Partnering with MSF Sugar to Improve Nitrogen Use Efficiency in Sugar Cane

RP101C - Final Report
BBIFMAC

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Report compiled by:

BBIFMAC : A. Rickert, TJ McShane, L. Buono, D.Stubbs

This collaborative study was undertaken with funding support from the Department of Environment and Heritage Protection (DEHP) Reef Water Quality Unit.
Major project partners include Marlborough Sugar Factory (MSF) and Burdekin-Bowen Integrated Floodplain Management Advisory Committee (BBIFMAC).
Supporting partnerships include the Wet Tropics Sugar Industry Partnership (WTSIP), Department of Agriculture and Fisheries (DAF), Department of Natural Resources and Mines (DNRM) and Canegrowers Innisfail Ltd.

Contents

Executive Summary

This multi-agency, collaborative project was established on an MSF property near Silkwood. The aim was to introduce the concept of monitoring rainfall induced runoff events in the Wet Tropics using Real Time Water Quality (RTWQ) Monitoring Trailers, and to use this technology to measure the impact on water quality of a modified fertiliser regime compared to a traditional fertiliser regime. The real time water quality monitoring trailers have proven very effective in the Burdekin sugarcane growing area as a means to engage farmers in water quality issues.

The project was conceptualised and gained funding support through the Department of Environment and Heritage Protection (DEHP) Reef Water Quality Unit. The two sub-catchments were instrumented by BBIFMAC with two RTWQ trailers, which automatically sampled and analysed rainfall induced farm runoff at hourly intervals. The data was immediately available via web site and mobile phone app to project and farm management staff. The instrumented sub-catchments were treated with two different fertiliser regimes to test the potential benefits of applying a slow release fertilizer product to a ratoon sugarcane crop compared with conventionally applied products.

Although the period of monitoring encapsulated a wet season, this was a smaller wet season than is normally encountered in the Wet Tropics. Nevertheless approximately twelve events were monitored.

The concentration and total flux of Nitrogen in runoff was less in the catchment on which the slow release product was used. The results while encouraging and successfully demonstrated the usefulness of the RTWQ instruments cannot be taken conclusively since the catchment areas and monitoring conditions were not ideal for comparison purposes.

Introduction

The Wet Tropics region has been identified as a high priority area for reducing Nitrogen losses from sugarcane farms to the Great Barrier Reef. The industry's inability to meet the water quality targets can partly be attributed to a lack of readily available, credible data for the land managers/farmers. This has resulted in the failure to convince the individual farmers to take real ownership of these water quality issues.

Providing robust data as evidence to highlight these issues, and address the gaps in information was seen as a high priority in the Reef Water Quality Protection Plan 2013, and is necessary to encourage farmers to adopt improved fertiliser management practices.

As a response to this, a collaborative project was developed with the Maryborough Sugar Factory (MSF), Wet Tropics Sugar Industry Partnership (WTSIP), Department of Agriculture and Fisheries (DAF), Burdekin-Bowen Integrated Floodplain Management Advisory Committee (BBIFMAC), Department of Natural Resources and Mines (DNRM) and Canegrowers Innisfail Ltd. The project was conceived by, and received funding support from the Department of Environment and Heritage Protection (DEHP) Reef Water Quality Unit.

The project ran for close to 12 months, and was established at two sites located on an MSF sugarcane property in the Wet Tropics area, near the township of Silkwood (see figure 1 overleaf). The two sites were chosen where surface runoff could be isolated at each site to allow measurement and comparison of water quality impacts from the modified and current practices applied to each farm site.

MSF management and staff were responsible for managing the farm and crop agronomy, BBIFMAC was responsible for undertaking the water quality monitoring and data collection, DAF undertook a farm economic analysis of the economic performance of each practice, while the other supporting agencies provided the extension connection with local industry.

Aims and Objectives

The aim of the project was to compare the water quality and economic outcomes of standard industry Nitrogen application rates and an improved Nitrogen efficiency practice using a controlled release fertiliser. The water quality and economic outcomes of using traditional granular nitrogen fertilisers applied at current industry standard rates compared to a controlled release fertiliser were assessed. Both runoff volume and Nitrate concentrations were measured in real time from the two sites and Nitrogen fluxes were calculated from those figures.

In the short-term the project aimed to establish two demonstration sites and establish intensive water quality monitoring equipment with software to communicate real time data to project participants. In doing this we hoped to identify the losses of dissolved inorganic Nitrogen in farm runoff events and track notable exceedances back to specific farm management practices. Another important aspect to the project was introducing industry to the concept of real time water quality monitoring, and to make the connection between farm management practices and the water quality leaving the farm.

The medium term objective was to engage the wider industry by activities, which would include conducting a field day to allow local cane farmers to inspect the demonstration sites. At these events it was hoped the participants might identify the relationship between farm management practices, nutrient inputs and Nitrogen losses, and ultimately communicate the results to the wider cane growing community.

Long term objectives include the adoption of management practices that are known to reduce Nitrogen losses, improve water quality in aquatic ecosystems by increasing knowledge and confidence in best management practices for water quality outcomes and use the dataset to inform the conditions of use for controlled release products in the Wet Tropics.

BBIFMAC was responsible for establishing the water quality instrumentation on site, servicing and maintaining the equipment and ensuring the results were accessible on the Agtrix on-line database.

Methodology

The trials were conducted on two un-replicated sites on neighboring farm blocks adjacent to Cassar Road, close to the Silkwood Township; both growing first ratoon crops (Figure 1 below).

Figure 1. Location of the two trial sites near Silkwood, North Queensland.

Broad-crested weirs were installed at each site (see Figure 2 below) with water level pressure sensor instrumentation that would enable the flow to be calculated from the respective sites. From this data a calculation of the flux of Nitrogen from the sites could be made. At one demonstration site (MSF 1) the traditional granular fertiliser was applied at a rate of 140kg/N/ha using the standard application method of side splitting the stool. At the second site (MSF 2) a lower rate of 80kg/ha N as a blend of 25%CR and 75% urea also applied to a split stool.

Figure 2. Weir constructed at monitoring site and water level sensor installed upstream.

The two sites were instrumented with real-time water quality monitors, equipped with TriOS UV sensors taking direct hourly measurements primarily of Nitrate - N (NO_3-N) concentrations in continuous runoff. Other water quality parameters of interest that were also collected were Chemical Oxygen Demand (COD), Electrical Conductivity (EC), and Total Suspended Solids (TSS). The water quality parameters were measured in real time by the equipment in the "Real Time Water Quality Monitoring Trailers", and uploaded via wireless mobile network to an AgTrix web-based database for remote access by the project partners (see Figure 3 overleaf). This data was also available on a mobile phone app, which allowed ready access to the data to all the project participants.

Prior to fertiliser application to the ratoon crop, a representative soil sample (at a depth of 0-20cm) was taken by bulking row position samples taken from four adjacent crop rows. Such representative samples were taken from three random locations in each block and kept separate. At each of the three random locations in each block, one soil core at 0-20cm, 20-40cm, 40-60cm and 60-80cm was also taken to characterize the mineral-N status of the block prior to fertiliser application.

Plant biomass sampling was conducted at stalk elongation (approx. 200 days after ratoon emergence) in four randomly selected five metre row sections in the zero N section of each block and also four randomly selected five metre row sections in the bulk crop of each block in proximity to where the soil profile cores were taken prior to fertiliser application. Mill able stalk sampling from crop face also occurred at harvest from four randomly selected five meter row sections in the bulk crop of each block.

Both the soil sampling and the biomass sampling were undertaken by other project partners and are not the subject of this report.

Figure 3. Real Time Water Quality Monitoring Trailer and Agtrix on-line database output (inset).

Results

For the purposes of this report only the part of the project for which BBIFMAC was responsible in delivering will be discussed. This is the water quality monitoring component. The other components of the project (e.g. economic analysis, soil testing etc) will be reported by the other partner organisations responsible for their delivery in separate reports.

Instrumentation was installed in August 2015 after harvesting of the fields had occurred and prior to nutrient application.

Runoff Volumes, Nitrate-N Concentrations and Flux

Nitrate-N (NO_3-N) concentrations and runoff heights over the weirs were collected at the two sites over the monitoring period and are presented in Figures 4 and 5 overleaf.

As can be seen from these figures, the period of monitoring was from the 10^{th} of October 2015 to the 14^{th} March 2016, comprising a five month period, which commenced immediately following harvest and ratooning, and includes the “wet season”. As it turned out this particular year had significantly less rainfall, both during the wet season and throughout, than normal.

A total of twelve runoff events were recorded in MSF 1 site and seven in the MSF2 site. The difference in the number of events and volumes recorded is a result of the different catchment size, surface conditions and soil type at each of the sites. The soil type and surface conditions in the catchment areas were also quite different. While the MSF 1 catchment contained a number of paddocks with different farm management practices applied, the MSF 2 site was uniform and typical of a ratooned sugarcane block with trash blanketing. These factors combined to produce a large difference in number of and volume of runoff from rainfall events. MSF 1 site recorded 887 megalitres of runoff compared to 7.7 megalitres from MSF site 2.

Apart from the runoff volumes being very different in the two catchments, the Nitrate-N concentrations were also markedly different. The MSF 1 site regularly had runoff concentration in the high range (5 – 15mg/L), whereas the MSF2 site only had two events with high Nitrate-N values and later events were below detectable limits of the instruments (less than 1.0 mg/L).

As mentioned earlier these results would have been confounded by the difference in the two catchments and may not be readily comparable. MSF1 site had areas of conventionally managed/fertilised sugarcane and paddocks where mill mud was applied, whereas the MSF 2 site was fertilised with lower rates of slow release product applied uniformly over the whole catchment area.

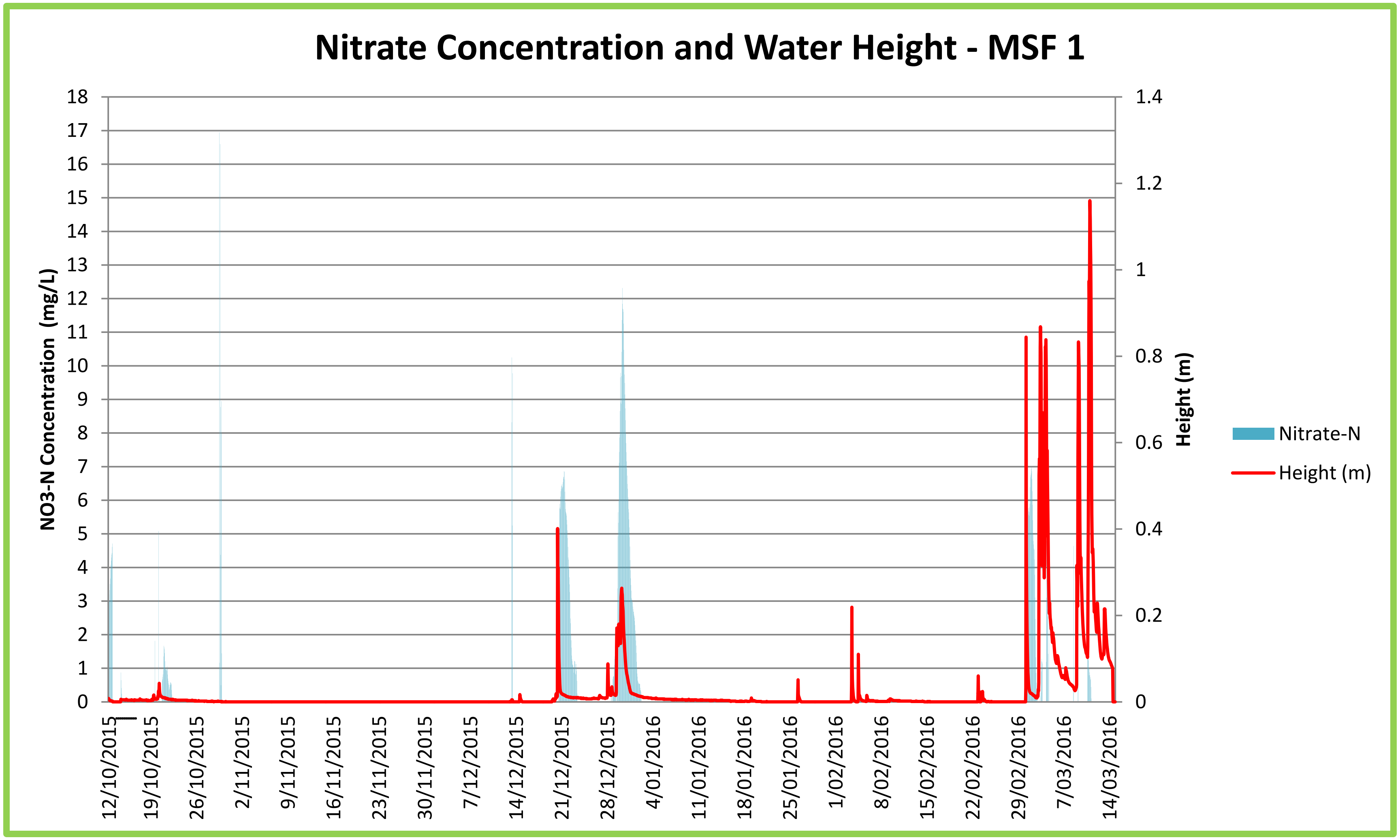

Figure 4. Nitrate Concentrations and Water Height over the Weir for Trial Site 1 (MSF 1).

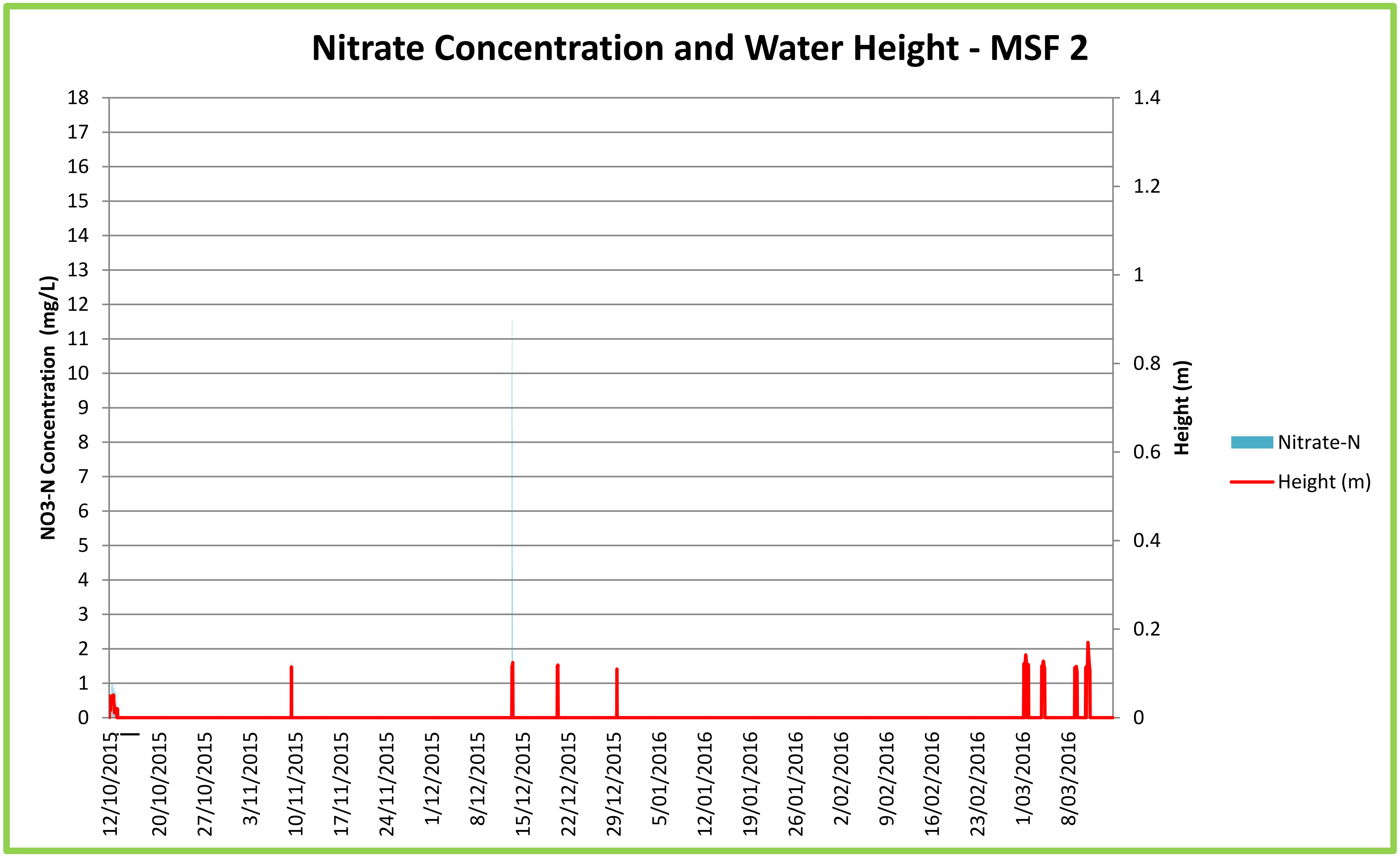

Figure 5. Nitrate Concentrations and Water Height over the Weir for Trial Site 2 (MSF 2).

The total Nitrate-N flux for MSF 1 for the monitoring period (October 2015 to March 2016) was approximately 636kg. Figure 6 below shows the Nitrate-N flux for each of the major rainfall events recorded from the MSF 1 site.

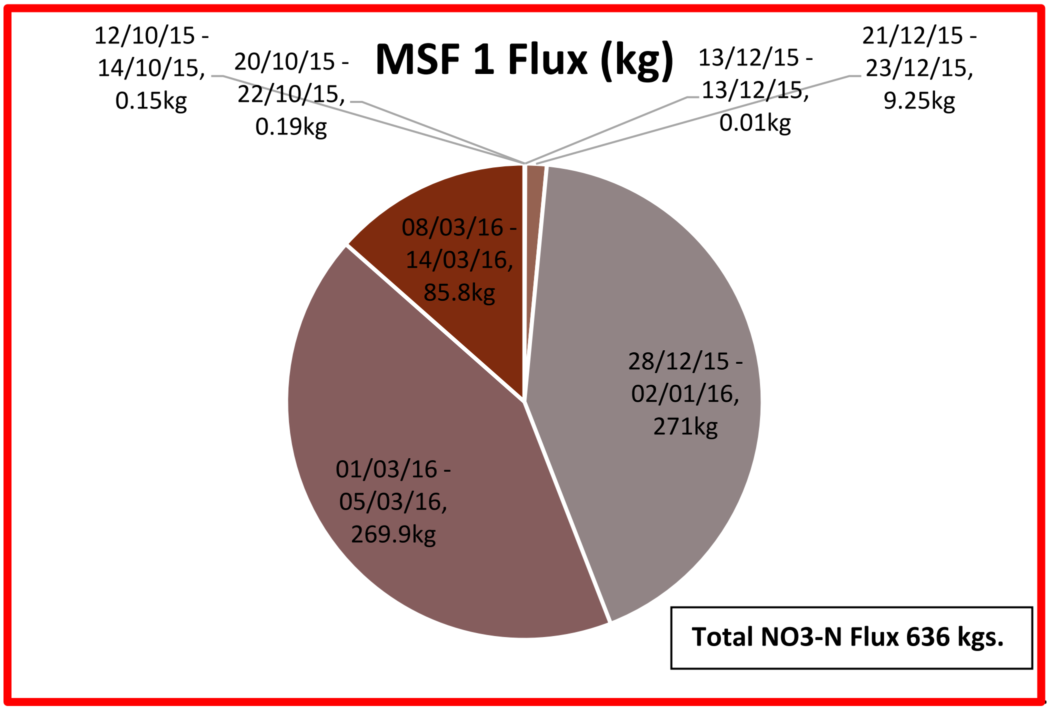

Figure 6. Nitrate-N flux for MSF 1.

For MSF 2 the total Nitrate-N flux for the monitoring period (October 2015 to March 2016) was 45kg, and figure 7 below shows the Nitrate-N flux for each of the major rainfall events recorded at MSF2.

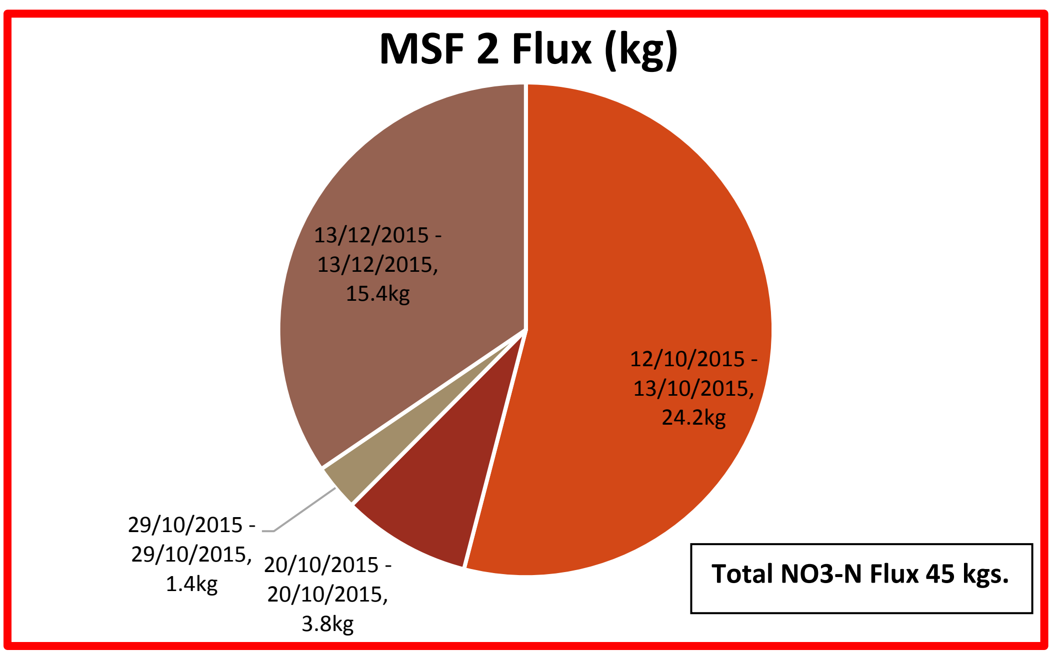

Figure 7. Nitrate-N flux for MSF 2.

For MSF 1 each of the rainfall events resulted in a rise in water height above the weir as well as a rise in Nitrate-N levels (see Figure 8 below). This is a standard pattern that is evident at many sites that BBIFMAC has monitored over the years. However MSF 2 did not show a similar pattern as the rise and fall in water heights were very rapid and small, and the concentrations of Nitrate-N were very much smaller than at the MSF 1 site. The low volumes and concentrations evident at MSF 2 are likely due to the high infiltration capacity of this site leading to greater sub-surface losses, which were obviously unable to be captured by the instrumentation.

In instances where there was very high turbidity in the runoff water, this compromised the ability of the instruments to read Nitrate - N levels. This is evident in Figure 9 overleaf where the Nitrate- N levels show consistently zero until the TSS levels start to decline. This appears to be a limitation of the instrumentation and one that will be addressed if further work is to be conducted in highly turbid areas.

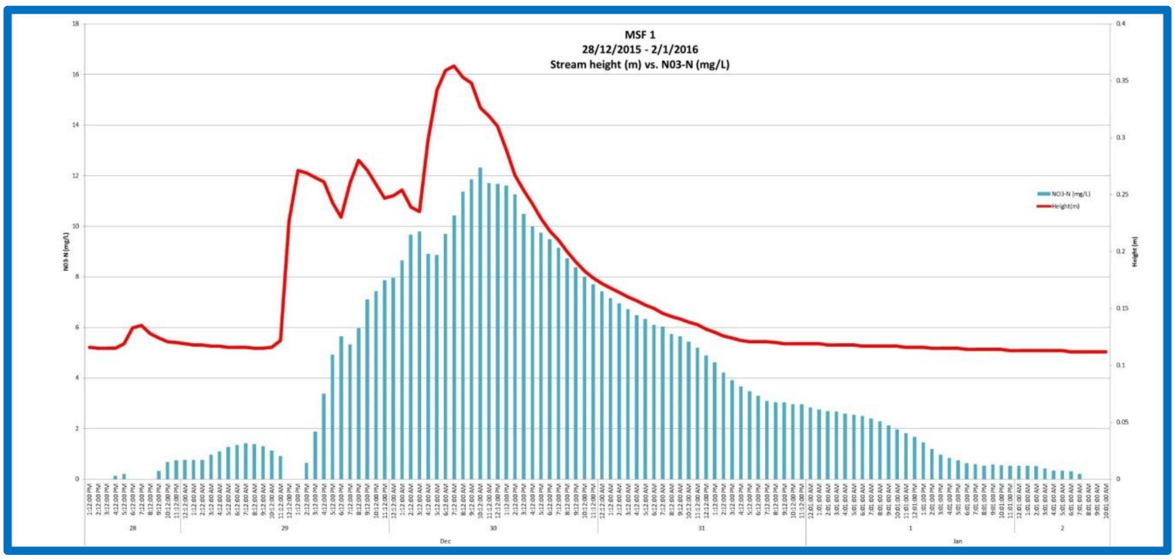

Figure 8. Stream Height and Nitrate-N concentrations for the December - January rainfall event - MSF 1.

Total Suspended Solids

Total Suspended Solids (TSS) is the measure of water-borne suspended material in the runoff flow events. This material is primarily clay and silt, although organic material can also contribute. Environmentally this parameter is quite significant in the Wet Tropics area, with relatively high slopes and erodible landscapes, although with the industry adoption of green cane trash blanketing the issue is controlled to some degree.

In Figure 9 overleaf it is evident that in the MSF 1 site the TSS reading rose rapidly early in the event and dropped sharply soon after. This is typical of wet season events in the wet tropics where soil losses occur early in the event where exposed surface soil is vulnerable to erosion. As discussed above the high TSS reading affected the ability of the instrument to record Nitrate-N levels during that period of time and hence the low Nitrate - N reading until the TSS had declined.

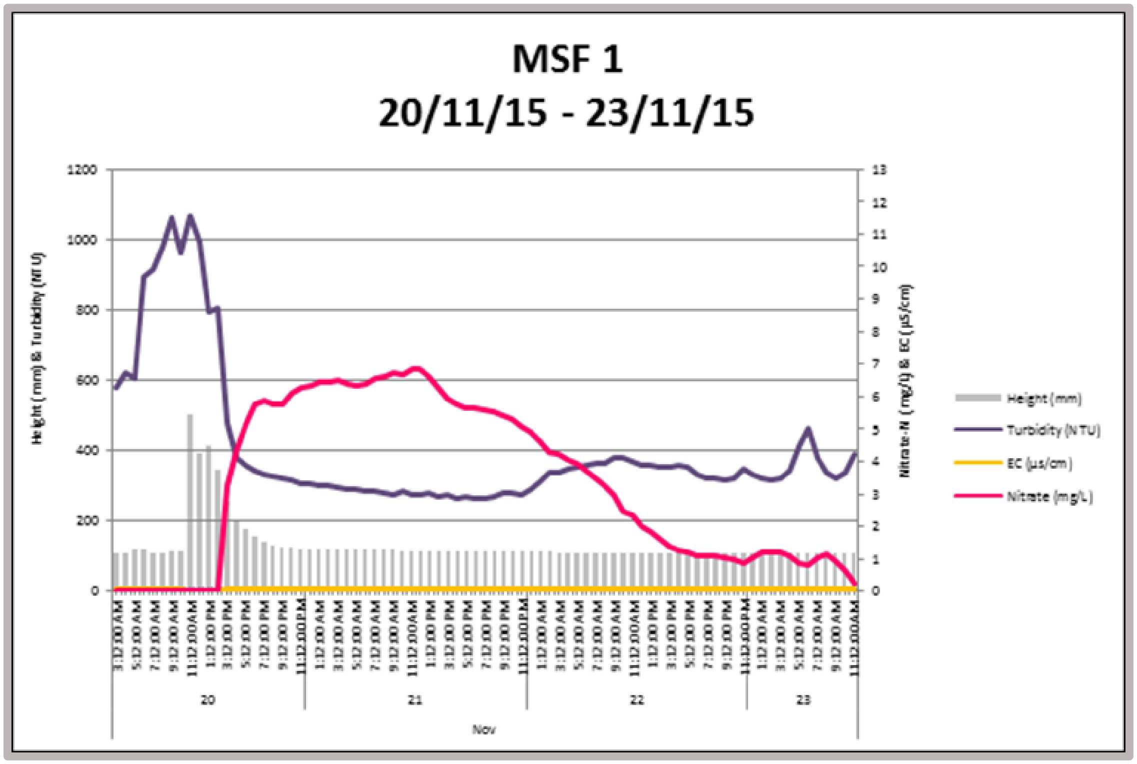

Figure 9. Early wet-season event at MSF 1 where TSS values were high in early stages of event.

Figure 10 shows that in the trash blanketed MSF 2 site the TSS values were only a fraction of the MSF 1 value (100 vs 800 NTU's). Undoubtedly this confirms the practice of Green Cane Trash Blanketing greatly reducing the erosion of soil from the farmed landscape. The high infiltration capacity at this site also appeared to influence the runoff volumes recorded.

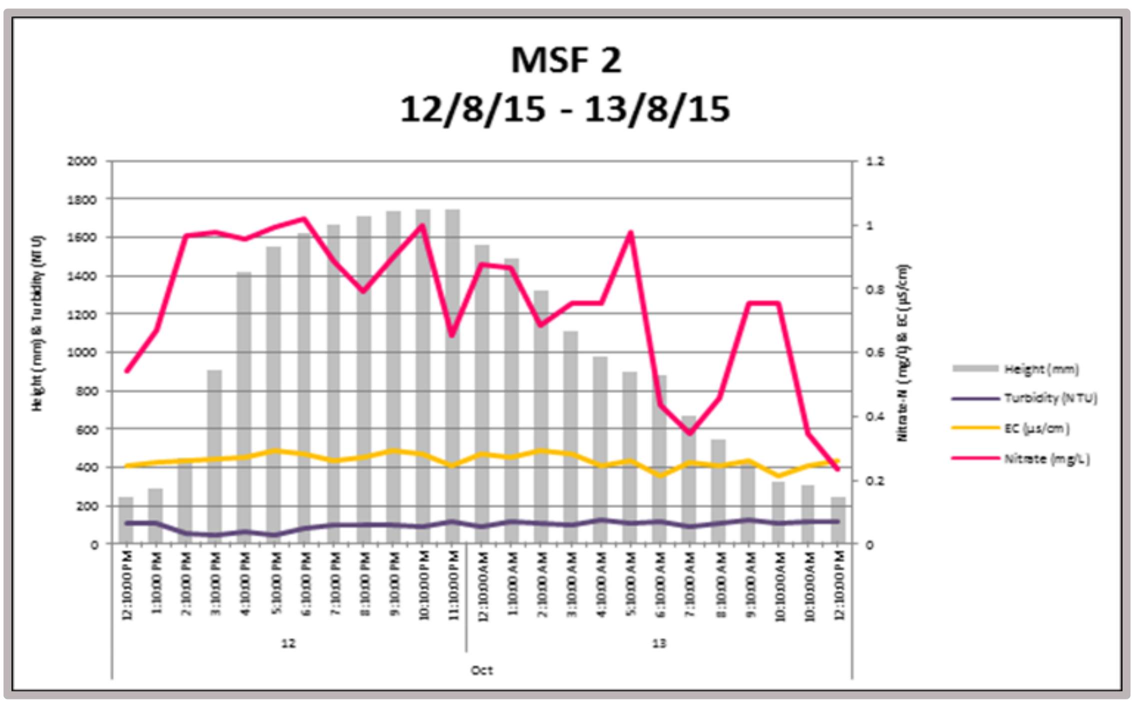

Figure 10. The TSS values in the event on the MSF 2 site were consistently low throughout the event.

Other Measured Parameters.

Electrical Conductivity (EC) is a measure of salinity in the runoff water and was very low in the large event in MSF 1, and only slightly elevated in events in MSF 2 site (see figures 9 and 10). Again this is expected since the large flows in MSF 1 would dilute salts leached for the soil in runoff.

While the TriOS also measured Chemical Oxygen Demand (COD) there were no particular trends worth reporting. Generally COD was quite low and this is expected given the catchment areas and events monitored.

Figure 11. A large wet season flow event compared to a smaller rainfall event at the same site.

Extension and Communication of Results

A field walk was held on one of the Silkwood demonstration farms on the 26th May 2016 to communicate the results to the broader extension and canegrowing community. At this event BBIFMAC manager, Tom McShane also demonstrated the operation of the portable water quality monitoring trailer that was used on site, as well as some smaller portable event samplers recently developed by BBIFMAC (KP Samplers). Tom also discussed some of the more interesting water quality results from the trial with the attendees. The field walk was well attended by local extension staff and industry representatives. Another event is planned for the future to target local sugarcane growers.

Figure 12. Silkwood field walk attendees look on as BBIFMAC's Tom McShane demonstrates the operation of the portable real time water quality monitoring trailer on site (photo credit D. Telford).

Conclusion and Recommendations

Whilst some interesting results were obtained from this project, unfortunately substantial differences between the two sites, particularly with regards to catchment size, runoff characteristics and soil type meant that comparing the results from the two sites was difficult. For the above reasons clear cut conclusions about the water quality impacts of the different fertiliser regimes could not be confidently made. The project however did provide the opportunity to demonstrate the benefits of on-farm water quality monitoring to the industry.

Key learnings from the project were:

- Total Suspended Solids (TSS) losses are highest early in rainfall events, particularly in the absence of green cane trash blanketing as in site MSF1.
- Nitrate-N concentrations in runoff tend to peak early and then taper as the event subsides.
- The RTWQ system allows tracking of N and TSS losses from the property, providing the landholder with the confidence to take remedial action where it will make a difference.
- The RTWQ system will in the future prove useful to engage land managers in addressing water quality issues.

- Catchment areas in high rainfall events are sometimes difficult to quantify, when selecting sites for water quality monitoring emphasis needs to be placed on selecting sites that are as similar as possible if comparing results.

Figure 13. Project staff undertaking routine maintenance on the real time water quality monitoring trailer on site (photo credit: MSF Sugar).