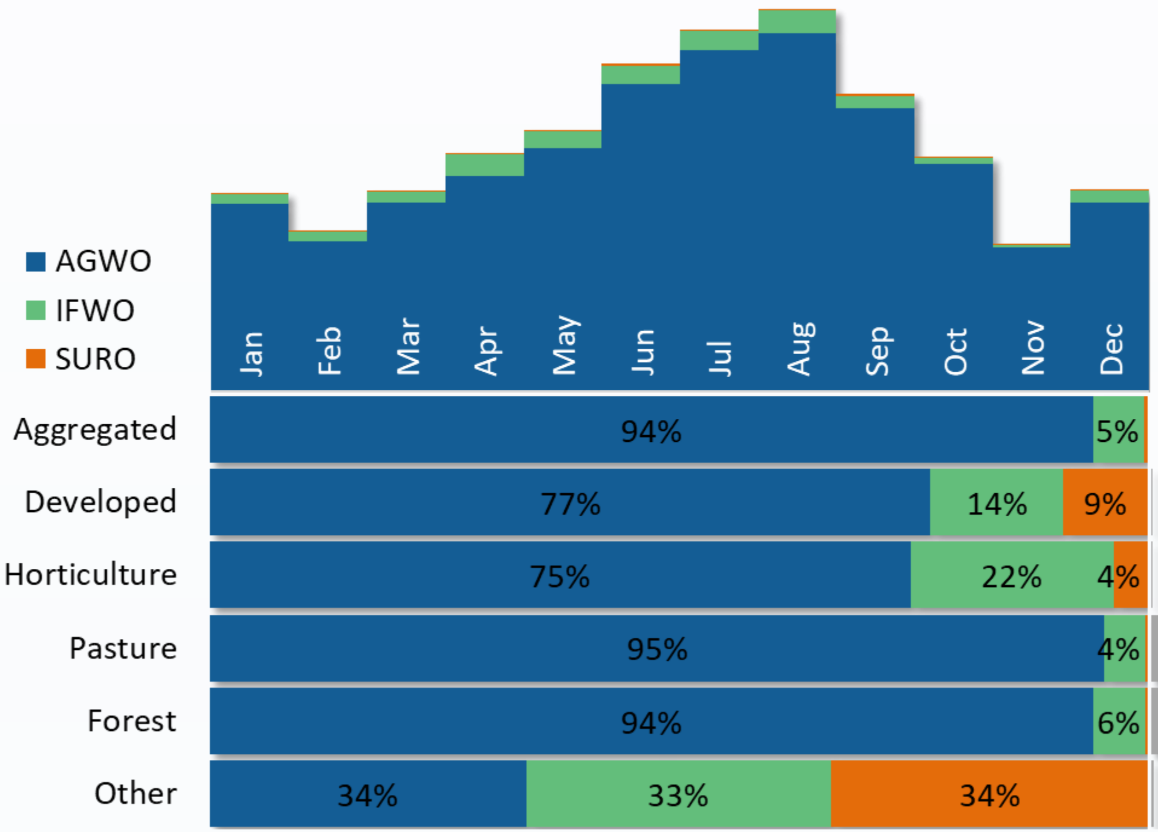


Hydrological Impact of A vs. A+ Soils

- *Tautau at Pyes Pa Rd*

DN517858

Volume:



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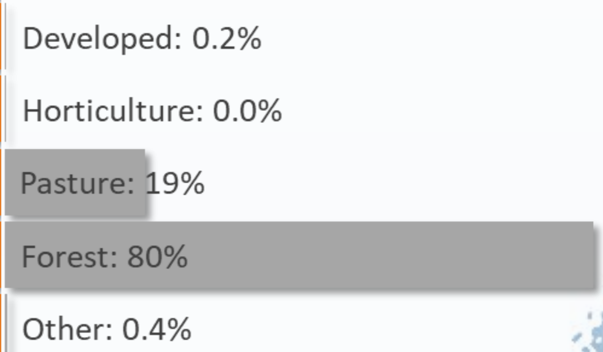
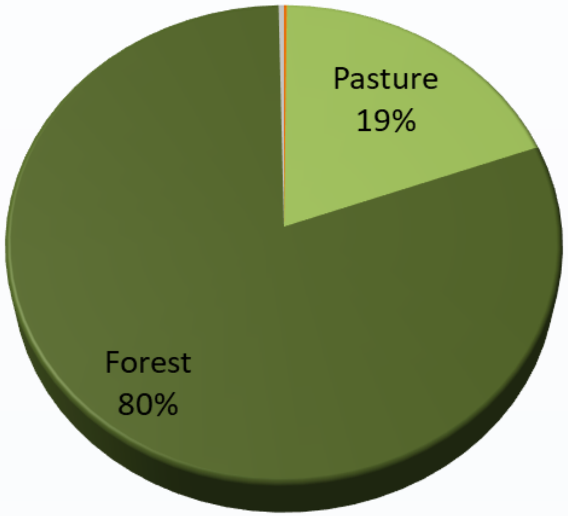
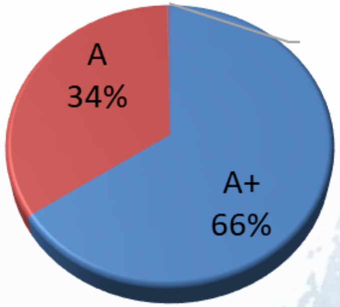
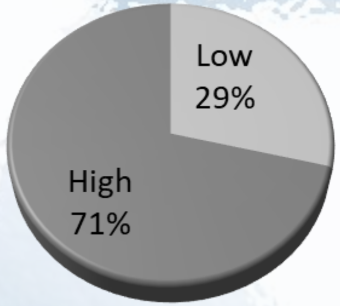


Lanuse Area:



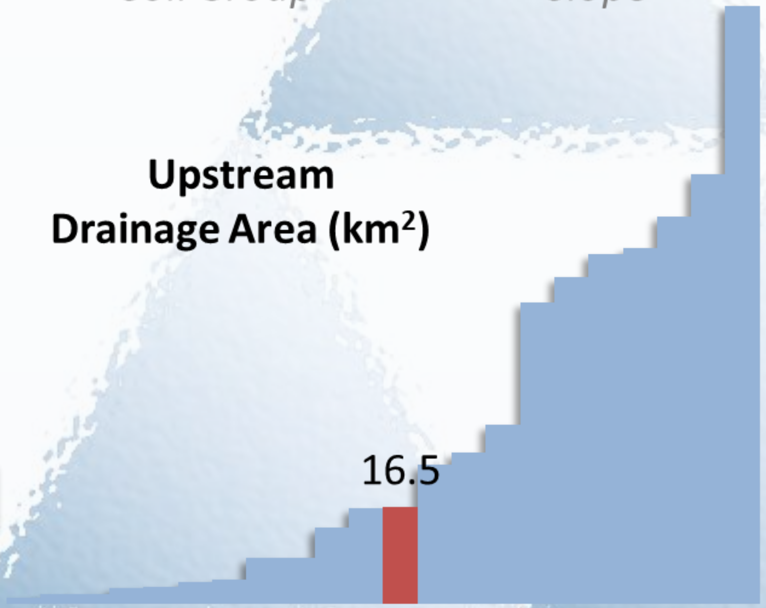


Soil Group

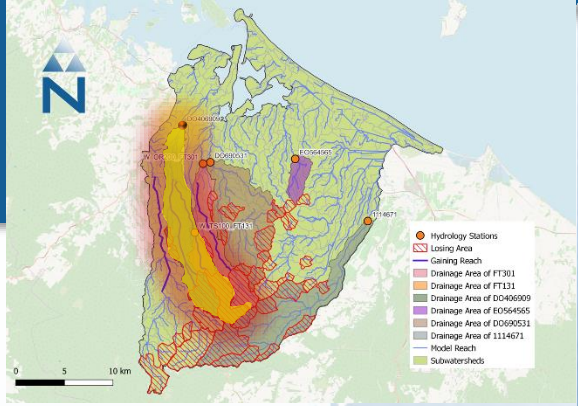


Slope

Upstream Drainage Area (km^2)



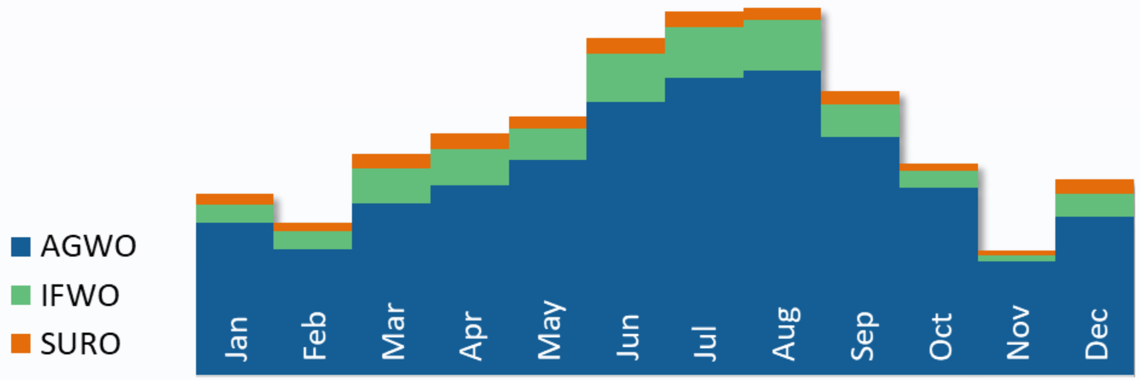
Edge-of-Stream Hydrograph Separation (Flow)

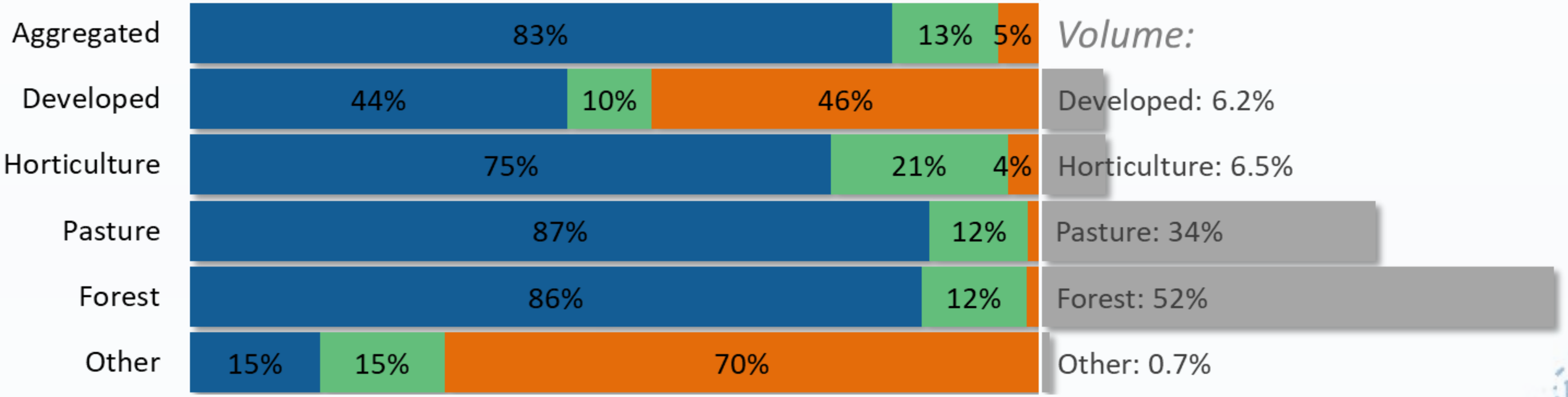


- *Kopurererua at SH29*

DO406909

Volume:





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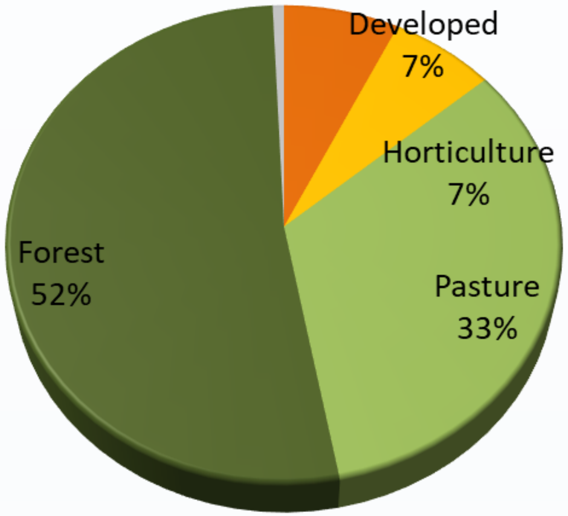
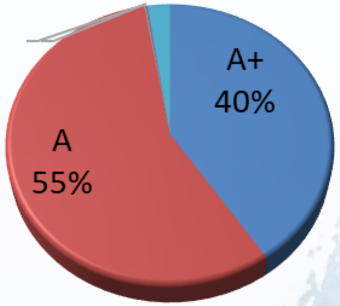
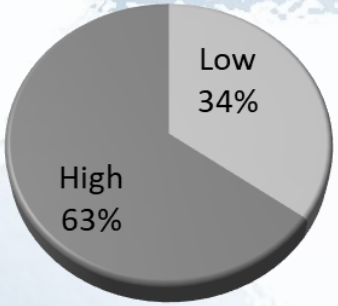


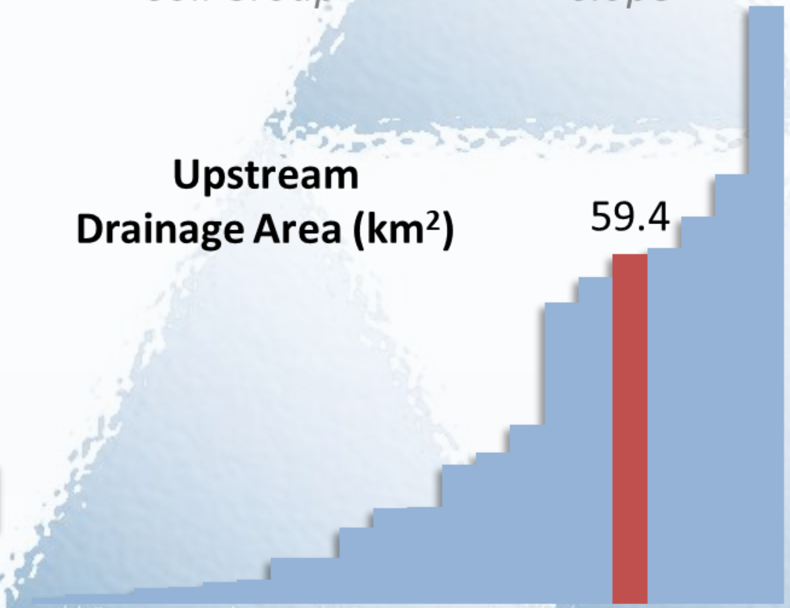


Soil Group

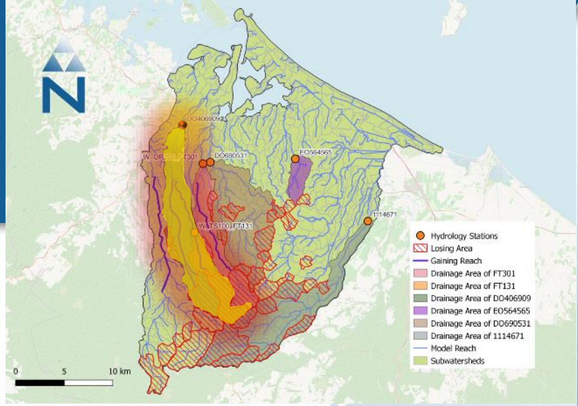


Slope

Upstream Drainage Area (km²)



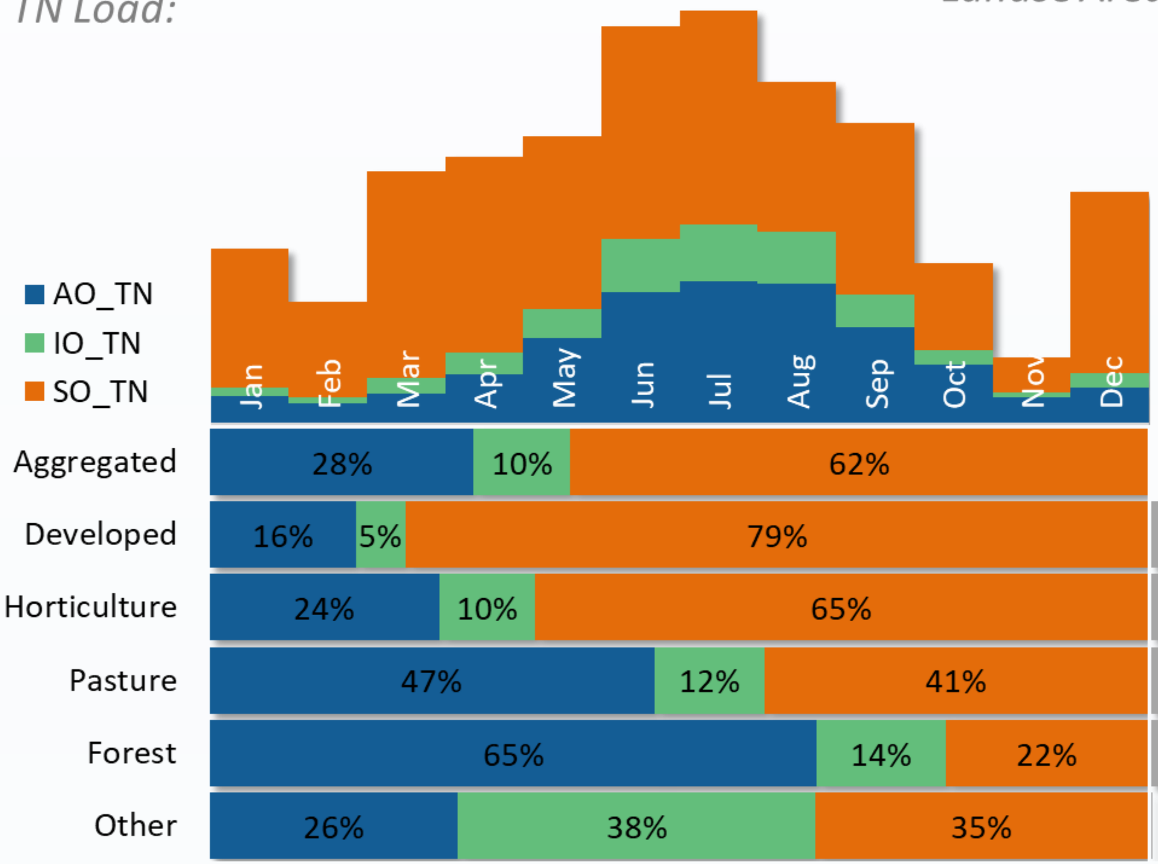
Edge-of-Stream Hydrograph Separation (TN)



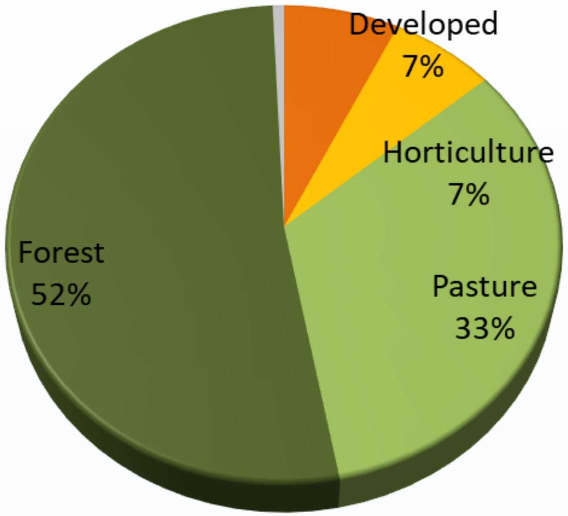
- *Kopurererua at SH29*

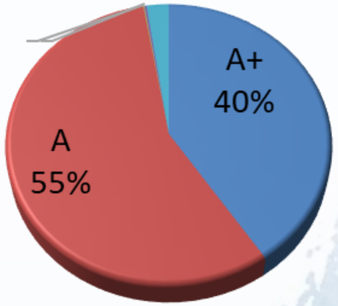
DO406909

TN Load:

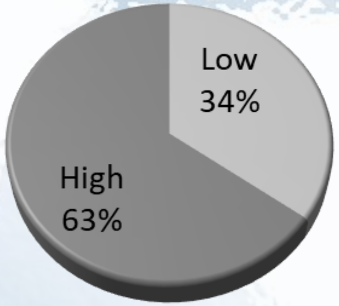


Lanuse Area:



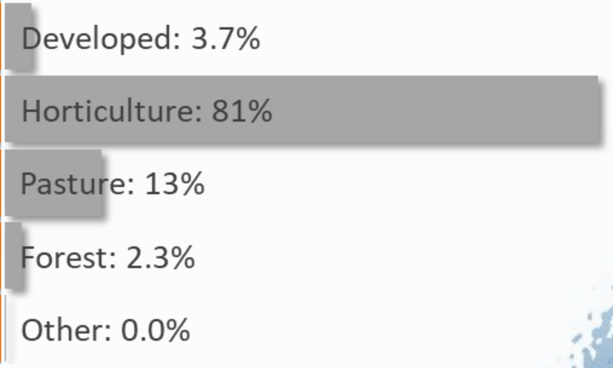


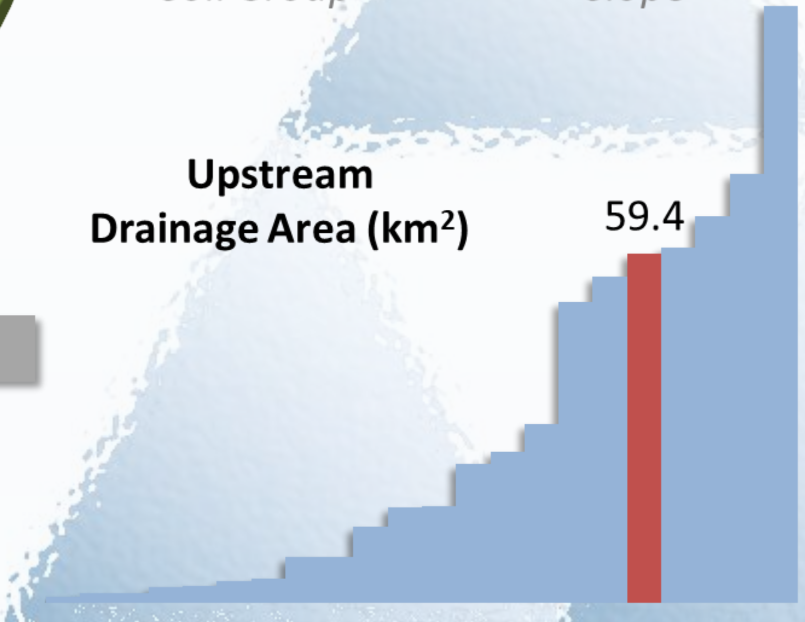
Soil Group



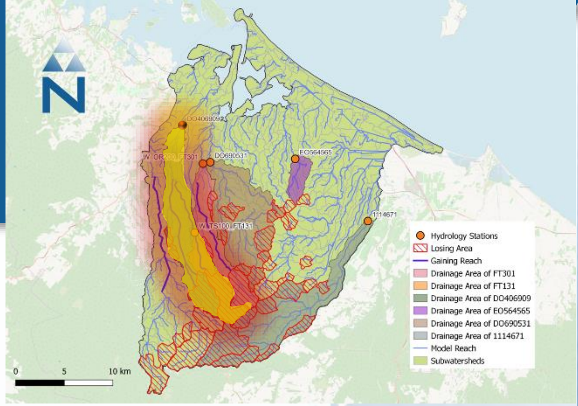
Slope

TN Load:





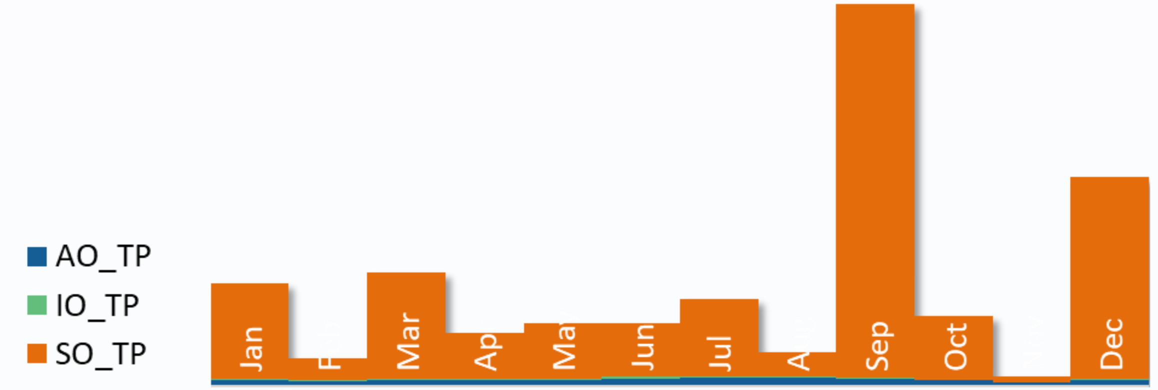
Edge-of-Stream Hydrograph Separation (TP)

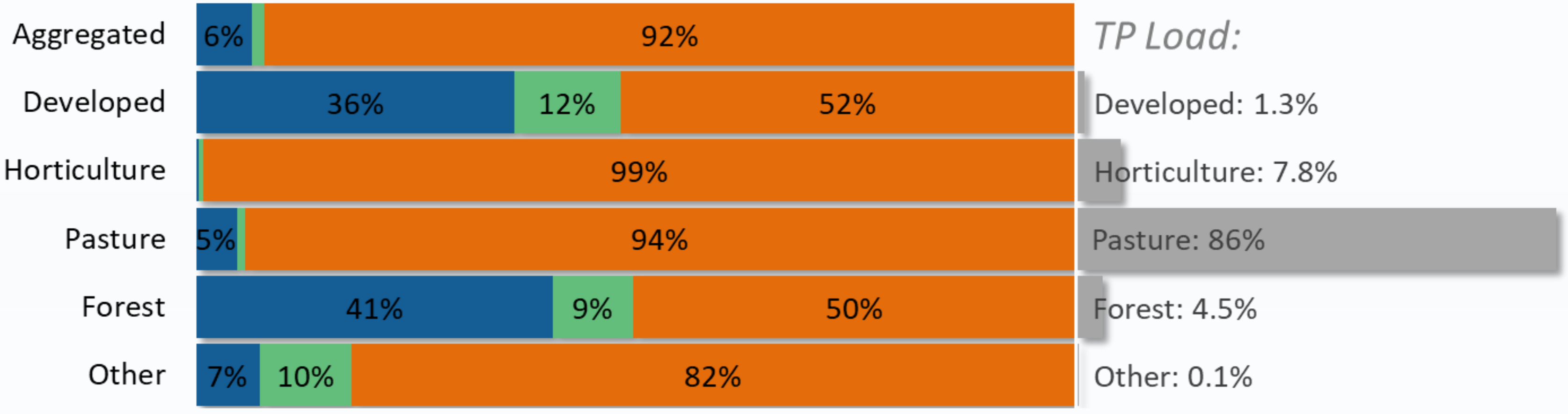


- *Kopurererua at SH29*

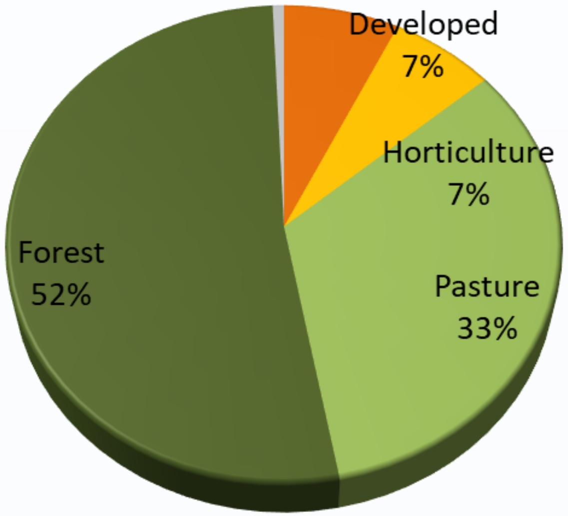
DO406909

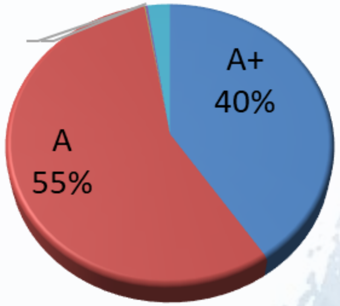
TP Load:



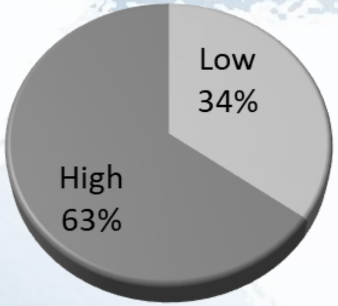


Lanuse Area:

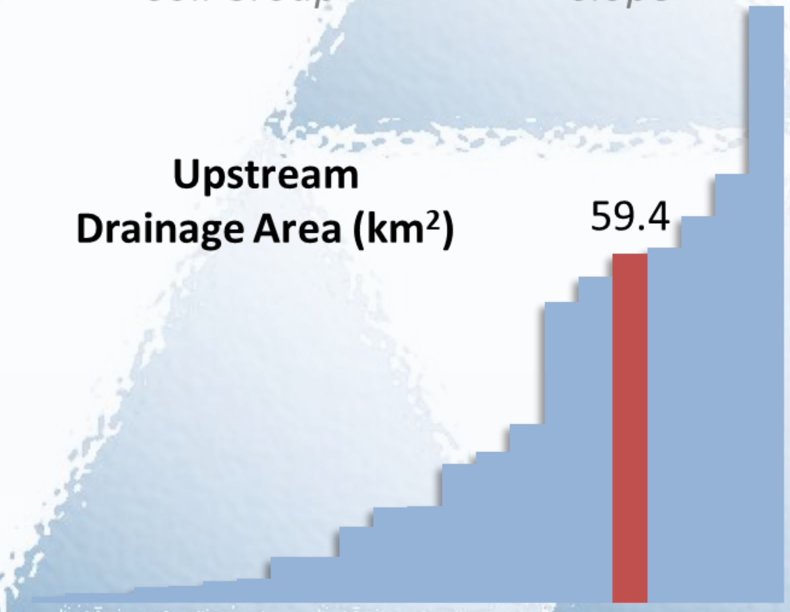




Soil Group



Slope



Summary

- FWMT underway to focus TCC planning on the holistic water cycle.
- Effort being applied to establish connection with Mana Whenua and understand how to work within Te Mana o Te Wai.
- Innovative workflows to leverage rich data and streamline regional scale water quality modelling.
- Key targets of hydrology, metals and sediment for TCC management and scenario and optimized strategy development.
- Preparation to understand implications of BoPRC Objectives setting.

THANK YOU.

Claudia Hellberg: claudia.hellberg@tauranga.govt.nz
Caleb Clarke: caleb.clarke@morphum.com