AGFIRST

Independent
Agriculture
& Horticulture
Consultant
Network

What's Coming out of Tile Drains? Year 2 Outcomes

This report is part of the Sustainable Food and Fibre Futures Fund Project SFFF 19079

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Thanks to our Funders

Hawkes Bay Vegetable Growers Assn

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1.0 EXECUTIVE SUMMARY

Year 2 monitoring, from 1st September 2022 to 31st August 2023, captured a year of abnormally high rainfall, as well as the impacts of Cyclone Gabrielle, meaning the project was able to capture valuable data around rainfall induced drainage.

Grab sampling base runs took fortnightly samples of tile drain discharge and receiving water bodies from monitored sites, as well as the introduction of a complementary proportional sampling dataset, and flow meter data from selected sites. Flow meter data showed that flow from sites initially quantified as "dry" was often flashy, with minimal lag times to peak flow, and quick falling limb times back to base flow, hence why they were often dry when a technician later visited the site. Additionally, the flow meter data gave resolution on flow behaviour of sites where the tile exits were often submerged by the receiving water bodies, therefore providing data which was otherwise not able to be captured. The addition of this data to compliment the visual flow assessment during sampling runs, allows for more accurate flow behaviour categorisation work to be done in Year 3.

The current approach of collecting fortnightly grab samples from the tile drains interspersed with rainfall triggered event samples is in line with best practice for establishing a baseline data set. However, caution is needed in assessing the year 2 data assessment to date, as it only represents a snapshot of benchmarking data against a dynamic environment. In terms of data robustness, the two-year dataset is not yet considered to be well developed enough for determining compliance with the associated guideline values, as per the NPS Freshwater and accompanying technical literature.

Thus, at the completion of Year 2, limited correlation or trends have been observed within the data set and assessment has not identified any clear correlating factors for on farm actions and associated discharges, meaning these are unlikely to be linear correlations.

To further investigate these relationships, Year 3 will be assessing a range of further environmental factors to help further understanding around what is coming out of tile drains.

2.0 OBJECTIVE & PURPOSE

The primary objective of this report is to document the observations and findings collected as at the completion of the second year of data collection on 31 August 2023. This 'Year 2 Findings Report' builds on the assessments and observations presented in the previous December 2022 and December 2021 reports.

This is the third report for the "What's Coming out of Tile Drains?" project as set out in the following reporting Schedule:

1) December 2021 – details the site selection and preparation, referred to as the 'Pre-monitoring phase' from March 2021 to the 31st August 2021.

2) December 2022 – added the 1st year of monitoring from 1st September 2021- 31st August 2022.
3) December 2023 (this report) – adding monitoring data and observations from from 1st September 2022 through to 31st August 2023.
4) December 2024 – Final report covering the entire project, including monitoring 1st September 2023 to 31st August 2024, and final project outcomes.

Year 2 monitoring encompassed Milestones 8 to 10 with Spring 2022 Monitoring, Summer 2022-2023 Monitoring, Autumn 2023 Monitoring and Winter 2023 Monitoring.

3.0 CLIMATE

Following on from Year 1 where La Nina conditions presented higher than annual rainfall, Year 2 rainfall has again been consistently above the 10-year average. Additionally, on the 14th February 2023, Cyclone Gabrielle brought significant wet windy conditions.

Evapotranspiration (ET) was lower than average throughout the summer months, otherwise close to the 12 year average for the majority of Year 2 monitoring.

The mean maximum temperature was close to the 12 year average except over the summer months, when it was lower. The mean minimum temperature tended to be slightly above the 12 year average except in March, July and August where it was slightly lower.

Consequently, monitored sites saw soil moisture levels well above field capacity during spring, late summer, autumn and winter, and as ET was lower than, or similar to the 12-year average, plant transpiration demand was not significant. Consequently, throughout the Year 2 monitoring period, continual soil drainage occurred both through tile drains and as surface drainage.

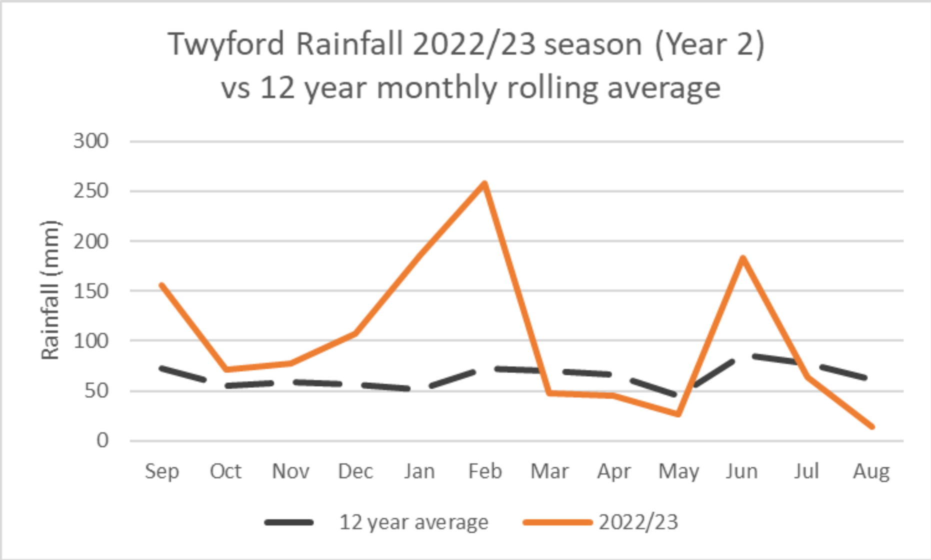


Figure 1 Rainfall data for Year 2 for the Hortwatch Twyford weather station for the 2022/23 season, compared to the 12 year rolling average

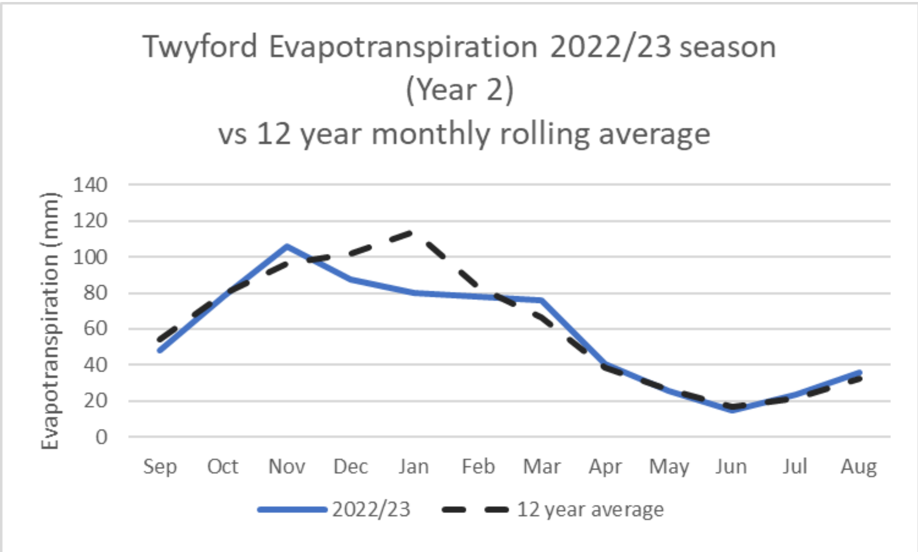


Figure 2 Evapotranspiration data for Year 2 for the Hortwatch Twyford weather station for the 2022/23 season, compared to the 12 year rolling average.

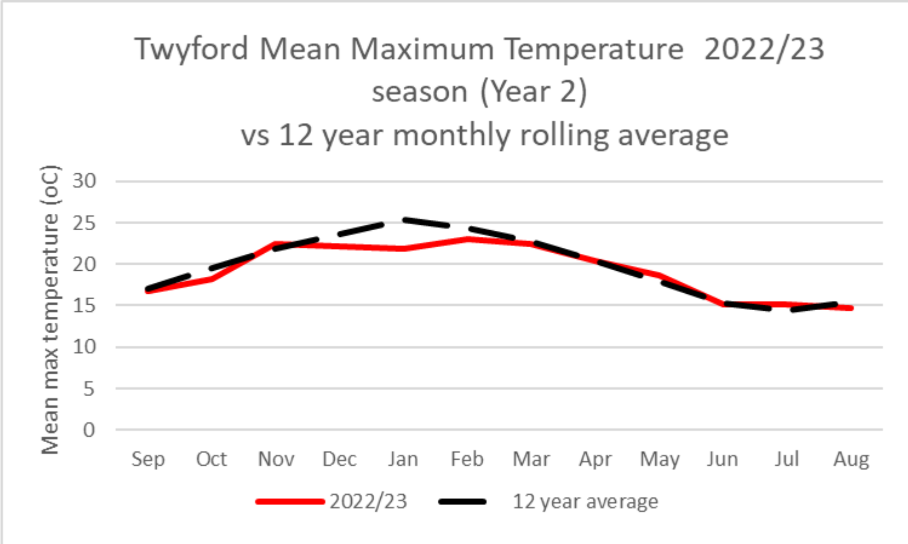


Figure 3 Mean maximum temperature data for Year 2 for the Hortwatch Twyford weather station for the 2022/23 season, compared to the 12 year rolling average.

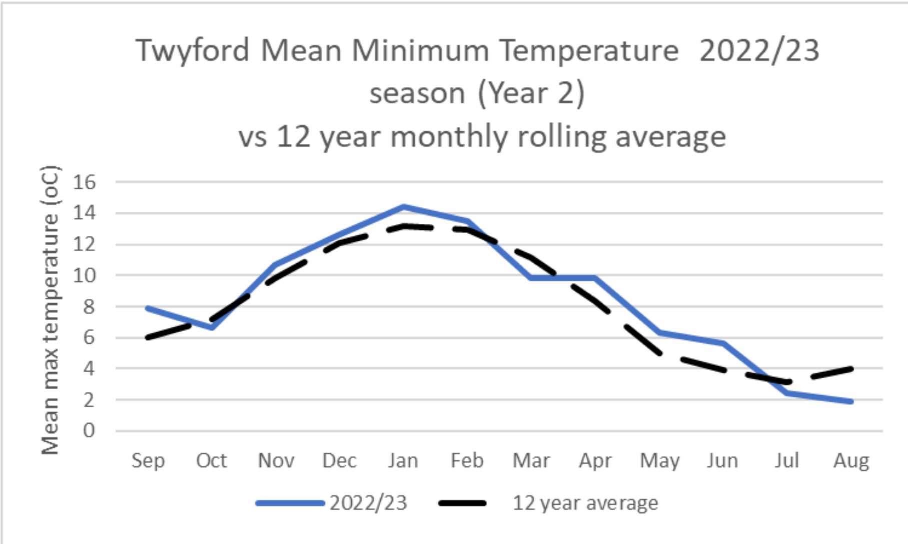


Figure 4-: Mean minimum temperature data for Year 2 for the Hortwatch Twyford weather station for the 2022/23 season, compared to the 12 year rolling average.

3.1 Cyclone Gabrielle

On the 14th February 2023, Cyclone Gabrielle hit the East Coast of the North Island, significantly impacting Hawke's Bay. Immediately following Cyclone Gabrielle, the AgFirst Tile Drains project team carried out a risk assessment across all monitored sites to determine any site-specific impacts to equipment and sampling ability, as well as the new Health and Safety risks.

The project experienced a range of different cyclone impacts across all monitoring locations. No samples were taken during February due to site accessibility and various Health and Safety risks (silt, flood water, bank erosion, collapsed canopies etc). However, after working with site participants and managing these risks, from the 8th March 2023, fortnightly grab sampling schedule continued across all but one site.

Massey University assisted with the repairs and maintenance on all proportional sampling and flow metering equipment following the cyclone, with all sites except A05 fully reinstated and monitoring by June. Repairs included flushing all equipment of silt, realigning pipework within the drains, and some rewiring of flow meter controllers where these were inundated with floodwater.

While servicing equipment, the stored flow meter data was also downloaded. Several of the flow meters were able to capture tile flow over this extreme event, creating a valuable addition to the project dataset and allowing for some analysis of high intensity, high flow events.

Following the cyclone, the project team undertook significant "passive project extension" as many discussions with growers and industry were centred around the importance of drainage, and the impacts of high intensity, high flow events.

3.1.1 Site A05

This site was the most significantly impacted by Cyclone Gabrielle. Electronic equipment at this site was damaged beyond repair, and site access following the cyclone and for the remainder of Year 2 was hazardous due to the extensive silt deposits across the orchard, on the tracks and along the drain edge. The orchard itself has now been pulled out, with replanting to occur.

The governance group unanimously agreed to retire the site, with the In Drain equipment to be extracted in the summer of 2023/24 when the water level in the drain recedes. Some "event" samples may be taken where possible from this site during Year 3.

Figure 5 (a,b), cyclone impacts to monitoring equipment

4.0 YEAR 2 MONITORING – DATA COLLECTION

Year 2 monitoring has continued to follow the grab sample protocol on a fortnightly schedule (referred to as "Base Runs") alongside Event Runs where sampling is triggered by a 15mm rainfall event (unless a Base run already covers the event). A total of 24 Base Runs between 1 September 2022 and 31 August 2023 were completed alongside eight Event Runs.

In addition to the above grab sampling programme, eight sites had flow meters and proportional sampling equipment installed to enable a representative proportional water sample collection across the fortnightly flow programme. Almost 200 proportional samples were collected between 1st September 2022 and 31st August 2023.

4.1 Water Grab Sampling

Grab sampling is a "point in time" sample and flow measurement from both the tile drain exit and associated receiving water point during the site visit.

On each base run, a technician visits each monitoring site to sample the two tile exits and receiving water points. If the technician is unable to take a sample, the reason for this is recorded, such as tile exits being submerged by the receiving water body, or the sampling site is unsafe to access. Where no flow is occurring, the tile is recorded as dry.

4.1.1 Field Tests

The ProQuatro handheld meter was used to record the temperature, pH, dissolved oxygen, and conductivity of each water grab sample collected. The meter is pH calibrated on a regular schedule by our sampling technicians, and gets sent away annually for a full calibration of all functions.

Figure 6 Field data collection from tile drain discharge sample from a cropping paddock

4.1.2 Lab Tests

Water sampled from both the tile exit and receiving water point received the following lab analysis:

- Total Nitrogen, calculated through the following tests:
  - Ammonical Nitrogen
  - Nitrite-Nitrogen
  - Nitrate/Nitrite Nitrogen
  - Total Kjedahl N
- Dissolved Reactive Phosphorus
- Total Phosphorus
- Total Suspended Solids

Additional samples for Lab EColi analysis are taken from both the tile exit and the receiving water body when there are animals present in the paddock above the monitored tile.

4.1.3 Laboratory QA/QC

Following Cyclone Gabrielle, the project had to change water testing labs as ARL sustained significant damage. All samples taken from 8th March 2023 onwards have been processed by Water Testing Hawke's Bay and analysed through Analytica. Consequently, all samples analysed from Analytica, are frozen upon submission to Water Testing Hawke's Bay, prior to being couriered to Analytica for testing. Both laboratories are accredited by International Accreditation New Zealand (IANZ) and all results are sent to ARL for additional quality assurance prior to issue of official laboratory transcripts.

4.2 Proportional Water Sampling and Flow metering equipment

Permanent proportional and tile drain flow meter sampling equipment was installed at 8 sites in August, September and October 2022 comprising of four apple sites, two cropping sites and two kiwifruit sites. Although the original intention was to have all the permanent equipment of the same design, this was not practical due to the unique characteristics of the locations of each of our tiles, resulting in two systems: Pod design and an In Drain design.

There was some difficulty experienced throughout the installation process, due to the very wet spring conditions raising the height of the receiving water bodies, and the Pod holes regularly filling with water, which had to be pumped out.

The In Drain design sits on the drain edge and attaches to the tile exit end. The water passes from the tile exit, through the proportional sampler and flow meter, before discharging into the receiving water body drain. This design means that the sampling equipment footprint in in the drain itself, and not impeding on grower activity and use of the headland. This however, required coordination with Hawke's Bay Regional Council and their drainage network maintenance team.

Table 1: Monitoring equipment design by site

Site	Crop Type	Flow Behaviour	Monitoring Design
A02	Apple	T1- Event T2-Event	In Drain
A03	Apple	T1- Dry T2- Dry	In Drain
A05	Apple	T1- Event / Seasonal? T2- Event /Seasonal?	In Drain
A09	Apple	T1- Continuous T2- Continuous	In Drain
C02	Cropping	T1- Dry T2- Event	In Drain
C03	Cropping	T1- Event T2- Event	In Drain
K02	Kiwifruit	T1- Event T2- Event	Pod
K04	Kiwifruit	T1- Event T2- Event	Pod

The Pod design is a shell dug into the ground overtop of the tile, housing the flow meter and proportional sampling collection container inside. The water then runs from the tile, through the proportional sampler and flow meter, then passes back into the tile line.

Ongoing equipment maintenance tasks including pumping out water that has infiltrated the Pods, re-zeroing the flow meter, flushing the equipment, checking flow meter sensitivities and wiring is regularly carried out by sampling technicians.

As the tile drain discharge flows through the equipment, a proportional sampler siphons off some of the water from different heights in the flow, into a collection container dug in the bottom of the drain or secured to the bottom of the Pod. On each weekly collection run, the proportional samples are pumped out of the collection container into a water sample bottle and frozen.

Then, samples collected from a paired fortnight are unfrozen, combined and refrozen as a composite sample, to be submitted to the lab.

The flow meter used is a Teren Instruments DTI-200F5 (DTI-200B) ultrasonic Flow Meter/Logger.

Figure 8 In Drain Proportional Samplng and Flow Metering equipment

Figure 7 Pod Proportional Sampling and Flow metering equipment

4.3 Soil Moisture Monitoring

Throughout Year 2, soil moisture readings were taken from a soil moisture tube along the monitored tile lines, using a Diviner 2000. Soil moisture tubes have been permanently installed in all apple and kiwifruit sites, however in the cropping sites, these need to be installed and removed alongside the cropping rotations to avoid damage during planting, cultivation, and harvest events.

During the irrigation season, (October to March), soil moisture readings were on a weekly sampling frequency, and on a fortnightly frequency for all other months.

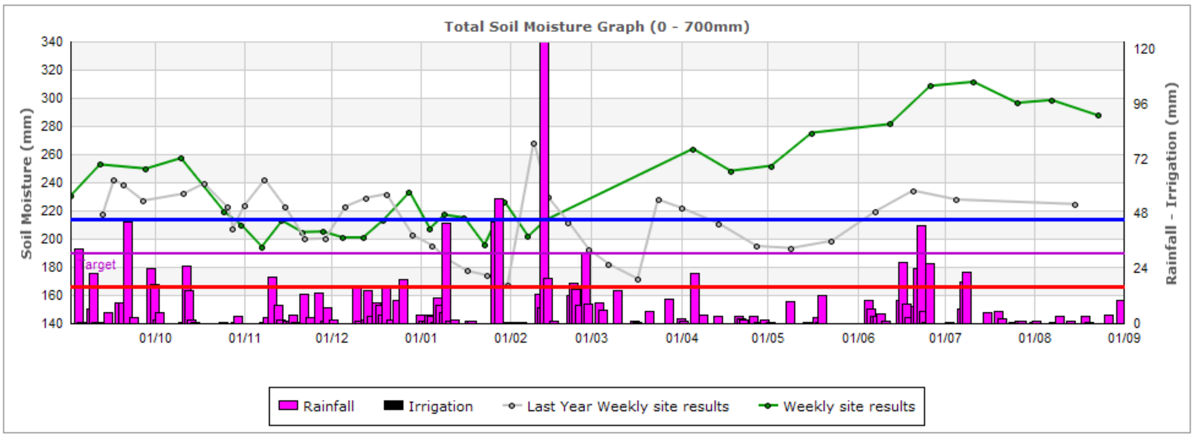


Figure 9 Soil Moisture graph at site K01 for the Year 2 period, showing the soil moisture levels from February 23 to end Aug 23 well above the full point

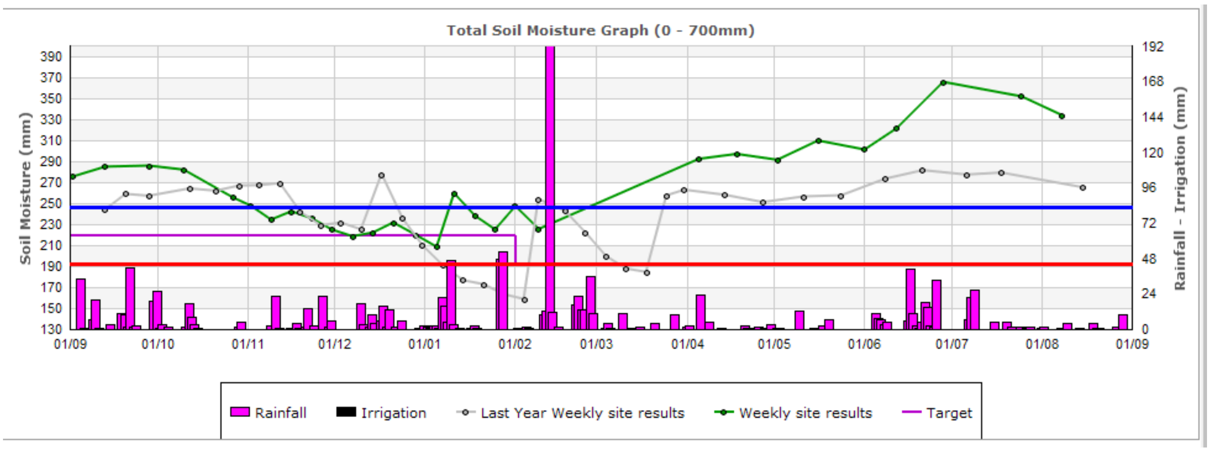


Figure 10 Soil Moisture graph for A06 showing spring, autumn and winter soil moisture levels were above full point during the monitoring year

4.4 Site – specific Climate Data

Rainfall and Evapotranspiration data is taken from the Hortplus weather station closest to each monitoring site and where rainfall over 15mm a day was recorded, an event run was undertaken.

Localised rainfall data is included in the soil moisture graphs and flow meter graphs, to give site specific context.

4.5 Farm Practice Data

Farm practice data was collected from growers throughout Year 2, including but not limited to irrigation, fertiliser, and organic matter application(compost), cultivation, harvest yield and the presence of any animals.

5.0 YEAR 2 FINDINGS

Findings across Year 2 have expanded on the findings presented for Year 1 regarding external influencing factors for each site and identifying individual Tile discharge behaviours alongside interim review of all data collected. Interim assessment of monitoring parameters identified initial clear trends regarding temperature, pH, Total Suspended Solids (TSS), and nitrite. However, recorded concentrations of the remaining parameters have not identified any clear trends.

Caution is required in assessing the Year 2 data collected to date considering the extent of data points collected and the strength of statistical assessments. Further discussion on the population data set, goodness of fit, and extent of findings are set out in Sections 5.3.3, 5.4 and 5.5 below.

For the purposes of this Year Two Findings Report, analytical results have been assessed against the National Policy Statement for Freshwater Management 2020 (Ministry for the

Environment, 2023) ('NPS Freshwater') Attribute Levels and National Bottom Line Values. Where the NPS Freshwater does not prescribe an appropriate value, the Australian & New Zealand Guidelines for Fresh and Marine Water Quality Default Guideline Values and applicable Hawke's Bay Regional Council TANK Plan Change reference values. The Water Services (Drinking Water Standards for New Zealand) Regulations 2022 have also been consulted in assessing analytical results.

5.1 Flow Characterisation

As set out in previous reporting, Tile Drains all exhibit unique flow behaviours and have been grouped by the following flow characteristics:

- Dry: None or very few flow events recorded during our sampling runs
- Event: Only flows following a rainfall event of over 15mm
- Seasonal: Flows during spring, autumn, and winter, but are summer dry
- Continuous: Flow regularly year-round with continuous flow recorded

Observations and assessment throughout Year 2 grab samples have reinforced that tile drain behaviours are unique and follow the above groupings. Table 2 below sets out the flow behaviour characterisations for the Tile Drain sites as per visual observations at the completion of Year 2.

As the Year 2 monitoring period received above average rainfall, Tile Drain outlets were submerged on numerous occasions where sampling cannot be undertaken, and flow behaviour cannot be ascertained. These are recorded as submerged within the data series and not assessed further.

Table 2 Tile Flow Characterisations as at Year 2

Site	Crop Type	Flow Behaviour as at Year 2
A01	Apple	T1 – Event T2 – Event
A02	Apple	T1- Event T2-Event
A03	Apple	T1- Dry T2- Dry
A04	Apple	T1 – Dry T2 – Dry
A05	Apple	T1- Event / Seasonal T2- Event /Seasonal
A06	Apple	T1 – Event / Seasonal T2 – Event / Seasonal
A07	Apple	T1 – Continuous T2 – Event / Seasonal
A08	Apple	T1 – Dry T2 – Dry
A09	Apple	T1- Continuous T2- Continuous
C01	Cropping	T1 – Dry T2 – Dry
C02	Cropping	T1- Dry T2- Event
C03	Cropping	T1- Event T2- Event
C04	Cropping	T1 – Continuous T2 – Continuous
K01	Kiwifruit	T1 – Dry T2 – Dry
K02	Kiwifruit	T1- Event T2- Event
K03	Kiwifruit	T1 – continuous T2 – Continuous
K04	Kiwifruit	T1- Event T2- Event

5.2 Flow Meter Data

Flow data captured by the flow meters installed at selected sites throughout Year 2 monitoring, is presented in the following graphs. These demonstrate different lag times to peak flow, range in peak flow accumulated over the day, and quantify the falling limb times back to base flow. The flow meter and rainfall data hydrographs give resolution on flow behaviour of sites where the tile exits were often submerged by the receiving water bodies, providing data which was otherwise not able to be captured. The addition of this data to compliment the visual flow assessment during sampling runs, allows for more accurate flow behaviour categorisation work to be done in Year 3.

Cumulative flow for each of the sites that have a flow meter installed is set out in table 3, however sufficient data is not available for any estimate of cumulative flow at remaining sites. Cumulative flow totals are as follows:

Table 3 Cumulative flow totals for Year 2 Monitoring

Tile	Cumulative Flow (m3)
A02T1	3184
A02T2	Data needs correcting
A03T1	3984
A03T2	2650
A05T1	Data needs correcting
A05T2	7391 to February 2023
A09T1	10512
A09T2	15191
C02T1	Data needs correcting
C02T2	Data needs correcting
C03T1	Data needs correcting
C03T2	15543
K02T1	3937
K02T2	2557
K04T1	Data needs correcting
K04T2	Data needs correcting

5.2.1 A02

This site shows three significant periods of tile flow, through spring 2022, following the cyclone in Feb 2023, and then in winter 2023. From late March through to mid June 2023, there was little to no flow recorded, correlating to the reduction in rainfall over this period. These tile exits are often submerged by the receiving water and therefore technicians are unable to take regular manual samples, thus the addition of the flow meters at this site has further enhanced the flow data capture.

There is an issue with the A02T2 data, where the flow meter was wired incorrectly until 6th July 2023, and consequently, this data is inverted on the flow graph output. Massey is currently working on resolving this data issue.

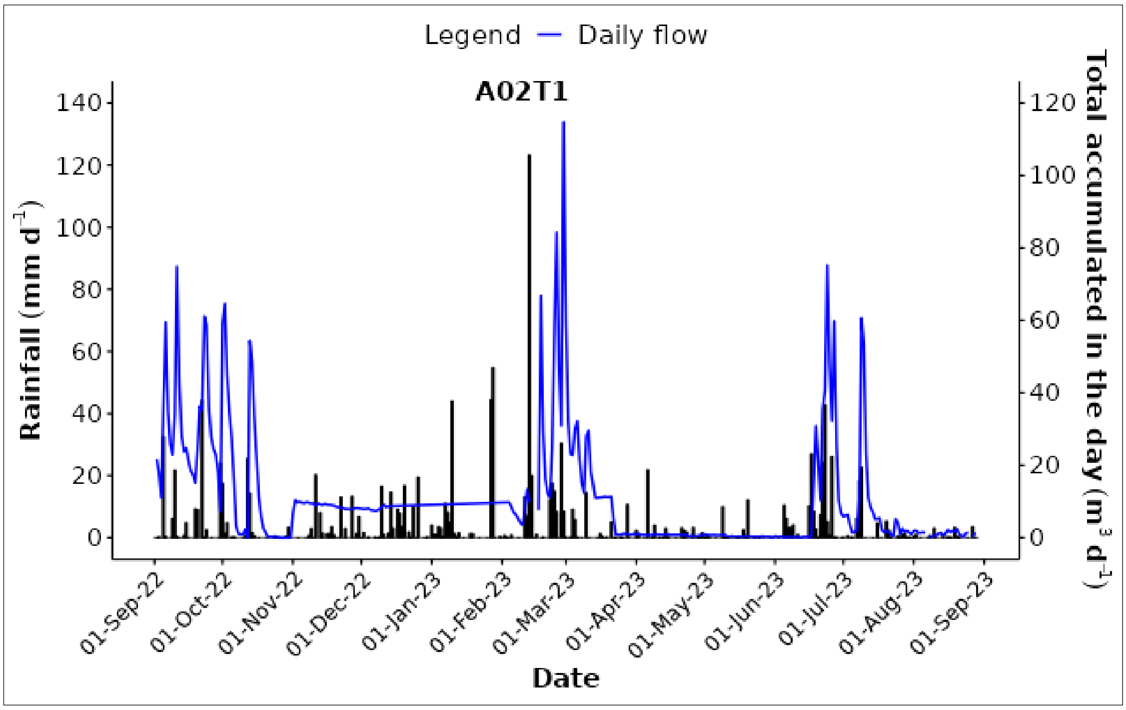


Figure 11 A02T1 Flow data vs rainfall

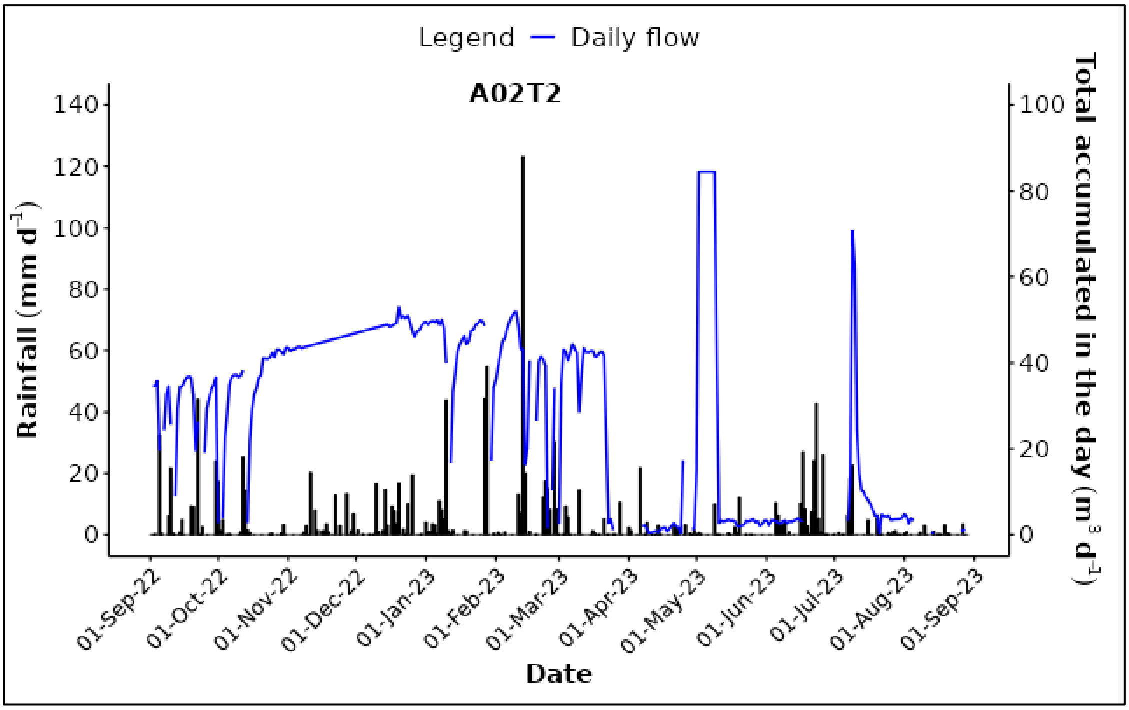


Figure 12 A02T2 Flow data vs rainfall

5.2.2 A03

This tile is often dry during sampling runs, however, the flow meter data shows relatively flashy flow with a short lag time following rainfall over approximately 30mm per day.

At tile 1, there is an anomaly in data from September 22- November 22, where the zero line isn't sitting correctly and Massey is currently working on resolving this data issue.

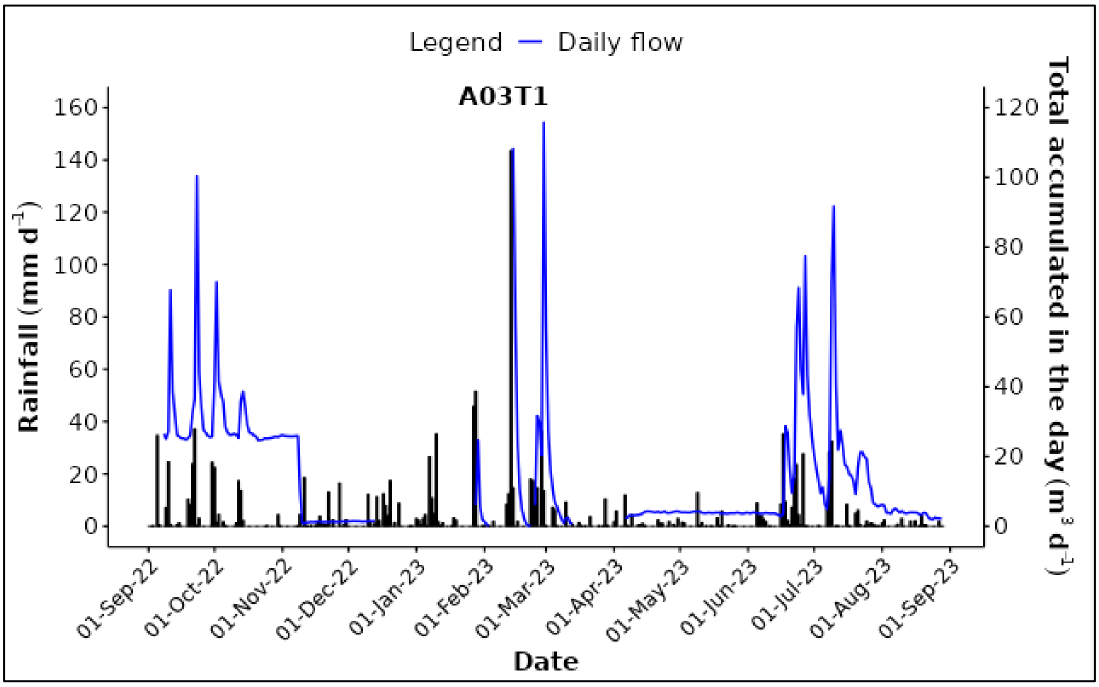


Figure 13 A03T1 Flow data vs Rainfall

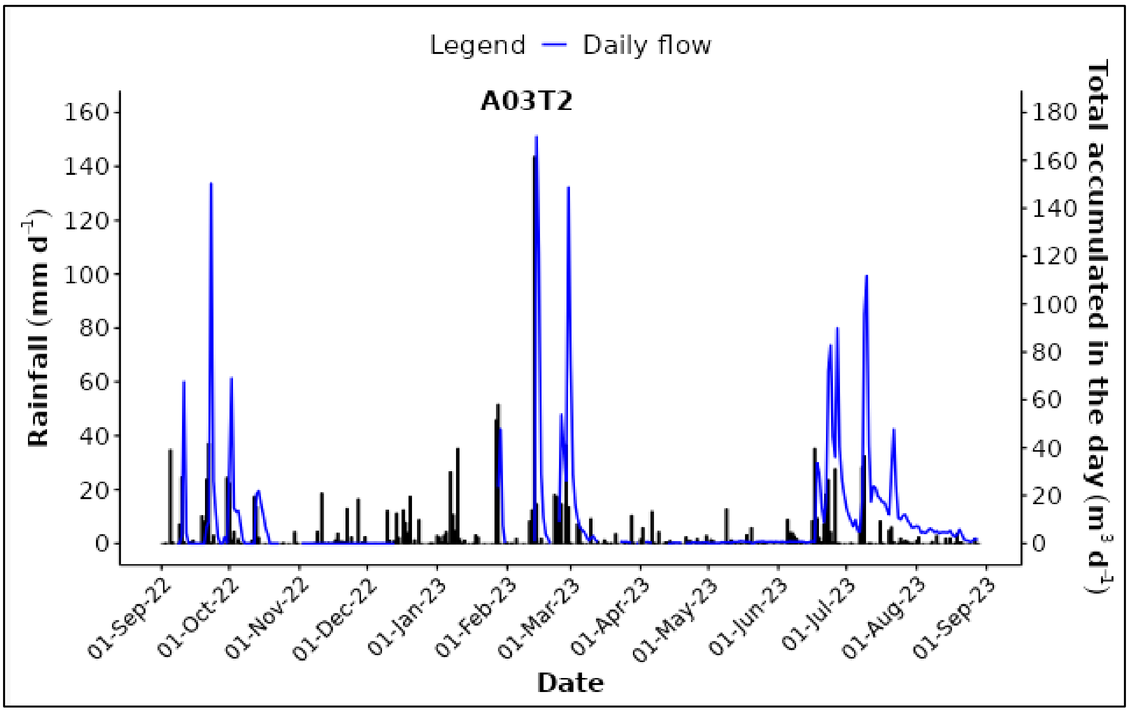


Figure 14 A03T2 Flow data vs Rainfall

5.2.3 A05

At this site, the tile exits were almost always submerged during sampling runs, therefore we were able to capture limited data on flow and nutrient discharge. The installation of the flow meter shows the tile flow was consistent through the period September 2022 to February 2023. However, this site sustained significant damage during Cyclone Gabrielle and therefore no further flow was recorded.

The flow meter at Tile 1 captured data reliably until early December 2022, where the dates began recording incorrectly, and Massey is working to resolve this issue, so the data December -February 2022 can be included in the graph output.

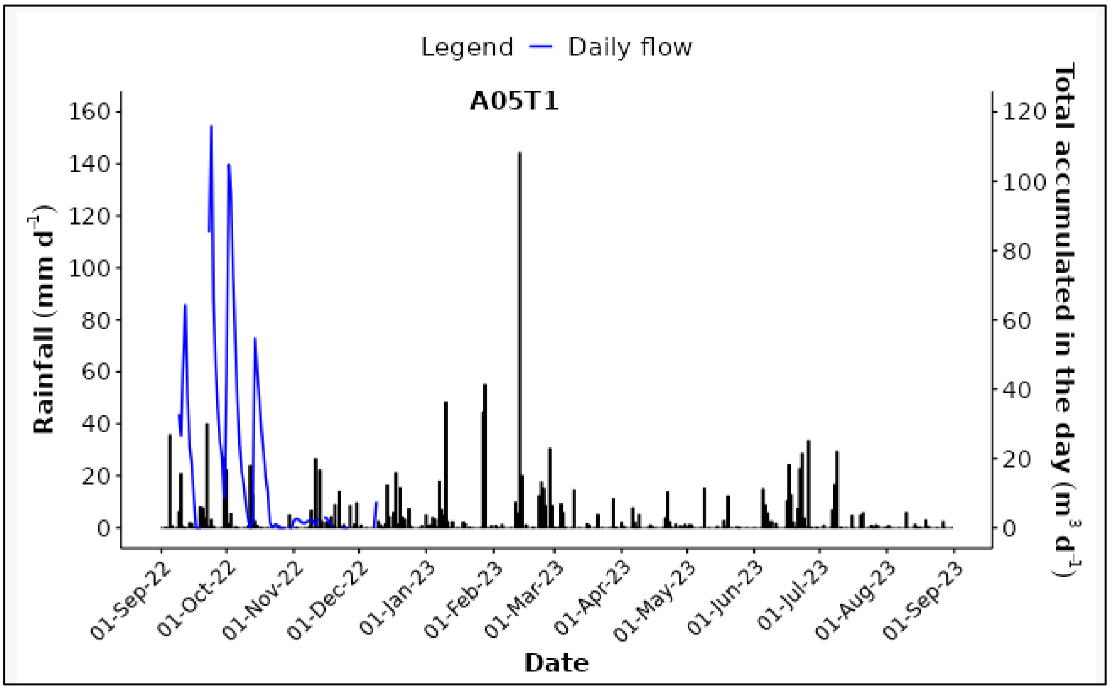


Figure 15 A05T1 Flow data vs Rainfall

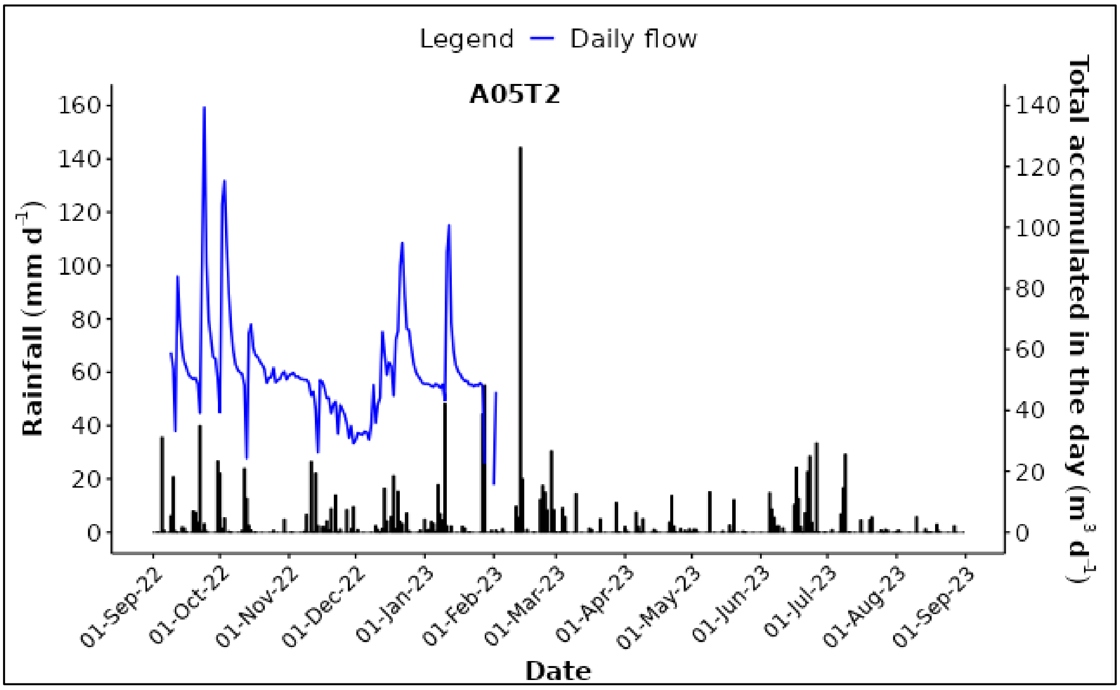


Figure 16 A05T2 Flow data vs Rainfall

5.2.4 A09

This site has continuously flowing tiles. Both flow meters at this site, sustained significant damage during Cyclone Gabrielle, and therefore there was no flow data capture from 14th February 2023 till late April 2023.

Tile 2 shows much higher accumulated flows, up to 480m3 per day. Included is a zoomed in graph, showing that for this tile, even periods of lower flow are accumulating 20-30 m^3 per day.

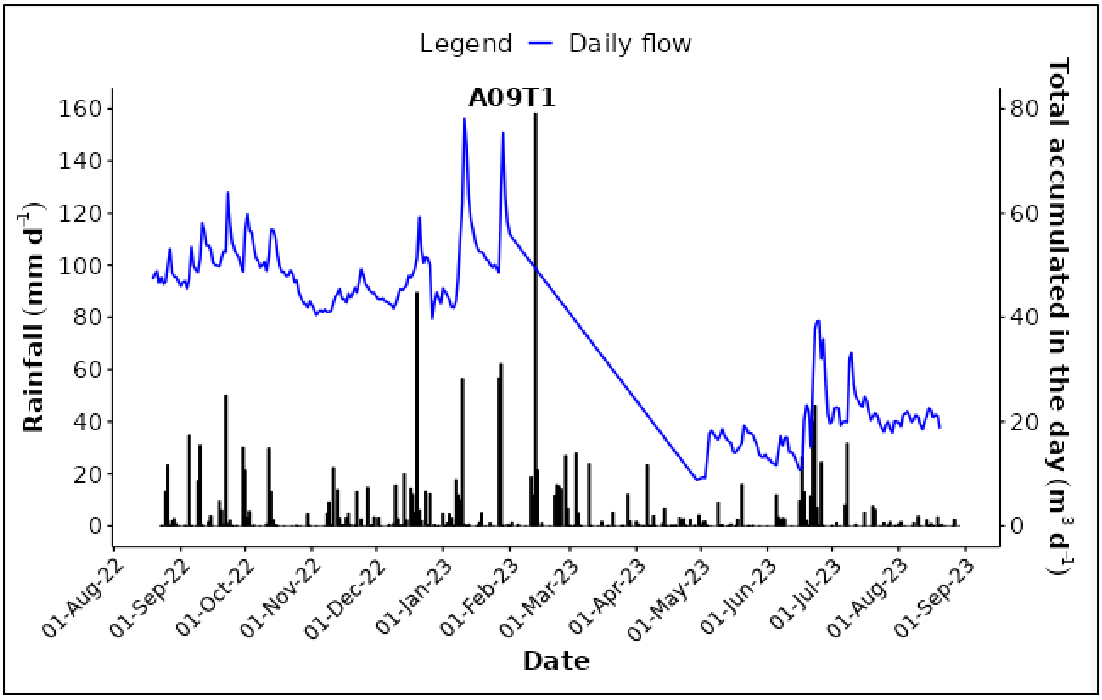


Figure 17 A09T1 Flow data vs Rainfall

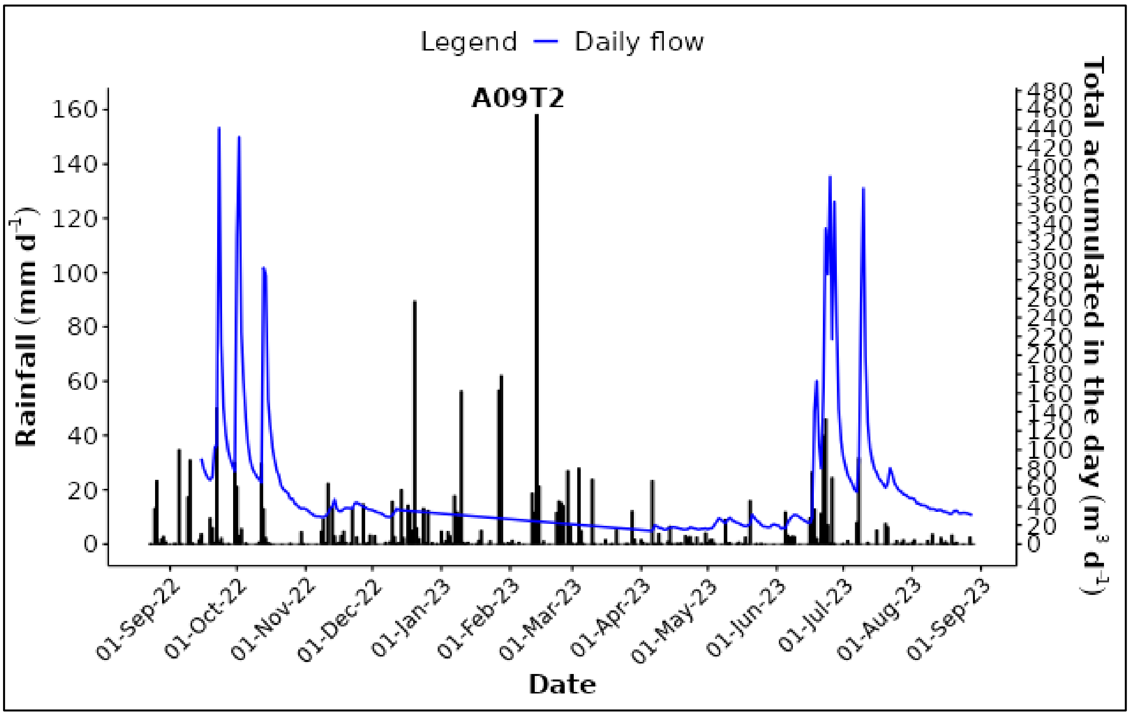


Figure 18 A09T2 Flow data vs Rainfall

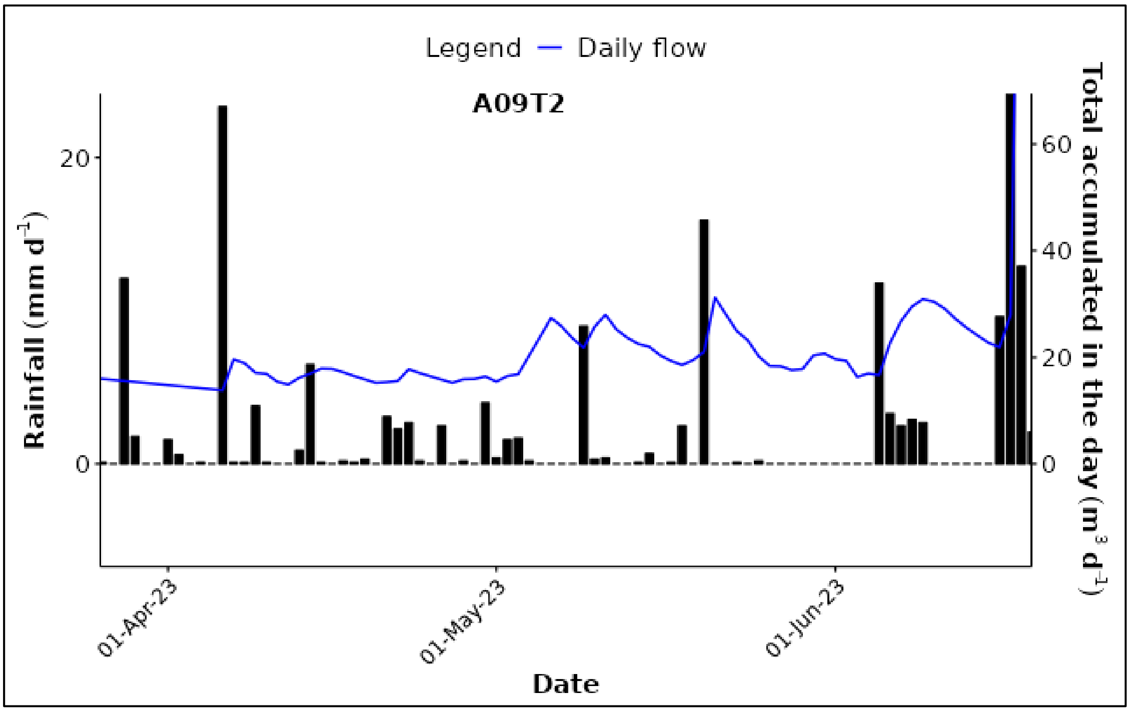


Figure 19 A09T2 Flow data vs Rainfall - shows that even the "low flow" periods at this tile have a significant accumulated flow in the day

5.2.5 C02

This site had been characterised as Dry at T1 and Event at T2 in Year 1 grab sampling, however, flow meter data shows the tiles at this site flow more regularly that was evident during grab sampling runs, with flow occurring more at Tile 1 than Tile 2.

There is significant flow recorded by the flow meter at Tile 1 in mid-November, which doesn't correlate to any rainfall and doesn't follow the usual flow pattern of this tile. It may be that this flow is a misreading and will need to checked alongside river flow levels to further inform the data recorded. Tile 2 has recorded less flow events than Tile 1, and potentially this may mean that the Flow behaviours could be reclassified at this site based on the flow meter records.

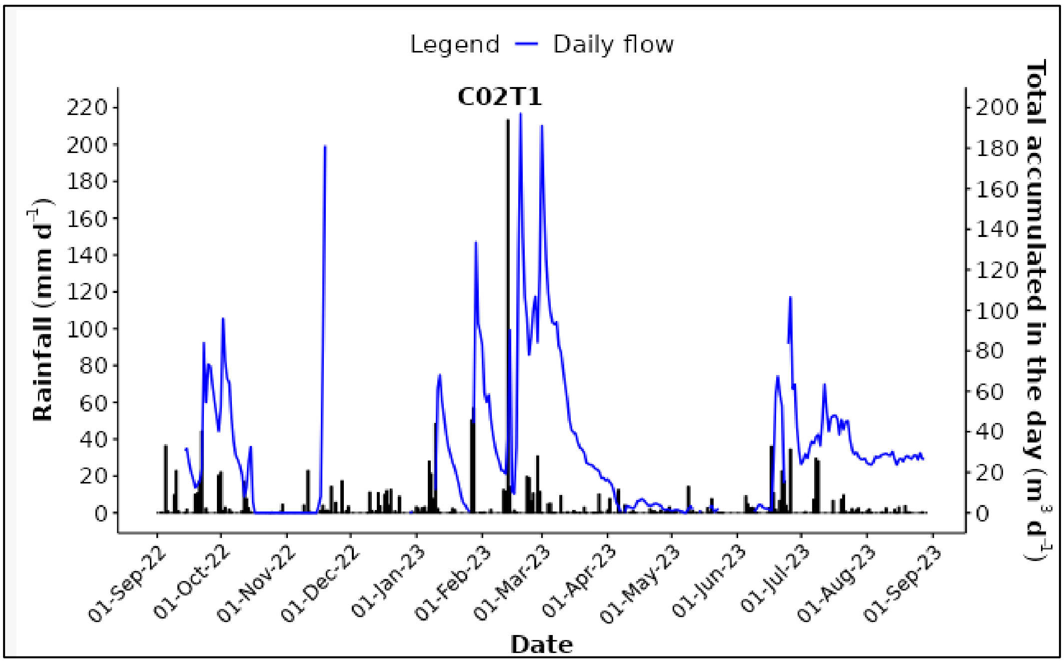


Figure 20 C02T1 Flow data vs Rainfall

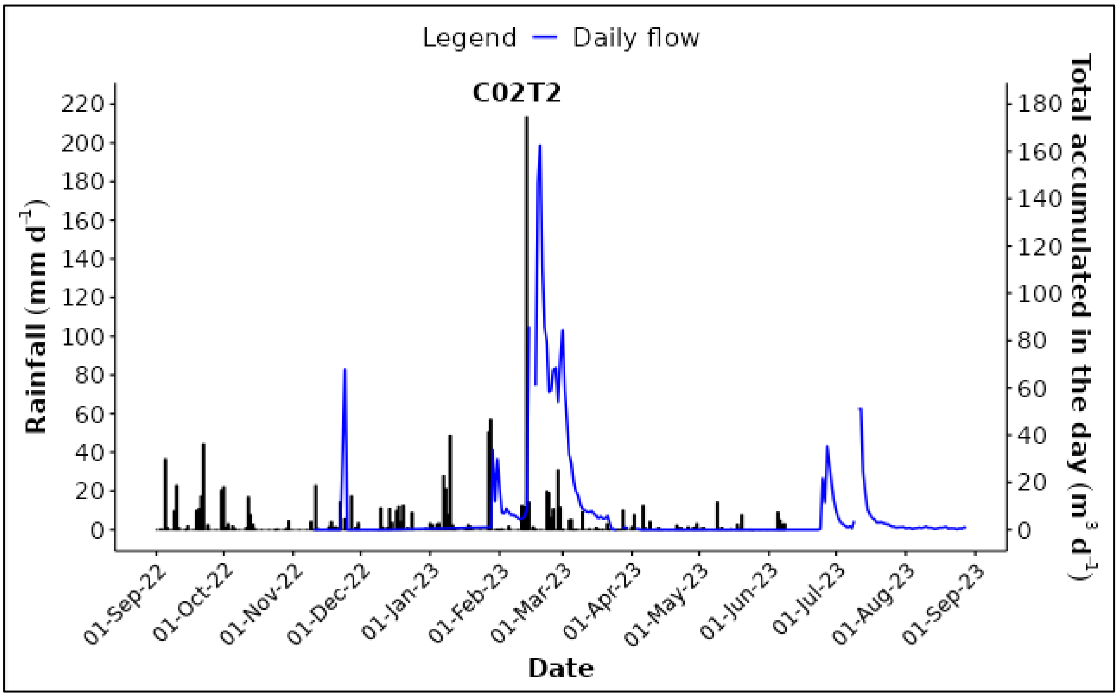


Figure 21 C02T2 Flow data vs Rainfall

5.2.6 C03

Both tiles had been classified as having event flow. Tile 2 shows frequent flow following rainfall, with a long falling limb time back to base flow. Tile 1 does not reach as high a peak as Tile 2, nor is the flow as regular following rainfall. There is a potential flow outlier in December, where the highest peak was recorded despite a reduced amount of rainfall, higher than the highest rainfall experienced during the cyclone.

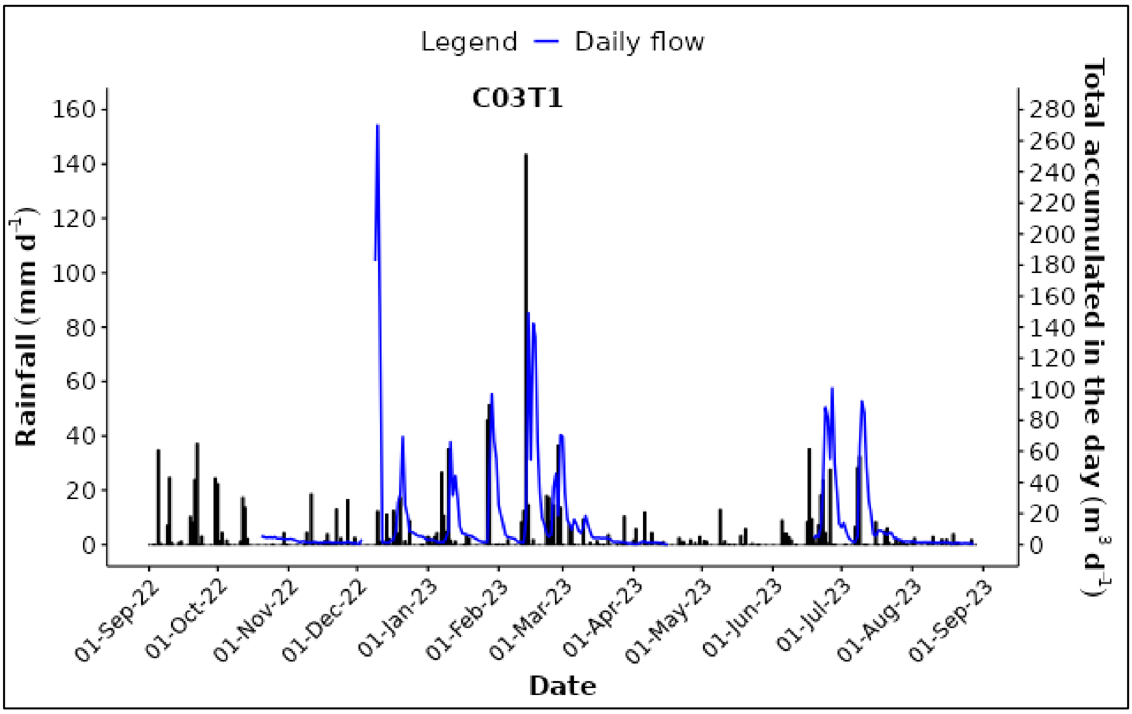


Figure 22 C03T1 Flow data vs Rainfall

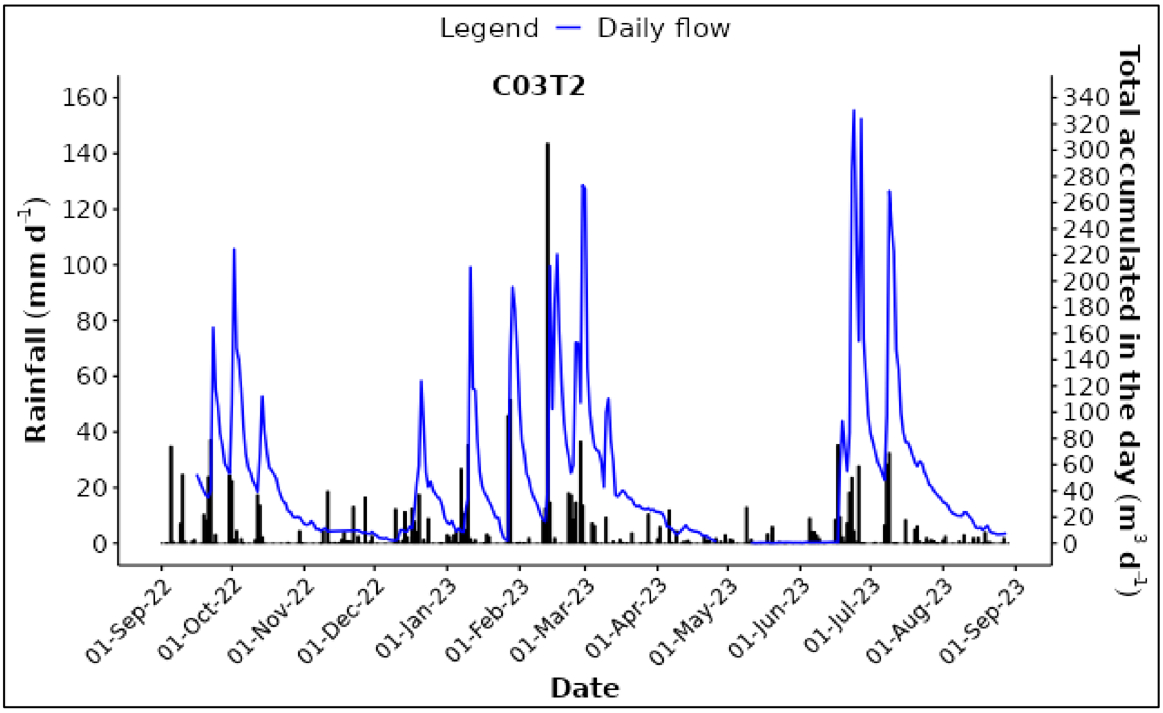


Figure 23 C03T2 Flow data vs Rainfall

5.2.7 K02

This site shows short flow lag times, with peaks happening immediately following rainfall events, and the falling limb times happening straight away back to base flow. This site was characterised as having event flow, and the flow meter data suggests the same.

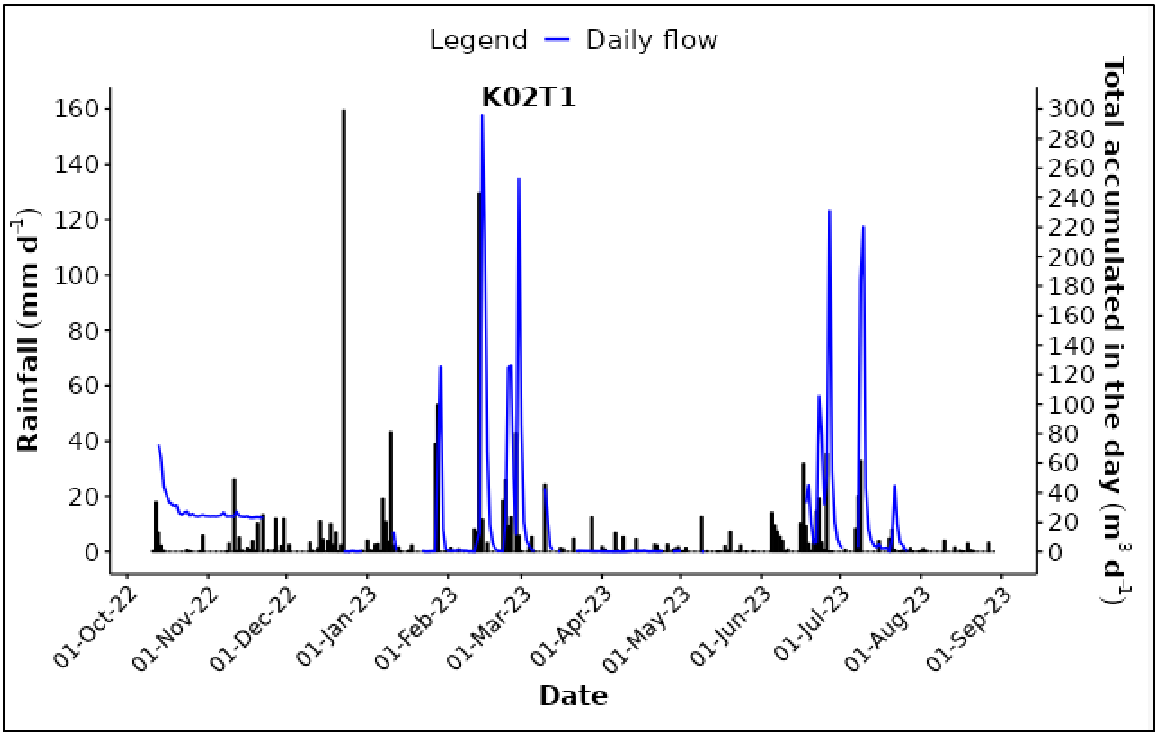


Figure 24 K02T1 Flow data vs Rainfall

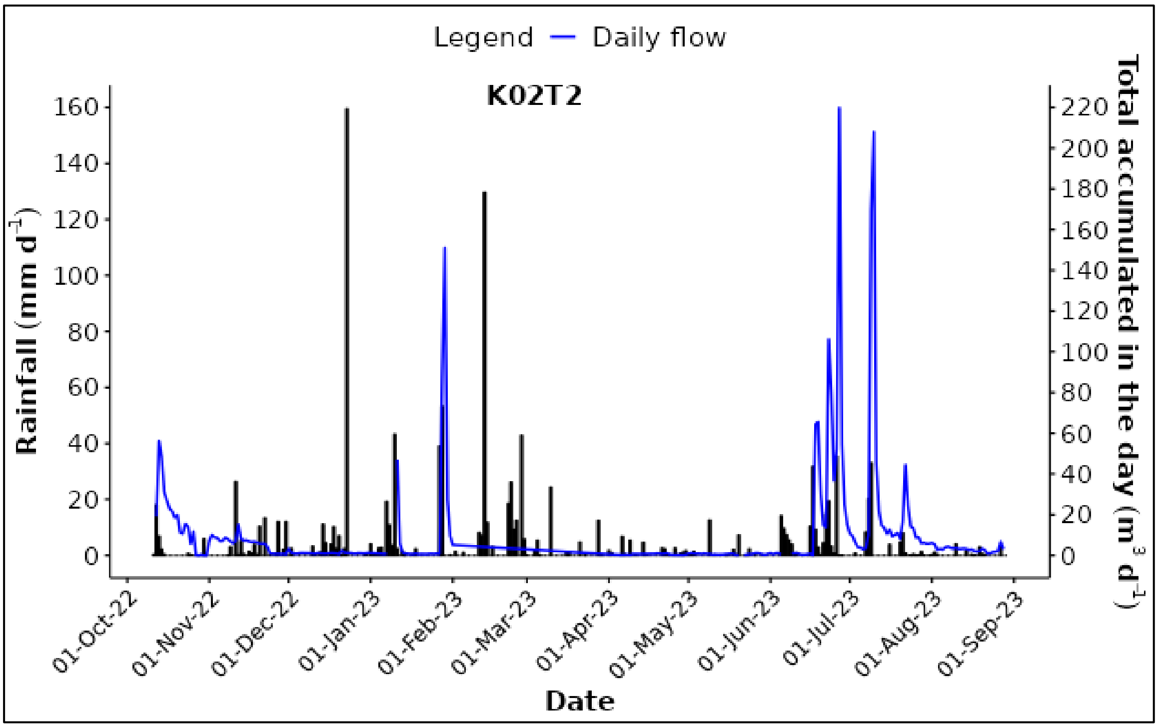


Figure 25 K02T2 Flow data vs Rainfall

5.2.8 K04

The flow meter graph output for each of these tiles needs correcting, as the flow meters zero point was set too high. However, the flow profile shows the event flow behaviour category to be accurate, and the falling limb to base flow to take a longer period than some of the other tiles.

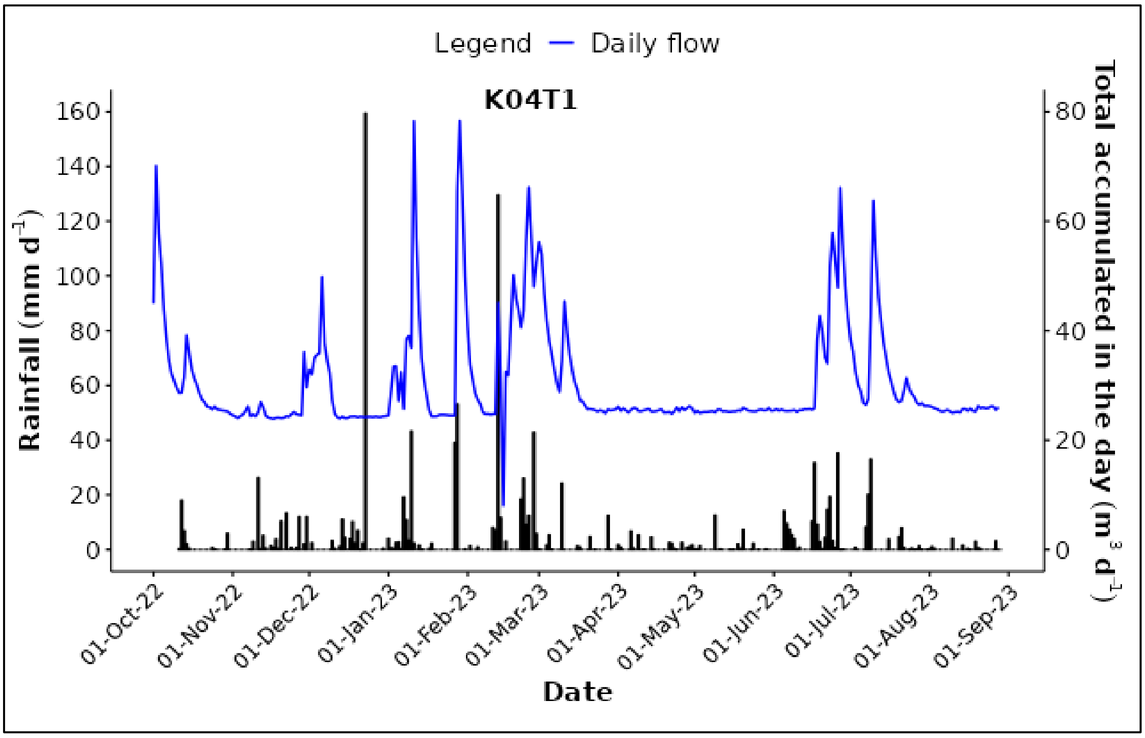


Figure 26 K04T1 Flow data vs Rainfall

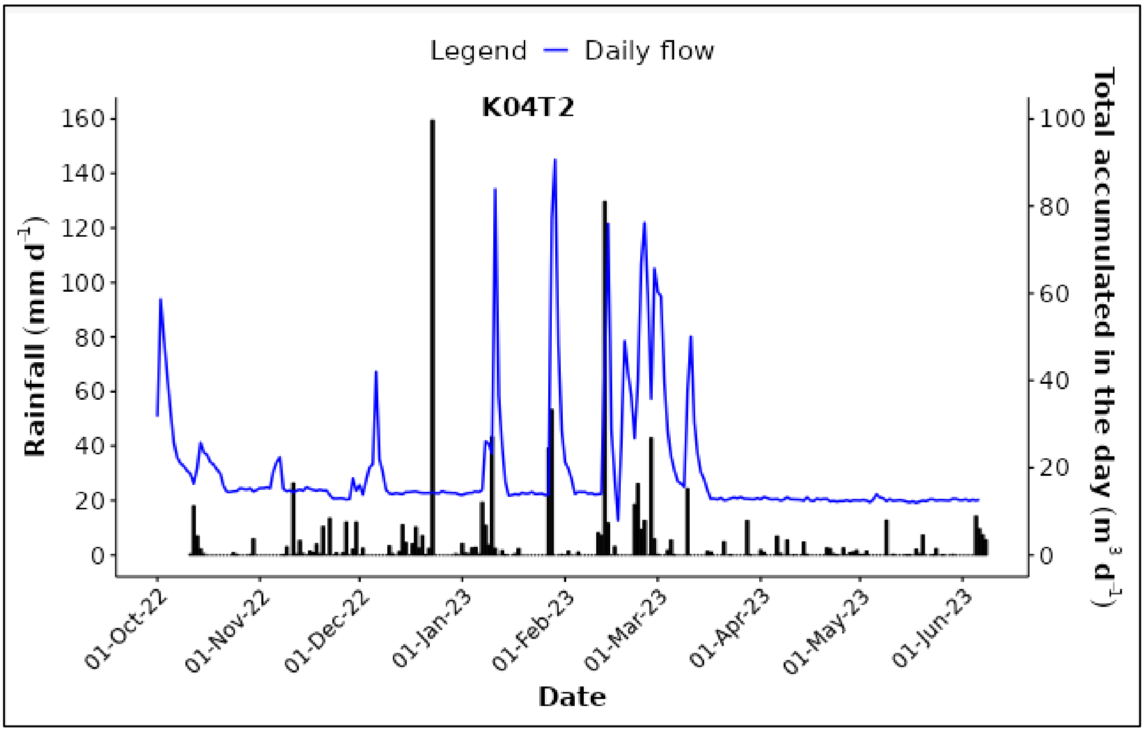


Figure 27 K04T2 Flow data vs Rainfall

5.3 Ruling Issues Out

Based on data collected across Year 1 and 2, the following conclusions can be reached:

- Temperature of tile drain flows is almost entirely within a range of 12 and 20°C with some sites exhibiting a clear seasonal pattern. Only one sample has exceeded 23°C, the default guideline value for the protection of instream biota, and this was recorded at 25.22°C in January 2022. At this time, 25.22°C was also recorded in the receiving water sample adjacent the Tile Drain, while the second receiving water sample recorded 26.33°C, meaning no additional load was presented by the tile drain. Tile Drains are therefore not contributing adverse temperature loading to reiving waters within the project;
- All concentrations of Nitrite recorded to date are <1 mg/L, the threshold set under Water Services (Drinking Water Standards for New Zealand) Regulations 2022. The highest recorded value at the completion of Year 2 is 0.13 mg/L, and little trend is observed in discharge patterns, confirming that Nitrite is not a priority issue within the tile drains assessed in this project;
- Of the 17 farms involved in this project[1], five (29.41%) have predominantly dry conditions, meaning they are not consistently discharging to their receiving waters, and are contributing insignificant loadings. While the coverage and range of sites selected

[1] Site A08 was discontinued at the end of Year 1 and replaced with A09, as per the Year 1 Outcomes Report Dec 2022.

for this project provides a range of conditions and locations across the Heretaunga Plains, further survey work is needed to correlate whether this is representative of all drainage systems across the Heretaunga Plains;

- Total Suspended Solids (TSS) within Grab Samples have been low across Year 1 and Year 2 with most samples <20 mg/L. When considered against the threshold used for assessing the efficiency of Erosion and Sediment Control devices (200mg/L) there are only four results that exceed this TSS threshold present. Given the nature of these values in the context of samples taken, they are potentially outliers in the data set caused by an issue with the sampling process;
- No correlation to cultivation or ripping practices is identified for TSS concentrations and farm practice data collected, confirming Tile Drains are isolated from surficial disturbance activities; and
- Only limited sites (3) have been running stock through Years 1 and 2 and consequently, E.Coli data is limited. However, from data collected across 7 monitoring events where tiles have been flowing, only 1 result has exceeded the TANK threshold of 540 MPN/100 mL where a value of 649 MPN was recorded. Insufficient data is present for determining the percentage of exceedances given the very limited data points within each tile series.

5.4 Nutrient Loading Analysis

In accordance with the National Policy Statement for Freshwater Management 2020 (Updated February 2023) (NPS Freshwater), statistical assessment of nutrient data collected up until the end of Year 2, being 31 August 2023, has been completed using descriptive statistical methods. For the purposes of determining whether individual tile discharges may be contributing to environmental impacts within water bodies, a 95% Upper Confidence Limit (UCL) calculation has been undertaken to determine with 95% certainty, what threshold tile drain discharges will not exceed.

The United States of America Environmental Protection Agency (US EPA) software package Pro-UCL was utilised to undertake 95% UCL calculations, including Shapiro-Wilk Normality tests to determine whether data series are normally distributed. While this assessment is not suitable for all analytical parameters, it is relevant for Nitrate, Ammoniacal-Nitrogen, Dissolved Reactive Phosphorous, and dissolved oxygen.

5.4.1 Goodness of Fit

Assessment of the population data series cannot be robustly undertaken at this stage as none of the Tile Drain data series present a statistically significant distribution. Further data will be required to increase the robustness of statistical measures. The following conclusions are reached:

- Tile Drain locations A04, A05, and C01 have no appropriate data for assessment;
- None of the remaining tile drain data series have a statistically significant distribution (either Normal at 1% or Lognormal at 10% that pass all goodness of fit tests).

- Assessment under Pro-UCL has been undertaken using the recommended distribution based on the data set at the time of this report. The majority of sites do not have discernible distribution at this stage, however normal, gamma and log normal have been utilised where recommended by Pro-UCL;
- Some data series (i.e. Farm A01, TD1) have strong negative skewness. This may need further consideration once the three-year data series has been collected; and
- Manipulation of the data series to remove the '0' values and attribute these to an inconsequential low number cannot be undertaken on nearly all data series, as dry tiles (and hence '0') occurs more than 25% of the time.

Caution must be applied in assessing the data series to date given the duration, goodness of fit results and associated significances. Further commentary is provided in Sections 5.4 and 5.5 for increasing the robustness of the data series.

5.4.2 Analytical Results

Summary tables are appended at the rear of this report setting out the applicable 95% UCL values for Ammoniacal Nitrogen, Nitrate, Dissolved Inorganic Nitrogen, Dissolved Reactive Phosphorous and Dissolved Oxygen across the Tile Drain grab samples, Receiving Water grab samples and Proportional Tile Drain samples. At the time of this report, analytical results have shown:

- Ammoniacal Nitrogen Tile Drain Grab samples are all compliant with the NPS Freshwater National Bottom Line. Values are either within the Attribute A or Attribute B bands, with nearly all receiving water samples higher than those recorded coming from tile drains. Some proportional Ammoniacal Nitrogen samples show higher loadings, however consideration on the integrity of these samples needs to be considered;
- DRP Tile Drain Grab samples encompass the full range of Attribute Levels from A through to D. Data is split with 15 of 32 data series having receiving water concentrations exceeding the tile drains, 11 data series having tile drain concentrations exceeding the receiving waters, and the remaining 6 data series having insufficient data for comparison assessment. All proportional samples analysed returned 95% upper confidence results elevated above those recorded by Tile Drain grab samples with some at least an order of magnitude larger;
- With respect to Nitrate, 18 of the 32 data series show 95% UCL values within the Attribute A level. Of the remaining 14, four series do not have sufficient data for assessment and three exceed the National Bottom Line. As with other nutrients, data is split with 17 receiving water data series exceed the tile drain concentrations and four data series have insufficient data to make an assessment. Of the remaining 11 data series, two show indistinguishable differences between tile drains and receiving water and the remaining nine data series have Tile Drain concentrations exceeding receiving water. But, given the prevalence of Attribute A & B concentrations, Nitrate concentrations are only a priority issue in localised small catchments. Like

concentrations from DRP and ammoniacal N above, nearly all proportional sample 95% Upper Confidence Limit calculations exceed the Tile Drain grab sample 95% Upper confidence calculations:

- Assessment of DIN values against the Default Guideline Values and Proposed TANK threshold for Ngaruroro and Lower Tributaries shows 12 of the 32 tile drain data series are compliant with the 0.444 mg/L threshold while 4 have insufficient data for assessment. When assessed against the receiving waters, 20 of the 32 receiving water samples exceed the tile drain 95% Upper Confidence Limit Thresholds suggesting the tile drains are providing some beneficial dilution. Proportional concentrations of DIN follow the same trend as the above nutrients with nearly all 95% Upper Confidence Limit values exceeding those of the tile drain grab samples, with many of these at least an order of magnitude larger. Only one proportional sample site (K04T1) has a 95% Upper Confidence Limit within the TANK thresholds.

5.4.3 Discussion

Caution is needed in assessing the year 2 data assessment to date as it only represents a snapshot of benchmarking data against a dynamic environment. The following aspects are noted regarding data robustness:

- Typically, '0' values would not be included in a data series for determining concentration. When assessing concentration values, the nominal consensus is that some minor amount would still be present and that a value of '1/Limit of Reporting' would be utilised where analytical results are considered non-detectable. The premise for this is that a maximum of 30% of data values should be adjusted for processing. However, in this instance many of the data series have more than 30% values that would require adjustment, which then influences the robustness of the statistical model. As the receiving waters also have dry conditions and where no flow is occurring, a true '0' can exist, these values have been left within the data series and non-parametric data assessment has been utilised for determining upper confidence limits at this stage;
- Recommendations within the NPS Freshwater and accompanying technical literature note that assessments should be based on data collected at least monthly over a five year period. As this data to date only covers two years, it is not yet considered well developed enough for determining compliance with the associated guideline values;
- Dissolved oxygen assessments for compliance comparisons are designed to be based on at least weekly sample collection over the summer period. The fortnightly monitoring regime has been utilised at this stage; and
- Proportional assessment results appear quite different from grab sample assessments and given the limited proportional data series and associated collection regime, further consideration against best practice (including methodology and laboratory withholding times) is required to ensure these are representative.

The above notwithstanding, assessment of data collected as at the completion of Year 2 has identified DRP concentrations in receiving water and tile drain flows present the most significant issue across the data series. High levels of compliance are present for Ammoniacal-Nitrogen and Nitrate, while issues are noted for Dissolved Inorganic Nitrogen concentrations against the TANK Plan change thresholds for the lower tributaries of the Tutaekuri and Ngaruroro Rivers.

The other notable finding from the appended data series, is that receiving water concentrations in most instances exceeds the concentrations recorded in tile drains suggesting that tile drains are contributing beneficial dilution to these systems. Observations across the receiving water data series shows that these concentrations appear to flux independently of the tile drains and have more notable impacts during event-based sampling consistent with higher overland flow contributions to these smaller water ways. Further assessment will continue within Year 3 to identify the primary contributing factors.

5.5 Regression Assessment

Data assessment at the completion of Year 2 has not identified any clear correlating factors for on farm actions and associated discharges. Focussing on Nitrate and DRP as the two key contaminants of concern, regression analysis notes:

- No clear relationship between DRP concentrations in Tile Drains and Olsen-P concentrations in soil (R^2 = 0.0437, polynomial relationship);
- Assessment of total phosphorous application (kg/ha) against Tile Drain DRP concentrations shows no discernible correlation (R^2 = 0.0198);
- No correlation between Tile Drain DRP concentrations and total base saturation or Cation Exchange Capacity exists (R^2 values of 0.0409 and 0.0637 respectively);
- Assessment of Tile Drain Concentrations against all assessed soil parameters did not identify any correlation of note with all R^2 values <0.1; and
- A weak correlation between mineralizable N (kg/ha) and Tile Drain nitrate concentrations is observed (R^2 = 0.1375).

5.6 Evaluation of Sample and Analysis Plan & Analytical Results to Date

At the completion of Year 2, limited correlation or trends have been observed within the data set and as such, it is important to evaluate the sample and analysis approach against the analytical results to ensure that the project aligns with current best practice. The current approach of undertaken fortnightly grab samples from the tile drains interspersed with rainfall triggered event samples is in line with best practice for establishing a baseline data set. However, the three-year length of the project presents a shortfall in being able to implement and actively monitor improvements from mitigation actions.

It is noted that National Policy Statement for Freshwater Management 2020 (NPS Freshwater, updated February 2023) recommends compliance against National Bottom Lines and attribute levels be based on:

a monthly monitoring regime where sites are visited on a regular basis regardless of weather and flow conditions. Record length for grading a site based on 5 years.

Similarly, Our Land and Water has several research projects either underway or recently completed that assess the timeframes and strengths of monitoring regimes for detecting changes within water quality.

Firstly, the *Linking Legacies to Wai* project identified an average lag time between land use changes and increased load of nitrate in streams and rivers of 4.5 years (average across 77 catchments that capture 50% of Aotearoa's agricultural footprint). The research assessed what realistic timeframes are necessary to decrease nitrate concentrations in streams and rivers. The outcomes suggest that the 3-year timeframe of the Tile Drains project will not be sufficient to assess changes in sub-surface discharges, with any improvements from the Farm Environment Plan and GMP/BMP assessed will not materialise within the life of the project. Similarly, a selection of sites within this study were only developed and taken into their current management framework in 2019/2020 and therefore changes from that management change will not be evident until 2024/2025.

Secondly, the *Monitoring Freshwater Improvement Actions* project has developed a tool kit (https://www.monitoringfreshwater.co.nz/) that while not fully operational, enables the assessment of a proposed monitoring regime within a distinct catchment as what the likelihood is of observing an improvement based on mitigation improvements. As an example, the monitoring site of Raupare Stream at Ormond Road was assessed for covering the general Twyford catchment. If 50% of the maximum potential improvements were applied across all catchment contributors within Twyford and a fortnightly monitoring regime was implemented across 5 years, there is only a 62% chance of observing a notable improvement in Dissolved Reactive Phosphorous. If the monitoring regime is extended to 10 years, this increases to an 89% chance (power) of observing an improvement. This toolkit reinforces that detection of incremental changes because of catchment improvements is difficult, and any mitigations employed within Year 3 are not realistically going to be detected within the monitoring programme.

Further work completed in this space in 2019 includes the Our Land and Water *Sources and Flows* project assess the effectiveness of On-Farm mitigation actions and released an interactive tool based on the data collected for determining actions to include within a Farm Environment Plan. While consideration has been given to these actions in terms of assessing mitigation options, it is useful to note that this work also focused on catchment scale contaminant transport for driving improved water quality outcomes.

Further discussion on investigation pathways and processes for Year 3 are set out in Section 9 below.

6.0 MITIGATION EVALUATION

Evaluation of a range of land based and edge of field mitigation options has been undertaken to determine whether mitigation options exist that provide a robust change where objective and measurable differences could be observed within the scope of the project. Land based mitigation options are discussion in Table 4, while edge of field mitigation options are discussed in Table 5.

Table 4: Land Management Mitigation Options Assessment.

Land Management Mitigation Options	Discussion
Change timing of fertiliser applications	Some rainfall is required for best effect of soil fertiliser application, however too much rain causes runoff. Both 2022 and 2023 were very challenging with above average rainfall and frequent heavy events however growers under GMP/BMP already monitor weather windows. No correlation on event vs baseline results is evident to date, but this may be a factor of delay for discharges from soil. Further assessment is needed alongside expansion of data series.
Split fertiliser dressings	Predominantly a cropping control mechanism, however this is already being completed in GMP/BMP processes for the cropping sites within the trial.
Fertigation versus contemporary applications	The Farm locations within this trial include both conventional and fertigation set ups and assessment is underway to determine differences between the two management mechanisms. No trends are noted yet however further assessment will continue to determine if best practice needs to change.
Variable rate irrigation	Farms in this trial use a variety of irrigation systems and are utilising soil moisture monitoring to determine specific irrigation requirements. A mix of irrigation systems are also incorporated within the trial, and these will be considered against the analytical results.
Change in ground cover / cover crops	Being assessed as an option and investigation into what benefits will be achieved for subsurface discharge. As sites with limited or no fertiliser application are still discharging, introduction of such a change is highly unlikely to show a demonstrable impact within the life of the project.
Reduce fertiliser use	All sites are already at GMP/BMP level, undertaking soil tests, leaf tests and nutrient budgeting. Most applications are based on

	nutritional target information, grower discussions have identified that many sites are already running at input levels that should create soil nutrient deficits once the crop nutrient removal has been considered. Current understanding does not support a scientific justification to further reduce fertiliser input values across different sites. Discharges from sites where no fertiliser has been applied, are suggesting a complex interaction is in play.
Regenerative farming system	Currently, there is a lack of consensus on a specific definition. Wider SFFF work via Landwise Carbon Positive Farming Trials and wider industry work show that these practices require significant time frames. Currently all sites are conventionally managed, and assessment of a regenerative system would be required over a 5-year time frame.
Use of filtration media as backfill for Tile Drains	Calcium, aluminium, and iron can all be p-sorbing materials and various media can be utilised to backfill tile drain trenches, however this is a significant cost against the normal scoria or pea gravel utilised and would be extremely damaging to retrofit within existing systems. Further investigation is needed to confirm applicability in newly developed systems.

Table 5 Edge of Field Mitigation Options Assessment

Edge of Field Mitigation Options	Discussion
Bio-reactor	Large area needed where woodchips and media can be installed within the drainage system. Early trials (i.e Lake Ellesmere) have yet to be prove N reduction and not yet proven on DRP. Installing systems of this nature in stream has significant implications for flood asset management. Not considered feasible in the currently utilised configurations.
Riparian Planting	Already required for catchment wide improvements and noted to be $30 – $40,000 / ha to install in typical configurations. While this may deliver catchment wider water quality improvements, it has implications on drain management & flooding. In the current configuration of the trial, it would be impossible to monitor and determine any improvement against Tile Drain outputs.
Filtration system	Installing a filtration system at the end of the drain is considered impractical given the size of installation required to account for flow and associated landuse configurations. Maintenance and cost of

	filter media are significant and therefore not considered feasible at this stage.
Constructed wetland	Similar to the filtration system above, a constructed wetland is not considered practical at this stage given the gradient of the drains, their depth from surface, and flow characterisations. Impacts on the drain waterways is likely to be significant during establishment and will likely exacerbate flooding issues.
Filamentous algae scrubbers	While these are showing promise for nutrient reduction, these systems require very high maintenance inputs and management making them impractical for most situations. Similar to the above options, the ability to install such a system onto a tile drain output would require significant retrofit and likely engineering of a pumped system. Flow volumes will likely make an engineered system cost prohibitive for size.

7.0 EXTENSION OPPORTUNITIES

There have been many different extension outputs throughout Year 2, across each of the four extension groups. A comprehensive list of each extension activity completed in a milestone can be found in the milestone deliverables for each.

Regular project updates have been circulated to industry through the AgFirst InBrief fortnightly newsletter, the Hawke's Bay Fruitgrowers Association articles and email distributed updates. Presentations to Level 2/3 Horticulturall certificate students at Eastern Institute of Technology, Te Aho a Māui (Te Pukenga), students on an educational study tour from Purdue University and various team members with relevant portfolios in Hawke's Bay Regional Council were all successful, with attendees engaged and wanting to be kept updated with further findings.

The short project video, released in November 2022 was a highly successful extension piece, and has been widely viewed and shared. This video focussed on education of what the purpose of a tile drainage system is, how the project monitors tile drain discharge water, and what we are hoping to learn through the project. A second, follow-up video will be released during Year 3 monitoring.

8.0 YEAR 2 PROGRESS TOWARDS PROJECT OUTCOMES

At the instigation of the project, seven (7) key objectives were set with 12 key performance indicators (KPI) documented to determine whether the objectives have been met. This report as been compiled based on the completion of Year 2 of data collection and has made significant progress towards the desired project outcomes. An assessment of each of the 12 document KPI's are set out in Table 6 below.

Table 6 Year 2 KPI Progress Assessment

KPI	Assessment
1. Collect a three-year dataset on water flow and quality characteristics of tile drain output and upstream receiving water from different land uses in the Karamu Catchment of Hawke's Bay	**On Track** – two years of data collection has now been completed, canvassing a range of climatic conditions. The full three-year data set is expected to be completed in August 2024.
2. Understand and clearly report whether there is any loss of Nitrogen, phosphorous, sediment or e.coli and if there is a clear relationship with crop, soil type, management practices, weather events or climatic features.	**In-Progress** – two years of data has now been collected; however, limited correlations have been identified to date. Assessment of the strength of the monitoring regime is underway to determine the best approach for quantifying whether any loss is occurring, and if so the relationship of that loss.
3. Understand and clearly report the influences occurring to the tile drain outflow sites (Natural N cycling, nutrients in rainfall, upwelling groundwater etc) outside of the management influence.	**In-Progress –** Collection of the two year data series is completed, with data analysis identifying a likelihood of upwelling groundwater in some tiles. Assessment of rainfall will be completed in Milestone 11 and 12, while measures for assessment of natural-N cycling are being investigated.
4. Understand water quality fluctuations in a range of smaller water bodies (open drains and streams). Answer whether these flux independently of tile drains or similarly, and whether the three year average quality of the receiving water is the same, lower or higher than the tile drain exit.	**In-Progress –** Two-year data set has been completed and relationships with tile drains are being assessed. Some early observations have been documented in this year two findings report and alongside tile drain assessment, the strength of receiving water assessment is also being considered.
5. Report the timing of losses, so that regional councils can potentially complete a study on whether timing of loss to waterways (autumn, early spring, late spring etc) changes the impact of a loss. The objective is to understand areas of focus in grower's Farm Environment Plans.	**In-Progress –** Seasonality of water quality is being assessed within the data series. While no correlations are evident at this stage, assessment of the strength of the monitoring programme is ongoing alongside quantification of any losses.
6. Increase grower familiarity with the Farm Environment Plan process.	**On Track** – Work done in the Pre Monitoring phase, and Year 1 with grower workshops to create Farm Environment Plans using the HortNZ EMS add on. During Year 2 winter, growers revied their original plans and updated when changes had been made. In Year 3, HortNZ and Agrilink will be creating a dashboard showing the project Farm Environment Plan results, as well as running

	further workshops to further upskill growers on this process and get them ready for Audit.
7. Report the 3-year losses from farms operating at the good management practice standard chosen. Report whether the addition of a suite of 'tile drain best management practices' made a difference to losses compared to a control site.	In-Progress – When monitoring commenced, all project participant sites were at GMP, with many operating at BMP. Further assessment is being done regarding what Tile Drainage best management practices may be, and how growers may implement these, if deemed feasible.
8. Identify the cost-benefit of the additional mitigations employed, making comparison to cost-benefit of riparian planting.	Underway – initial evaluation of mitigation options remains underway including a cost benefit analysis of riparian planting. Further feasibility assessment of mitigation options will continue alongside evaluation of riparian planting within flood control infrastructure.
9. Use the site examples to inform industry and regional council emphasis between: a. Riparian planting b. Currently understood good management practices. c. Additional tile drain best management practices d. edge of field mitigations.	In-Progress – This year two findings report builds the baseline data series and has commenced assessment of currently understood good and best management practices within the GAP framework. Cost benefit analysis of riparian planting is being completed while initial assessment of currently known edge of field mitigations has been completed. Assessments will continue within the next milestones to expand this understanding and identify further options.
10. If edge of field mitigations become likely, provide the data on flow and concentration fluxes through time to design the most efficient edge of field option.	Underway – To date, edge of field mitigation options have not proven feasible in the dynamic tile drain environment, however robust baseline flow and flux data has been collected to facto into mitigation design. Further assessment will continue into Year 3.
11. Show that the horticultural industry is working positively and transparently towards measuring and mitigating their impact.	On Track – All grower participants within the project are invested and interested in what the findings can be translated into. Similarly, the outputs have been well received by Hawke's Bay Regional Council. Data collection will continue to measure and quantify any impacts from Tile Drains while evaluation of feasible mitigation measures will continue in consultation with industry.
12. Provide information and understanding which can be used to help justify the need for, and/or reduce the compliance burden on growers.	On Track – Data collected to date is contributing towards a robust baseline for determining the relationship between surface operations and Tile Drain outflows. Quantifying outflows over time is the first step in reinforcing.

9.0 YEAR 3

Data analysis across Year 1 and Year 2 has confirmed that any relationships between on-farm actions and tile drain outputs are complex, and unlikely to be linear correlations. To further investigate these relationships, Year 3 will be assessing:

- Groundwater profile testing to assess nutrient profiles underlying the subject sites and consider whether:
  - Nutrients in groundwater are a significant contribution to nutrient budgeting;
  - Groundwater is a stronger influence on Tile Drain compared to rainwater and percolation;
- Rainfall nutrient quantities, to assess the extent of influence this might have in a nutrient budget;
- Assessment of Olsen-P soil concentrations within differing soil horizons to look at any discernible changes from surface through the horizons and whether this correlates with dissolved reactive phosphorous recordings within Tile Drain data;
- Riparian cost benefit analysis taking into account the findings to date and input from Hawke's Bay Regional Council flood asset management;
- Slake, Slump and Visual Soil Health Assessments of sites where concentrations are notable different to expected trends based on farm management actions and associated management strategies;
- Alternative mitigation options available and the practicability of implementing these within the dynamic drainage network;
- Evaluation of the sample and analysis plan to determine against best practice requirements; and
- Determination of the confidence of the data set and what, if any, further information may be necessary to formulate appropriate conclusions.

Data collection will continue with base sampling runs completed fortnightly and associated event-based sampling conducted when rainfall exceeds 15mm.

10.0 REFERENCES

Demonstrating efficacy of rural land management actions to improve water quality - How can we quantify what actions have been done? (Journal of Environmental Management, March 2020).

A strategy for optimizing catchment management actions to stressor–response relationships in freshwaters (Ecosphere, October 2018).

Mitigating the impacts of pastoral livestock farming on New Zealand's water quality III: What could be achieved by 2035? (NZ Journal of Agricultural Research, 2021).

11.0 APPENDIX 1- 95TH PERCENTILE NUMERIC ATTRIBUTE STATES AND TANK/DGV VALUES

Site	Tile Drain Ammoniacal N (mg/L)	Receiving Water Ammoniacal N	Proportional Ammoniacal N	Site	Tile Drain Ammoniacal N (mg/L)	Receiving Water Ammoniacal N	Proportional Ammoniacal N
A01 – T1	0.018	0.0444	NA	C01 – T1	NA	0.0199	NA
A01 – T2	0.0193	0.108	NA	C01 – T2	NA	0.0195	NA
A02 – T1	0.0188	0.0396	0.0624	C02 – T1	0.0361	0.296	0.0783
A02 – T2	0.0104	0.038	0.0734	C02 – T2	0.0123	0.361	0.133
A03 – T1	0.0258	0.329	2.225	C03 – T1	0.0109	0.0869	0.0407
A03 – T2	0.141	0.305	2.751	C03 – T2	0.0134	0.095	0.0936
A04 – T1	0.00359	0.0679	NA	C04 – T1	0.128	0.0788	NA
A04 – T2	Insufficient Data	0.0632	NA	C04 – T2	0.24	0.0817	NA
A05 – T1	0.00601	0.105	3.023	K01 – T1	0.0484	0.0073	NA
A05 – T2	Insufficient Data	0.108	0.183	K01 – T2	0.0362	0.00734	NA
A06 – T1	0.0118	0.0359	NA	K02 – T1	0.0142	0.2	0.0589
A06 – T2	0.0198	0.0291	NA	K02 – T2	0.021	0.206	0.424
A07 - T1	0.153	2.16	NA	K03 – T1	0.0325	0.0472	NA
A07 – T2	0.144	2.094	NA	K03 – T2	0.0282	0.0445	NA
A09 – T1	0.0248	0.0365	0.0349	K04 – T1	0.0197	0.0165	0.123
A09 – T2	0.0232	0.0359	0.0498	K04 – T2	0.0201	0.00626	0.185

Legend – 95th Percentile Numeric Attribute state

Attribute A ≤ 0.05

Attribute B ≤ 0.40

Attribute C ≤ 2.20

Attribute D > 2.2

Receiving water values in UNDERLINE are greater than the Tile Drain Discharge.

Site	Tile Drain DRP (mg/L)	Receiving Water DRP (mg/L)	Proportional DRP (mg/L)	Site	Tile Drain DRP (mg/L)	Receiving Water DRP (mg/L)	Proportional DRP (mg/L)
A01 – T1	0.0316	0.0641	NA	C01 – T1	Insufficient Data	0.0375	NA
A01 – T2	0.0289	0.0622	NA	C01 – T2	Insufficient Data	0.0365	NA
A02 – T1	0.0074	0.0225	0.0492	C02 – T1	0.0727	0.771	0.236
A02 – T2	0.00537	0.0214	0.0128	C02 – T2	0.0291	0.782	0.246
A03 – T1	0.00506	0.0207	0.0111	C03 – T1	0.0544	0.206	0.13
A03 – T2	0.00555	0.021	1.045	C03 – T2	0.0565	0.221	0.14
A04 – T1	Insufficient Data	0.0574	NA	C04 – T1	6.0	0.562	NA
A04 – T2	Insufficient Data	0.053	NA	C04 – T2	5.45	0.835	NA
A05 – T1	Insufficient Data	0.346	0.255	K01 – T1	0.1491	0.0193	NA
A05 – T2	Insufficient Data	0.353	0.255	K01 – T2	0.1719	0.0207	NA
A06 – T1	0.11	0.0811	NA	K02 – T1	0.0621	0.388	0.263
A06 – T2	0.30	0.0982	NA	K02 – T2	0.0661	0.405	0.304
A07 - T1	0.52	0.198	NA	K03 – T1	0.21	0.118	NA
A07 – T2	0.52	0.18	NA	K03 – T2	0.0698	0.127	NA
A09 – T1	0.04	0.0691	0.0674	K04 – T1	0.0700	0.0729	0.123
A09 – T2	0.05	0.0727	0.0667	K04 – T2	0.0914	0.0427	0.218

Legend – 95th Percentile DRP Numeric Attribute state

Attribute A ≤ 0.021

Attribute B ≤ 0.030

Attribute C ≤ 0.054

Attribute D > 0.054

Receiving Wate Values UNDERLINED exceed Tile Drain grab Sample results

Site	Tile Drain Nitrate (mg/L)	Receiving Water Nitrate (mg/L)	Proportional Nitrate (mg/L)	Site	Tile Drain Nitrate (mg/L)	Receiving Water Nitrate (mg/L)	Proportional Nitrate (mg/L)
A01 – T1	0.37	0.428	NA	C01 – T1	Insufficient Data	3.186	NA
A01 – T2	0.129	0.389	NA	C01 – T2	Insufficient Data	2.766	NA
A02 – T1	0.198	1.381	1.468	C02 – T1	5.883	6.075	17.68
A02 – T2	0.0108	1.355	1.417	C02 – T2	8.792	5.846	27.09
A03 – T1	0.0556	1.066	4.705	C03 – T1	2.338	1.431	6.523
A03 – T2	0.0371	1.177	2.057	C03 – T2	1.792	1.445	6.318
A04 – T1	0.767	0.73	NA	C04 – T1	1.744	1.338	NA
A04 – T2	Insufficient Data	0.716	NA	C04 – T2	1.218	1.329	NA
A05 – T1	0.38	2.164	1.543	K01 – T1	0.101	1.102	NA
A05 – T2	Insufficient Data	2.175	1.43	K01 – T2	0.0827	1.24	NA
A06 – T1	0.559	0.9	NA	K02 – T1	0.101	1.597	0.545
A06 – T2	1.917	1.574	NA	K02 – T2	0.121	1.49	0.236
A07 - T1	4.704	0.934	NA	K03 – T1	1.551	1.904	NA
A07 – T2	2.313	1.079	NA	K03 – T2	1.543	1.618	NA
A09 – T1	0.661	1.177	0.841	K04 – T1	0.184	0.203	0.183
A09 – T2	0.494	1.13	0.797	K04 – T2	0.556	0.147	0.527

Legend – 95th Percentile Numeric Attribute state

Attribute A ≤ 1.5

Attribute B ≤ 3.5 National Bottom Line

Attribute C ≤ 9.8

Attribute D > 9.8

Receiving Water Samples UNDERLINED exceed Tile Drain grab sample values.

Site	Tile Drain DIN (mg/L)	Receiving Water DIN (mg/L)	Proportional DIN (mg/L)	Site	Tile Drain DIN (mg/L)	Receiving Water DIN (mg/L)	Proportional DIN (mg/L)
A01 – T1	0.358	<u>0.474</u>	NA	C01 – T1	Insufficient Data	3.215	NA
A01 – T2	0.148	<u>0.48</u>	NA	C01 – T2	Insufficient Data	2.793	NA
A02 – T1	0.216	<u>1.435</u>	1.628	C02 – T1	5.53	<u>6.346</u>	17.98
A02 – T2	0.0234	<u>1.4</u>	1.533	C02 – T2	8.808	6.191	31.93
A03 – T1	0.0769	<u>1.349</u>	6.139	C03 – T1	2.3	1.51	6.591
A03 – T2	0.161	<u>1.445</u>	3.411	C03 – T2	1.707	1.524	6.795
A04 – T1	0.771	<u>0.866</u>	NA	C04 – T1	1.838	1.438	NA
A04 – T2	Insufficient Data	0.79	NA	C04 – T2	1.449	1.404	NA
A05 – T1	0.389	<u>2.297</u>	4.922	K01 – T1	0.147	<u>1.11</u>	NA
A05 – T2	Insufficient Data	2.312	1.59	K01 – T2	0.12	<u>1.248</u>	NA
A06 – T1	0.566	<u>0.938</u>	NA	K02 – T1	0.112	<u>1.792</u>	0.875
A06 – T2	1.947	1.611	NA	K02 – T2	0.141	<u>1.707</u>	0.668
A07 - T1	4.77	2.876	NA	K03 – T1	1.532	<u>1.912</u>	NA
A07 – T2	2.424	<u>2.961</u>	NA	K03 – T2	1.541	<u>1.658</u>	NA
A09 – T1	0.594	<u>1.208</u>	0.864	K04 – T1	0.206	<u>0.219</u>	0.168
A09 – T2	0.497	<u>1.161</u>	0.606	K04 – T2	0.576	0.154	0.91

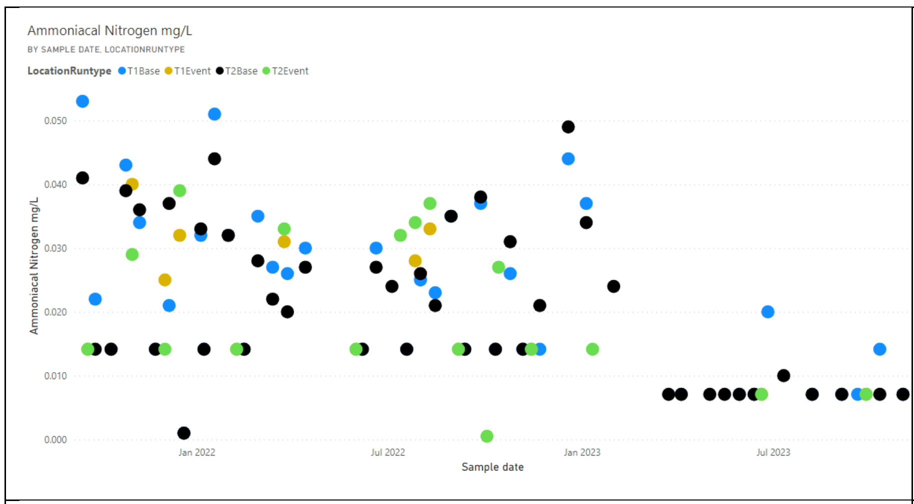
Legend – TANK / DGV

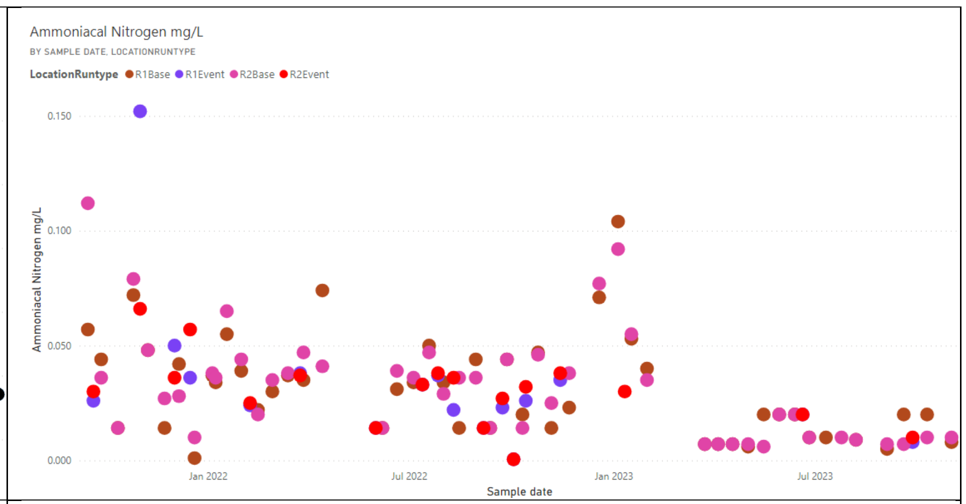
Lowland Tributariess Compliant ≤ 0.444

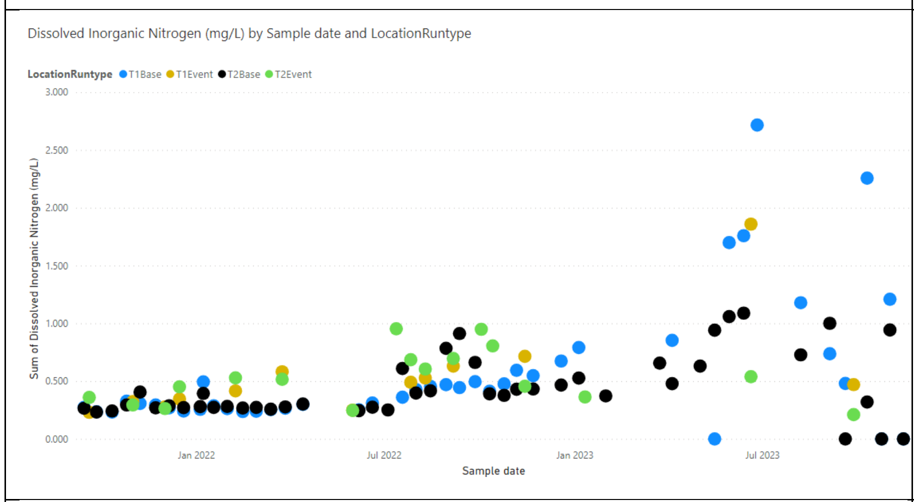
Lowland Tributaries Non-Compliant >0.444

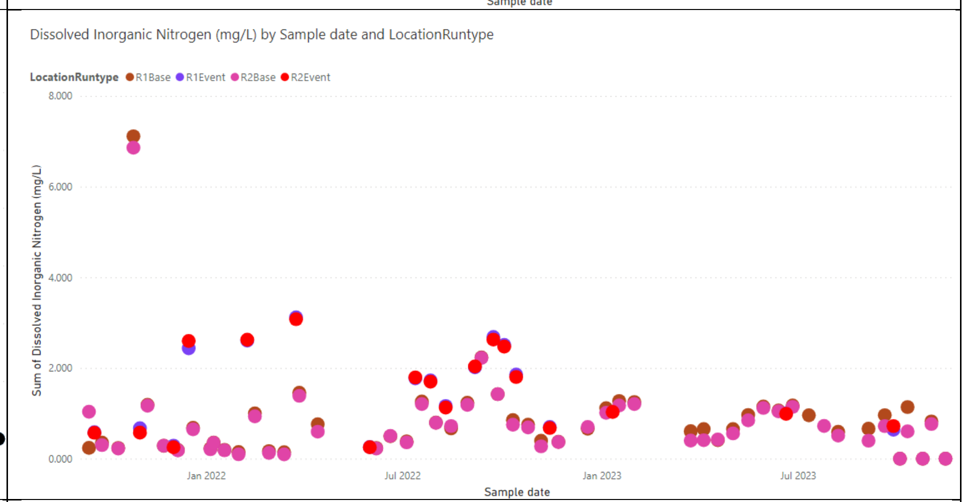
Receiving Water Values <u>Underlined</u> exceed Tile Drain Values

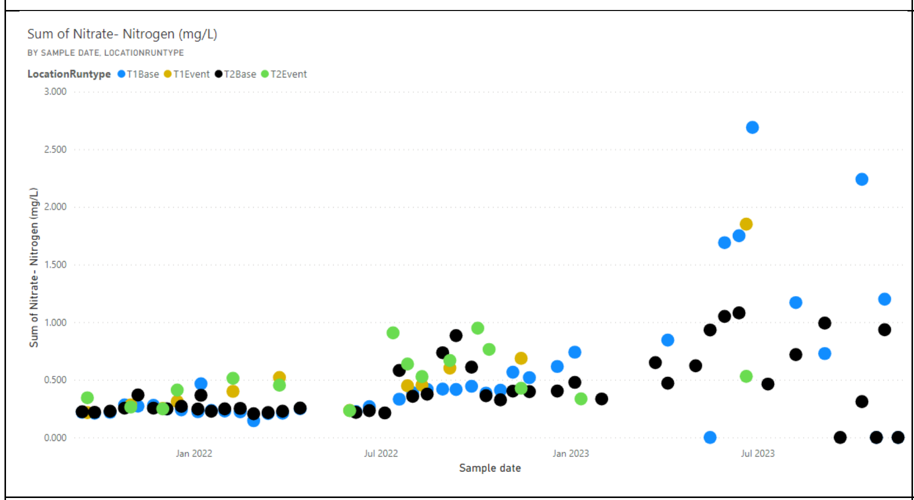
Farm A09

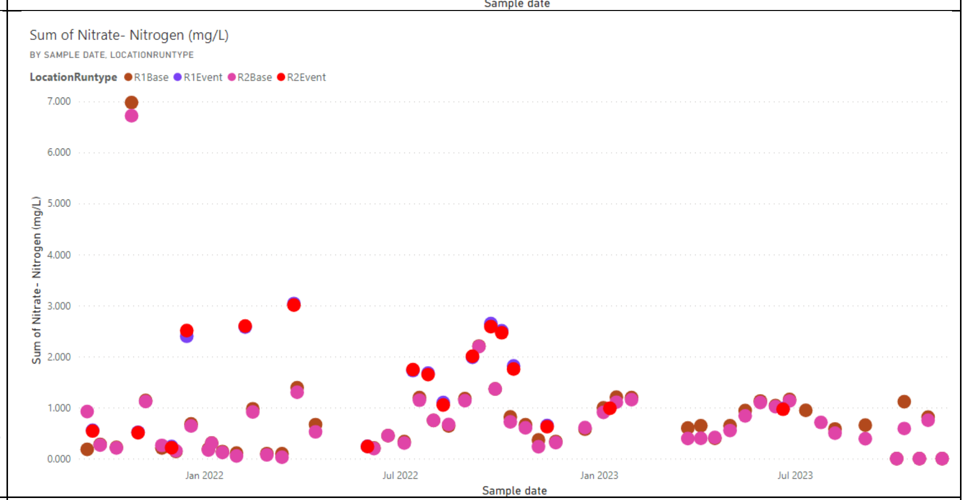

Ammoniacal Nitrogen mg/L
BY SAMPLE DATE, LOCATIONRUNTYPE
LocationRuntype ● T1Base ● T1Event ● T2Base ● T2Event
Ammoniacal Nitrogen mg/L
Jan 2022
Jul 2022
Jan 2023
Jul 2023
Sample date

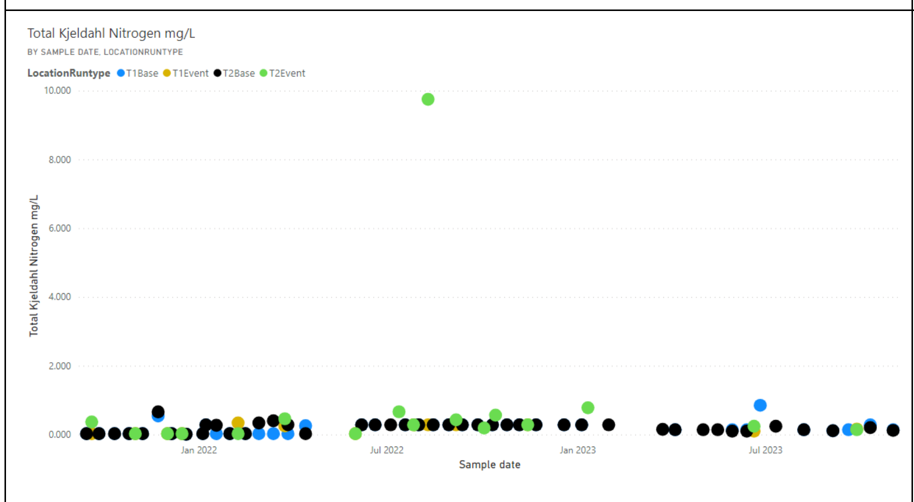

Ammoniacal Nitrogen mg/L
BY SAMPLE DATE, LOCATIONRUNTYPE
LocationRuntype ● R1Base ● R1Event ● R2Base ● R2Event
Ammoniacal Nitrogen mg/L
Jan 2022
Jul 2022
Jan 2023
Jul 2023
Sample date

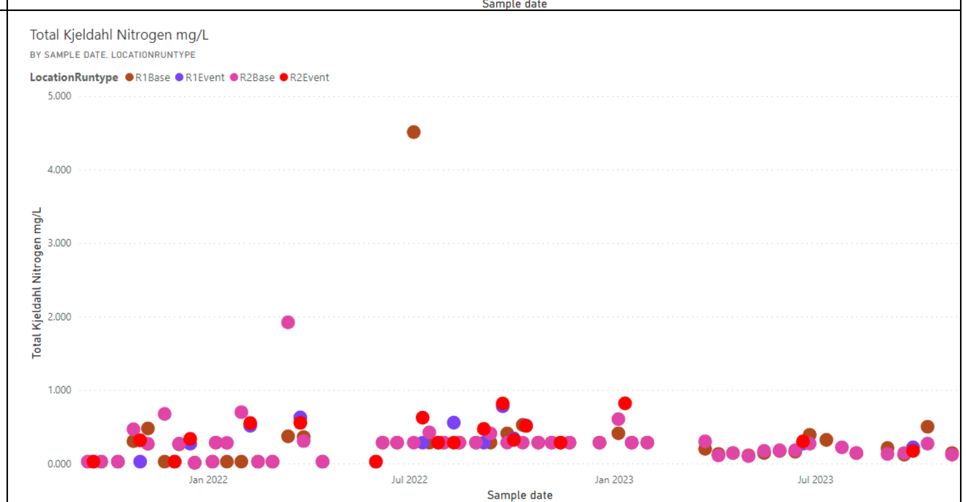

Dissolved Inorganic Nitrogen (mg/L) by Sample date and LocationRuntype
LocationRuntype ● T1Base ● T1Event ● T2Base ● T2Event
Sum of Dissolved Inorganic Nitrogen (mg/L)
Jan 2022
Jul 2022
Jan 2023
Jul 2023
Sample date

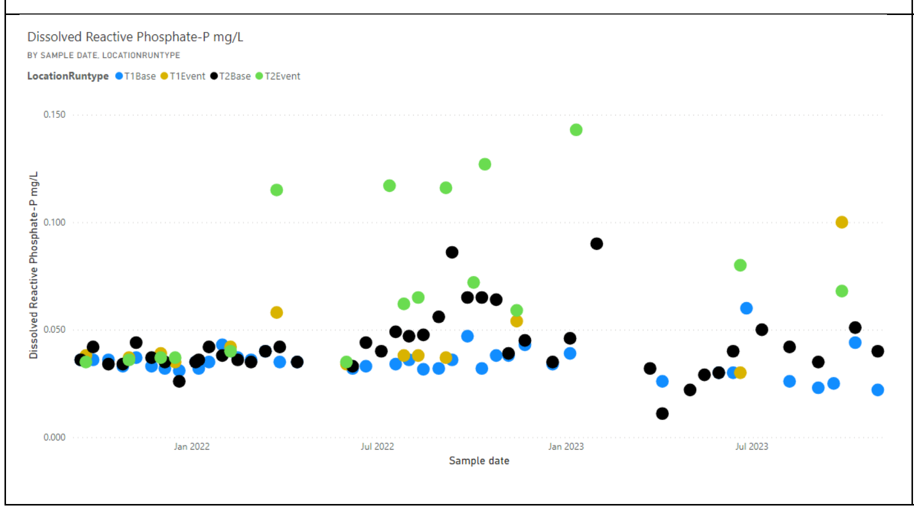

Dissolved Inorganic Nitrogen (mg/L) by Sample date and LocationRuntype
LocationRuntype ● R1Base ● R1Event ● R2Base ● R2Event
Sum of Dissolved Inorganic Nitrogen (mg/L)
Jan 2022
Jul 2022
Jan 2023
Jul 2023
Sample date

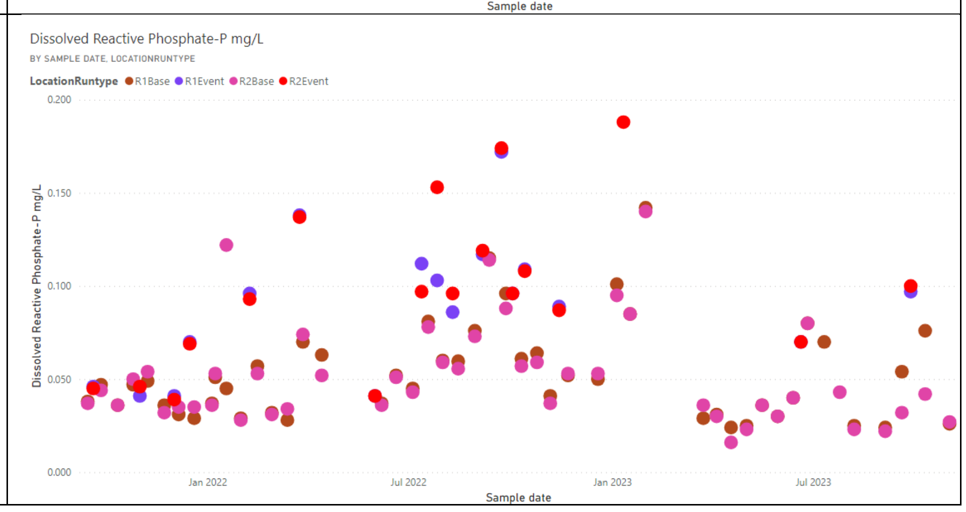

Sum of Nitrate- Nitrogen (mg/L)
BY SAMPLE DATE, LOCATIONRUNTYPE
LocationRuntype ● T1Base ● T1Event ● T2Base ● T2Event
Sum of Nitrate- Nitrogen (mg/L)
Jan 2022
Jul 2022
Jan 2023
Jul 2023
Sample date


Sum of Nitrate- Nitrogen (mg/L)
BY SAMPLE DATE, LOCATIONRUNTYPE
LocationRuntype ● R1Base ● R1Event ● R2Base ● R2Event
Sum of Nitrate- Nitrogen (mg/L)
Jan 2022
Jul 2022
Jan 2023
Jul 2023
Sample date


Total Kjeldahl Nitrogen mg/L
BY SAMPLE DATE, LOCATIONRUNTYPE
LocationRuntype ● T1Base ● T1Event ● T2Base ● T2Event
Total Kjeldahl Nitrogen mg/L
Jan 2022
Jul 2022
Jan 2023
Jul 2023
Sample date


Total Kjeldahl Nitrogen mg/L
BY SAMPLE DATE, LOCATIONRUNTYPE
LocationRuntype ● R1Base ● R1Event ● R2Base ● R2Event
Total Kjeldahl Nitrogen mg/L
Jan 2022
Jul 2022
Jan 2023
Jul 2023
Sample date


Dissolved Reactive Phosphate-P mg/L
BY SAMPLE DATE, LOCATIONRUNTYPE
LocationRuntype ● T1Base ● T1Event ● T2Base ● T2Event
Dissolved Reactive Phosphate-P mg/L
Jan 2022
Jul 2022
Jan 2023
Jul 2023
Sample date


Dissolved Reactive Phosphate-P mg/L
BY SAMPLE DATE, LOCATIONRUNTYPE
LocationRuntype ● R1Base ● R1Event ● R2Base ● R2Event
Dissolved Reactive Phosphate-P mg/L
Jan 2022
Jul 2022
Jan 2023
Jul 2023
Sample date

Farm C04


Ammoniacal Nitrogen mg/L
BY SAMPLE DATE, LOCATIONRUNTYPE
LocationRuntype T1Base T1Event T2Base T2Event
Ammoniacal Nitrogen mg/L
Sample date
Ammoniacal Nitrogen mg/L
BY SAMPLE DATE, LOCATIONRUNTYPE
LocationRuntype R1Base R1Event R2Base R2Event
Dissolved Inorganic Nitrogen (mg/L) by Sample date and LocationRuntype
LocationRuntype T1Base T1Event T2Base T2Event
Sum of Dissolved Inorganic Nitrogen (mg/L)
Dissolved Inorganic Nitrogen (mg/L) by Sample date and LocationRuntype
LocationRuntype R1Base R1Event R2Base R2Event
Sum of Nitrate- Nitrogen (mg/L)
BY SAMPLE DATE, LOCATIONRUNTYPE
LocationRuntype T1Base T1Event T2Base T2Event
Sum of Nitrate- Nitrogen (mg/L)
BY SAMPLE DATE, LOCATIONRUNTYPE
LocationRuntype R1Base R1Event R2Base R2Event
Total Kjeldahl Nitrogen mg/L
BY SAMPLE DATE, LOCATIONRUNTYPE
LocationRuntype T1Base T1Event T2Base T2Event
Total Kjeldahl Nitrogen mg/L
BY SAMPLE DATE, LOCATIONRUNTYPE
LocationRuntype R1Base R1Event R2Base R2Event
Dissolved Reactive Phosphate-P mg/L
BY SAMPLE DATE, LOCATIONRUNTYPE
LocationRuntype T1Base T1Event T2Base T2Event
Dissolved Reactive Phosphate-P mg/L
BY SAMPLE DATE, LOCATIONRUNTYPE
LocationRuntype R1Base R1Event R2Base R2Event
Jan 2022
Jul 2022
Jan 2023
Jul 2023
Sample date

Farm K03


Ammoniacal Nitrogen mg/L
BY SAMPLE DATE, LOCATIONRUNTYPE
LocationRuntype T1Base T1Event T2Base T2Event
Ammoniacal Nitrogen mg/L
LocationRuntype R1Base R1Event R2Base R2Event
Dissolved Inorganic Nitrogen (mg/L) by Sample date and LocationRuntype
Dissolved Inorganic Nitrogen (mg/L) by Sample date and LocationRuntype
Sum of Nitrate- Nitrogen (mg/L)
Sum of Nitrate- Nitrogen (mg/L)
Total Kjeldahl Nitrogen mg/L
Total Kjeldahl Nitrogen mg/L
Dissolved Reactive Phosphate-P mg/L
Dissolved Reactive Phosphate-P mg/L
Sample date
Jan 2022
Jul 2022
Jan 2023
Jul 2023

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