SRDC Grower Group Innovation Project

Final Report

SRDC project number: GGP027

Project title: Developing a sediment trapping system in the Silkwood drainage area (SDBA)

Group name: Silkwood Drainage Board

Contact person: Mr. Ian Brooks – 0428652339

Email: farmlets@internode.on.net

Due date for report: 01/05/2010

Funding Statement: This project was conducted by Silkwood Drainage Board in association with the Sugar Research and Development Corporation (SRDC). SRDC invests funds for sugar R&D derived from the sugar industry and the Australian Government.

Australian Government
Sugar Research and Development Corporation

Executive Summary:

Background:

The Silkwood Drainage Board Area (SDBA) encompasses a catchment area of approximately 1200 hectares using a system of drains which are both man made and redesigned natural streams. There are roughly 16 kilometres of drainage system. In the North Queensland Wet Tropics it is essential to have an efficient and effective drainage system to allow sugar cane or any other crop to be free of water logging and excessive flooding. The SDBA is an ideal demonstration area because most of the farm runoff is contained within the drainage scheme. This allows for the collecting of data to evaluate the effectiveness of different drainage models. By incorporating a system of sediment trapping into the farm layout, off farm sediment losses can be reduced. Soil erosion by water has been identified as a research priority especially for the farms within the Great Barrier Reef Catchment Area. Environmental factors such as slope, rainfall intensity, soil structure and soil cover are interacting factors producing sediment runoff. Farmers can manage soil structure and soil cover in ratoon cane through green cane thrash blanket and minimum tillage systems but currently the plant cane farming systems still entails the intense cultivation of ground. There are combinations of factors restricting change on the ground to a total minimum tillage planting system. Factors such as; the high cost to change equipment, the necessity to carry out earth works on particular paddocks such as levelling and drainage works and the changing over of row widths and wheel centre spacings to the new dual row system. These all require complete cultivation of the paddock. Other environmental factors such as slope and rainfall also have an effect on sediment runoff. Therefore farm management needs to consider how it can offset the effects from these factors. Sediment trapping systems should be considered as an effective solution in a farm management program to mitigate the effects of paddock cultivation, high rainfall and slope erosion.

The Aims:

The Project aims are listed as:

1. Develop ideas toward the best practice of controlling sediment flow within a wet tropics sugar cane farm drainage system.
2. Encourage SDBA farmers to include sediment trapping in their farm drainage system.
3. Contribute to the sustainability of sugar cane growing in the Great Barrier Reef Catchment Area (GBRCA).

The benefits:

1. Farm Sustainability:

The reduction in soil erosion and nutrient loss through the drainage system is of significant importance for the sustainability of farm productivity. Top soil contains the fertility and nutrients which grow the crops and therefore should be looked after. Any pesticides which are applied are mostly locked up in the soil particles and should be kept on site and not loss off farm through the drainage system. The establishment of a sediment trap allows a landholder to visually see and measure sediment runoff from their property.

2. The Environmental Benefits:

The environmental benefits stem from achieving the sustainability benefits of keeping soil on farm. Control systems such as sediment traps put in place to limit soil and nutrient runoff can become part of the farm environmental management systems.

3. The Social Benefits are:

The project develops the information building and sharing capacity of farmers through discussing and developing innovative ideas in farm management systems. It challenges existing methods of drainage systems and recommends improvement. Farmers' research skills will also be improved.

Methodology:

The plan of action for the project is;

1. Ask for the collaboration and support of the members of the SDBA.
2. Use best practice concepts in grower group participative research and information sharing to design sediment trap models.
3. Apply these models to the chosen sites and construct the traps.
4. Conduct a monitoring program on water quality and sediment discharge.
5. Hold a field day to explain the project and its outcomes.
6. Publish a flyer on sediment trap design and benefits.

To initiate the project the SDB held a meeting with interested growers in the SDBA to discuss the creation and design of a system of sediment traps in a typical farm layout. All farmers' present indicated approval for the concept of sediment traps. This first meeting was important to get the collaboration and support of the members of the drainage board. The strategies to achieve this were;

- Meeting invitation letters were sent to members introducing the project proposal.

- There was an emphasis on the farmers' environmental obligation to reduce soil losses off farm as it is important to be seen to be doing something because it shows a willingness to improve.
- It was explained that once these systems are in place, members will actually appreciate a lower drain maintenance cost through a reduction in the drain cleaning program. This occurs because, instead of sediment runoff being distributed throughout the drain system it will be contained at specific sediment trap sites. Therefore it will not be as necessary to strip the drain floors every year to remove silt, which is a process that leaves headlands mounded up with grass and dirt making it difficult for the farmer to remove.
- It was also explained that it is important for farmers to support the project so that SRDC will provide funding to establish the proposed sediment trapping system, which would become an asset to the drainage system.

Sediment traps are employed to reduce the amount of sediment leaving a property. Generally they are located at sites where they can trap as much sediment as possible while allowing easy access for removal of trapped sediment. Farmers were asked to consider making available their farm, at a site of their choosing, for sediment trap construction and the monitoring of that. The meeting then decided to conduct a bus trip to seek information on sediment trapping design models which could be applied to local farm situation.

The design of the system has to address developing a reduction in sediment movement given the variety of factors which have been identified in the background section of this report. A field trip was undertaken to travel to particular areas where these systems are working successfully. This bus trip was conducted to the Tully/Murray areas to investigate the different sediment trap systems and was very successful with a total of nine participants attending. The agenda for the day is described in figure 1.0. It highlights two parts to the day; the first being a shed meeting discussion on important aspects of; stream design, sediment generation and movement and water flows. Possible designs for sediment traps were also discussed. The second part of the day was the field trip to three different farms. These farms were; Messer Dore, Crema and Digman, who have working models of sediment traps. Photos of the field trip are included. All participants felt they learnt something and it increased their interest in best practice management for farm drains.

These sediment trap design concepts were then applied to SDBA farm trial sites. These farms are Allan Cross (Bundaberg Sugar), Ian & Robert Brooks and the Rosendall farm natural sediment lagoon. Other farmers who showed interest were the Cassar Farm, the Bilic Farm and the

Taifalos Farm. It was anticipated to develop eight sediment traps into the SDBA. These are to be strategically positioned to achieve a high sediment collection outcome.

Following on from the field trip the SDB has held numerous meetings with the Natural Resource Management department Innisfail (NRM) to evaluate which are the best designs to construct sediment traps. It is important to appreciate that sediment traps in general are limited in their ability to capture suspended sediment. The nature of suspended sediment in flood water means that drain water runoff needs to be held still (in a sediment trap) for around 30 minutes to be effective in removing the heavier suspended sediments (NRM). The courser dirt particles which travel along the bottom of the drain are easily caught by the drop off nature of the sediment trap or sump floor.

According to (Stewart 2010) “Turbidity is a measure of the suspended solids and coloured dissolved solids. The relationship between turbidity and the solids is affected by a number of things including particle size. However, we can say that 1 Nephelometric Turbidity Units (1 NTU unit) = 1 mg/litre of sediment as a useful rule where no calibration is done. Of course that makes sense because that is how the NTU system was developed. Silt settles in still water at a rate of 2 cm per minute and suspended clay settles at rate of 1.2 cm per hour. Typically you need fairly still water detention for 30 to 40 minutes with an overspill type exit to intercept some fine particles. Sediment traps are used to trap mobilized sediment. Mobilised sediment is minimal under ratoon cane with trash blanket and sediment traps will do little to improve quality of water. They are a tool for cultivated soil” (Stewart 2010).

A confronting problem for sediment trap design is the large catchment area verses the size of the sediment trap (most drained cane paddock areas are 10 to 20 hectares). Therefore the design of the sediment trap will never be ideal due to the limiting size of the trap to service the larger area of the catchment. In summary the factors contributing to sediment loading of the drain system were identified as; slope of the land, soil type, rainfall intensity, area of cultivation in the catchment and the amount of road & headland sediment being stirred up. Therefore limiting factors of sediment capture is the size of the sediment trap in relation to the catchment area and the above sediment loading factors.

Following on from the bus trip there were a number of field inspections and discussions with farmers and resource management consultants. From these discussions changes have been made to how we will position sediment traps in drains and streams. Originally the plan was to place the traps in the main drains of Buckley creek and Berryman creek. This is now no longer feasible. The reasons for this are:

- a normal sediment trap will not work in a high volume/flow situation unless a significant holding lagoon were constructed which would be outside the criteria and concept of this sediment trapping project
- there are a number of Governmental licences required to place, construct and service such a sediment lagoon
- the cost is prohibitive and it would consume a large area of land.

The preferred positioning is now in the main farm drains prior to its flow into the upper creek systems. We believe that this will allow for better trapping of sediment. It is important to appreciate how water flows in different individual farms and the need to tailor sediment trapping to that situation.

The construction phase of the project moved on to complete a total of six sediment traps. A further six sump traps have been constructed to improve the overall outcomes of the project. There were a number of factors which lead to farmers deciding not to go ahead with a sediment trap on their farm with the three main factors being listed below. This project has crossed some significant traditional boundaries for landholders. The idea of constructing an in drain structure to regulate the flow of water through a main farm drain did require farmers to rethink their understanding of how a drainage system should work. There were three main concerns from building sediment traps which caused the most difficulties with farmers;

1. **Altering the speed of water flows in the drain system through the placement of a rock wall on the drain floor**. This issue is being managed by altering and manipulating the rock wall to create the desired sediment trapping results with the least side effects.
2. **Enlarging the existing size of the drain which leads to encroachment onto farm headlands and the enhanced risk of drain erosion and subsidence**. Sediment trap placement is restricted to positions where the least interference to farm operations is possible. Drain erosion and subsidence was controlled through designing the drain batter and depth to suit the particular soil conditions but it remains an ongoing management issue which will be closely monitored.
3. **The placement of a trap structure on a farmer's land which does not directly benefit that farmers drainage**, that is, it benefits the up stream landholders only. My approach to this was to not place a sediment trap on a landholders section of drain where this scenario was the case.

Each sediment trap has been designed to fit the particular drainage environment within which it is sited. This has lead to a number of different shapes and sizes of sediment traps. This will have the advantage of producing a diverse range of data from the future water monitoring program in 2009/2010.

Sediment Trap Design:

The Reference Table 1. below shows the approximate size of the sediment trap required to hold water for either 10 or 20 minutes from the different size paddock catchments. This is based on rainfall at 10 millimetres per hour and a runoff coefficient of 0.5 (50%). Please note that very sandy soils will have a lower runoff and very clay type soils will have a higher runoff. The holding time achieved for drain water in the trap is dependent on many factors. Farmers need to evaluate their own situation to establish what trap holding time they will aim for, given the cost of trap construction and the drain space available. Bear in mind that traps could be enlarged at a latter date to improve effectiveness.

Table 1. Quick reference guide on trap size

Catchment area as paddock hectares	Trap holding time in minutes	Trap size required in cubic metres
10 ha	10 mins	83 cu mt
	20 mins	167 cu mt
20 ha	10 mins	167 cu mt
	20 mins	333 cu mt
30 ha	10 mins	250 cu mt
	20 mins	500 cu mt
40 ha	10 mins	333 cu mt
	20 mins	667 cu mt

Table 2. Approximate costing for the construction of a single sediment trap.

Action	Hours	Cost	Total
Excavator	12	$140	$1680
Truck	8	$90	$ 720
Manpower	7	$40	$ 280
Rock fill			$ 520
Backhoe to place rock	4	$90	$ 360
Revegetation (including maintenance)	40 stems	$11	$ 440
			$4000

Silkwood Drainage Board sediment trap monitoring details

A total of seven sediment traps and four sump traps were monitored. Each of the sediment traps have been designed to fit the particular drainage environment within which it is placed. This has lead to a number of different shapes and sizes of sediment traps. This has the advantage of producing a diverse range of data from the water monitoring program in 2009/2010. The sump traps are of a common simple design which did not provide variation in results.

The two means of monitoring the effectiveness of the sediment trap system are the rising stage sampler and manual sampling. There has also been an inspection of the traps whist empty during the latter part of 2009. The rising stage sampler works successfully as an industry common measuring tool. It is simply a one litre plastic sample bottle fitted to a star picket and placed in a drain system where it will be exposed to rising flood water. The lid is fitted with special double curved stainless spouts which allow rising flood water to enter the bottle and once full rejects further water entry. This produces a sample from a particular rising flood event without the need for someone to be there at that particular time to take a sample. According to Drewrya et al who reports that; “The simple rising-stage samplers were successful in collecting water quality samples during the rising-stage of the hydrograph. Our strategy involved limited investment through the use of inexpensive rising-stage sampling equipment supplemented by manual sampling.”(Drewrya, Newhama, Croke, 2007) **Table 3. Sediment Trap details**

Trap Site	Trap Location	Monitoring system	Landholders name
1	Cassar road	Rising stage, manual sample & dry trap inspection	Brooks Farm
2	On farm main drain	Manual sample & dry trap inspection	Brooks Farm / boundary with Bilic
3	On farm just up of Berryman creek	Manual sample	Brooks Farm / boundary with Despot Farm
4	Side drain into Buckley creek at rail line bridge	Manual sample	Bundaberg Sugar Farms
5	Side drain into Buckley creek on farm	Rising stage, manual sample & wet trap inspection	Bundaberg Sugar Farms
6	At the end of Thredingham road	Rising stage & manual sample	Bundaberg Sugar Farms
7	On farm drain through natural small lagoon	Manual sample	Rosendahl Farm

The field data collected has been recorded into the water quality monitoring data sheet over the 2009/2010 season. This data was analysed and transferred into tables which demonstrate what levels of sediment has been trapped relative to the design of the trap. The following Table 3 identifies details of trap monitoring systems. Table 4 collates the physical attributes of each trap and the area being serviced by the trap. There is corresponding tables for the sump trap recording also.

The Table 4. below utilises a rainfall run off coefficient. The runoff coefficient of 0.5 (or 50%) is according to the CALM manual of Urban Erosion and Sediment control, 1992. Department of Conservation and Land Management N.S.W. and also the Water Survey of Canada use the coefficient of 0.5 as an average across their high rainfall runoff basins.

Trap Site	**Total area of catchment (hectares)**	**Water flow cubic metres/hour at 10mm rain/hr at runoff coefficient of 0.5 = 50 cubic metres/hectare**	**Size of trap in cubic metres**	**Average settling time per load of trap water in minutes**
1	35	1750	$30 \times 6.5 \times 2 = 390$	13.4
2	81	4050	$18 \times 4 \times 1 = 72$	1.1
3	32 + 64	4800	$20 \times 10 \times 2 = 400$	5.0
4	35	1750	$30 \times 3 \times 1.5 = 135$	4.6
5	40	2000	$80 \times 4 \times 1.5 = 480$	14.4
6	40	2000	$15 \times 10 \times 2 = 300$	9.0
7	N/A	Main in drain lagoon	$80 \times 8 \times 1.5 = 960$	unknown

Table 4. Sediment trap geographic makeup

Trap Site no.	**Sump trap Location**	**Monitoring system**	**Landholders name**
1	Off Cassar Road at corner of Peterson Road	All monitoring by visual inspection of the sediment collected	Ian & Robert Brooks Farms
2	Downstream of new Rail bridge Buckley creek out flow	As above	Bunderberg Sugar Farms
3	As above	As above	Bunderberg Sugar Farms
4	As above	As above	Bunderberg Sugar Farms

Table 5. Sump trap monitoring details

Monitoring the effectiveness of sediment traps.

Monitoring the effectiveness of a sediment trap can be done in a number of ways:

1. Measure the suspended solids in the water entering and leaving the sediment trap.
2. Measure turbidity of water entering and leaving the trap using a standard turbidity tube. (See http://www.environmentmonitor.green.net.au/water/turbid.htm for the relationship between turbidity units and depth of water in a turbidity tube)
3. Develop the correlation between turbidity and sediment content.
4. Measure the material retained in the trap (count number of buckets of sediment removed)

This project needed a simple, cost effective way to estimate suspended sediment. Measuring turbidity is considered as a means to do this. There are however weaknesses in this method. Mr Bob Stewart of Terrain NRM Innisfail who was consulted, says that it is difficult to draw a relationship between turbidity and suspended solids. He states, "As you would expect the relationship between the two is not very consistent. Turbidity depends on the colour of the water as well as the particle sizes as much as it does on the actual weight of solids in the water. Also the technique of measuring turbidity is not useful for water below 5 NTU and it is also dependent on the readers' eye sight." (Stewart 2010). Despite these short comings in measuring turbidity and its co relationship to sediment load this project has chosen turbidity NTU as the field measure to establish sediment loadings with regard to the projects time and cost constraints.

Turbidity

Turbidity measures the clarity of the water. An increase in suspended matter increases the turbidity of the water. The suspended matter consists of inorganic and organic material made up of algae, storm water runoff in urban areas and soil particles from erosion over a wide range of land uses. Some of the turbidity will be the result of very fine soil colouring attributes, such as red soil colour. Soil erosion is a major input of sediments into a waterway and high turbidity measurements show this as murky or cloudy. Turbidity limits the amount of light able to penetrate through the water which affects the stream habitat. Removal of stream bank vegetation can mean soil is more easily washed into a waterway causing erosion and an increase in turbidity. Revegetation of verges and eroded banks can help reduce the amount of sediments entering a waterway. (Waterwatch Victoria Methods Manual 1999)

Method of measuring of turbidity

Equipment

• Hand held Turbidity Tube

• A pole mounted retrieval sample container (clean) or at least a 500 mL sample bottle (Polyethylene)

Procedure

1. Collect sample in a clean bucket or sample bottle.
2. Ensure sample is well mixed before testing.
3. Gradually pour the sample into the turbidity tube while looking vertically down the tube (See picture below). Hold the tube out of direct sunlight during this procedure.
4. Stop pouring at the point where the black mark on the bottom of the tube is just visible.
5. Note the reading from the scale on the side of the tube.
6. Record the reading as NTU. 15
7. If the reading is above 200, dilute the sample 1:1 with distilled water. Repeat testing procedure and multiply the final result by 2.
8. If you fill the turbidity tube to the top or past the last reading and the black lines are still visible, take the reading as less than the last number, eg <10 NTU.

(Waterwatch Victoria Methods Manual 1999)

Excellent	Good	Fair	Poor	Degraded
< 15	<17.5	<20	<30	>30

Table 6. Turbidity tube NTN value as a field guide to water quality
(Waterwatch Victoria Methods Manual 1999)

For a project such as this it is desirable to have event-based measurements such as heavy rain after a dry spell and during the wet season. To determine a pattern of sediment trapping effectiveness it is best to establish a relationship between turbidity and suspended solid concentration for each soil type. This has been done by referring to existing research data by Post & Jakeman 1995 which has established a reference table stating that sediment concentration can be calculated to be: [Sediment in mg/lt = 1.47 * NTU + 1.917] and this sediment load can be converted to a tons per day figure by the next formula [tons sediment/day = sediment concentration (mg/lt) * stream flow (cumecs) divided by 11.57] (Post & Jakeman 1995). These figures can be affected by soil type and organic mater concentrations but overall it can be used to arrive at an approximate sediment loading (numerous papers cite figures around the 1.50 as the variable multiple).

As a note of caution to the ability to accurately determine sediment loading from NTU values John Downing from Campbell Scientific suggests that the formulas which map correlation between NTU values and sediment loads can not be just blanket applied to any chosen environment due to the large variations which occur in soil particle size and colourings. Downing has produced a graph below which does show reasonable correlation in a number of circumstances.

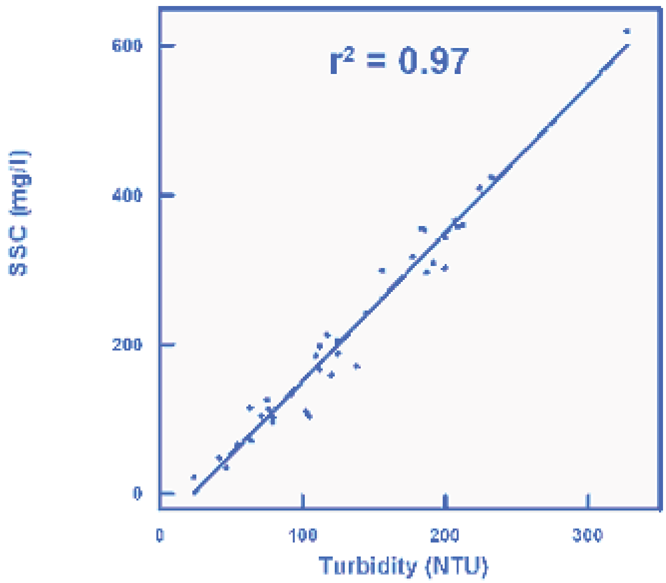


Table 7. Correlation between SSC and turbidity (Copyright © 2005, 2008 Campbell Scientific, Inc).

For the purposes of this report the Post & Jakeman formula has been used. If you did require more precise data then a calibration procedure will be as follows:

- Measure the turbidity using the standard turbidity tube or disc Sampling water at various turbidity.
- Retain a sample quantity of the same water for laboratory determinations
- Filter a known quantity of water on weighed filter paper
- Dry the filtrate and filter paper to constant weight at 105°C (using ovens at a research station or mill)
- Plotting the relationship between turbidity and suspended solids.

Dry trap Inspection

The clearing of a silt trap is done at a time of convenience when dry and needs only to be done every one or two years. (At clean out time it is important that the amount e.g. number of truck loads of sediment, is recorded). During the dry season period in late 2009 inspections of three sediment traps were carried out to evaluate the effectiveness of these traps over the previous 2008-2009 wet season. On close inspection of the bed of the traps it was observed that approximately 40 mm of sediment had accumulated in the largest trap (site 1) and no more than 15 mm had accumulated in the smallest trap (site 2). When you refer to the trap geographical makeup (table 3) and compare the average settling time or holding time of a traps body of water to the sediment accumulation there appears a relationship between the times needed for sediment to fall from suspension from the retained flood water. This appears to be regardless of the quantity of water flowing through the trap (site 2 has more than twice the catchment area of site 1). An important point or contributing factor to sediment collection at site one is that it lays next to a gravel road which does get graded every four to six months.

Wet trap inspection

During March 2010 wet trap inspections were carried out on sites 3, 4, 5 & 6. At site 5 it was observed that approx 500 mm of sediment was present along its 80 metre length.

Field Recordings:

Date	Site number	Entry collection bottle NTU	Exit collection bottle NTU	Comments: These bottles fill only after drain floods high enough to record (heavy rain event)
08/05/09	1	65	30	
11/05/09	1	55	45	
26/05/09	1	38	30	
12/11/09	1	50	25	
23/02/10	1	20	20	At < 20 water looks a little off clear
23/02/10	5			Algae spoilt sample (left too long to check sample)
23/02/10	6			Buckley creek up too high
03/03/10	1	50	15	
03/03/10	5	90	150	Plant cane runoff into trap after entry sample reading (60 NTU from cultivation)
03/03/10	6	100	n/a	Spoilt sample
11/03/10	1	58	55	
12/03/10	5	110	130	Plant cane runoff after entry bottle collection point (20 NTU from cultivation)
17/03/10	1	60	50	
17/03/10	5	70	80	Plant cane runoff (10 NTU from cultivation)

Table 8. Sampling data for rising stage sample bottles

Date	Site number	Entry sample	Exit sample	Comments
11/05/09	2	29	26	At >30 NTU water begins to look cloudy
26/05/09	2	20	15	

23/02/10	2	32	28	
23/02/10	4		15	Runs into Buckley stream which is 20 NTU
23/02/10	5	25	25	
23/02/10	6	12	20	Exit side dirty from Buckley creek back up
03/03/10	1	15	5	
03/03/10	3	5	5	Also checked at water furrow 50 upside = 15 NTU (plant cane)
03/03/10	4	5	5	
03/03/10	7	5	5	This site received heavy sediment from road works on Bruce highway earlier. The lagoon had no effect at these low NTU values.
11/03/10	1	32	32	
11/03/10	2	35	32	
12/03/10	1	17	17	
12/03/10	4	0	0	Very clean water
12/03/10	5	110	130	
17/03/10	4	0	0	Clear water
17/03/10	2	0	0	Clear water
17/03/10	6	0	0	Clear water
17/03/10	5	0	0	Clear water

Table 9. Sampling data for manual collection

Trap Site no.	Inlet Turbidity values	Outlet turbidity values	Percentage % improvement in turbidity
1	59	34	42%
2	39	36	8%
3	10	9	10%
4	5	5	0%
5	98	106	Site readings distorted by plant cane runoff between inlet & outlet
6	195	248	Contamination problems from Buckley Creek flooding

Table 10. Collected field data from turbidity tube in Nephelometric Turbidity Units (NTU)

The table below uses the Post & Jakeman (1995) formula to establish an approximate co relationship between NTU value and sediment load. This table highlights possible reductions in sediment load.

Reduced turbidity as a NTU value between entry & exit points	Volume of water in cubic metres per hour from 30 hectares at 10mm rain/hr at 0.5 coefficient	Volume of sediment reduction in kilograms per hour using Post & Jakeman formula	Volume of sediment reduction in kilograms per 24 hours period
5 NTU	1500 cu/mt	14 kg	336 kg
10 NTU	1500 cu/mt	25 kg	600 kg
15 NTU	1500 cu/mt	36 kg	864 kg
20 NTU	1500 cu/mt	47 kg	1128 kg
25 NTU	1500 cu/mt	58 kg	1392 kg
30 NTU	1500 cu/mt	69 kg	1656 kg

Table 11. Approximate sediment reduction in kg/cu mt of runoff using the Post & Jakeman (1995) formula (Sediment load in milligrams per litre of water = NTU value * 1.47 + 1.917)

Calculations of detention times from field visit of site 1 during March 2010.

A number of measurements were carried out by Stewart, Brooks & Cross of the SDB at sediment trap 1 on Cassar Road. The Inflow velocity of water coming through a 450 mm pipe into trap 1 was measured at 18.6 l/sec or 67 cum/hr. The sediment trap was measured in detail to calculate the cross-sectional area in the sediment trap. The cross section of water obviously depends on the depth of water on the day. The cross section was measured to be 5.6 m^2 . The velocity of water through the sediment trap = 12 m/hr. The Trap length = 20 m. This gives a detention time = 1 ⅔ hours. The depth of fall of various particles over this period of time is as follows:

- Silt (0.02mm particle) will fall 1.6 m in this time. i.e it will bottom out.
- Clay (0.002mm particles) will fall only 2 cm in this time. But clay particles can flocculate so all clay is not present as particles smaller than 0.002mm. So we remove some clay too, especially the clay moving through close to the bottom.

“This example of the 450 mm road way pipe with the inflow area of 0.1 sq metre enlarges into the area through the sediment trap of 5.6 sq metres. That is impressive as we have reduced the velocity to 1/56 of its original assuming there is no short circuit in the trap” (Stewart 2010).

A dynamic of runoff through sediment traps is, when water flow increases during rainfall, detention time will decrease with increased drain flow and therefore you would think sediment drop out would reduce. But the increased flow generally brings increased sediment, especially on a rising stage, which means sediment capture will tend to go up in relation to the greater water flow.

Date	Rainfall over 24 hours South Johnstone station	Drain flow cubic metres over 24 hours	Reduction in NTU value	Reduction in sediment load (estimated)
08/05/09	19 mm	3,325 cu mt	35	177 kg
11/05/09	107 mm	18,725 cu mt	10	311 kg
26/05/09	26 mm	4,550 cu mt	8	62 kg
12/11/09	58 mm	10,150 cu mt	25	392 kg
23/02/10	41 mm	7,175 cu mt	0	0 kg
11/03/09	47 mm	8,225 cu mt	3	52 kg
17/03/10	12 mm	2,100 cu mt	10	35 kg

Table 12. Field data showing an estimation of sediment retention at one site using the Post & Jakeman (1995) formula stating: sediment load in Kg /Cu Mt = [1.47 * NTU value + 1.917 / 1000 * cu mt flow]

Observations:

Sediment traps work better with higher concentrations of sediment which are poorly dissolved ie; on a rising stage of flow or increasing sediment loads, which is generally the result of heavy rain. This is because the initial heavy rain impacts on the ground fastly creating dissolved sediment. Once the flow has peaked and sediment load is falling sediment capture is less. It has been observed that when the NTU value is less than 30 the remaining dissolved sediment tends to be more highly dissolved and therefore differences between the entry point and exit of a sediment trap NTU values are small. Whereas when readings are over 50 NTU and there is noticeable/visible sediment in temporary solution or suspension, differences in NTU are found between entry and exit points. Plant cane blocks in particular have much higher sediment runoff as compared to ratoon cane as was shown by sediment trap NTU readings (see site 5 readings).

Sump traps are ideal for course sediment capture which is the bottom flowing or poorly suspended sediment. This is especially useful when the farm drain flows directly into a main stream. The Bundaberg Sugar sump traps are a clear example of this. The Brooks sump trap site 1. has shown sediment build up in one third of the trap over a period of six months.

Intellectual Property and Confidentiality:

There is no protected Project Technology or information that has been kept confidential and there nothing in this report that should be treated as confidential.

Capacity Building:

The Group's capacity to conduct R&D and implement better farming systems has been enhanced through the process of monitoring sediment trap operations.

Outcomes:

We have created a field booklet for farmers and other organisations who are interested in sediment runoff controls as part of an overall drainage system. It documents the field work and results surrounding this proposal. Easy to understand diagrams show drainage system design options. The booklet is a tangible model which they can be added to farm management systems to address sediment runoff.

Environmental Impact:

Sediment trap construction generally has a program of revegetation as part of the outcome to lessen any possible environmental impacts. This has occurred on four of the trap sites with appropriate tree/bush species being planted such as Bottle brush which has an intense root system which stabilizes banks well (common along the banks of the Johnstone River). Bottle brush shrubs could be planted in two rows around the edges of the traps leaving a convenient access point for cleaning out. Bottle brush can also be planted in the rock weirs in order to stabilize them where they are subject to strong flows. However, doing this removes the option of lifting and resetting the rock weirs when they become clogged with sediment and cease to be leaky" (Stewart 2010). Other species that could be appropriate for a farm situation would be Lilly-pilly shrubs. If there is no problem with tall trees then you could also plant River Cherries, Golden Pendar and if you are close to brackish water Cottonwood would be suitable.

Communication and Adoption of Outputs:

The results will be communicated/promoted in the sugar industry by means of:

1. Local shed meetings
2. On site field trip for farmers to explain the system
3. A project report will be written on conclusion of trial work and sent to SRDC.
4. Send the model to other drainage boards for dissemination
5. Articles in industry magazines.
6. Send copies of the report to relevant State and Federal Government departments.

The results will be taken up and used by:

1. Members of the Silkwood drainage board area
2. Members of other drainage board areas
3. Farmers who need to address erosion control problems
4. Local Shire Council in their design work of road drainage systems.

Recommendations:

As the research carried out in the SDBA is located in the wet tropics area of Far North Queensland it would be necessary to do some similar field trials in the drier areas of Central North Queensland, that is areas from Townsville south, to evaluate and see if the methods used here are adaptable and applicable to all other areas.

Publications:

(List and attach copies (electronically if possible) of all articles, newsletters and other publications from the project.)

Sediment Trap Field Guide

The original project anticipated that a booklet could be produced to communicate the outcomes from the project. What has been designed is a 12 page field booklet which landholders can refer to as a guide to help decide whether or not to install sediment traps. Once a decision has been made to go ahead then the booklet could be referred to as a field guide to the design and installation of sediment traps. It is important to note that the booklet has sourced its data from traps that are working only in the Silkwood Drainage Board wet tropics area. This booklet as produced below, gives a clear step by step explanation as to the methods and benefits of installing sediment traps within the farm drain system of the Silkwood Drainage Board area. Once again the booklet can not recommend outright to landholders to install sediment traps but it can help farmers make their own decisions.

Milestone	Due date	Total cost of activity	SRDC contribution
1. (a) Signing of Agreement with SRDC. (b) Send out shed meeting letters (c) Conduct meeting with grower members of the drainage board, who will constitute the grower group for this project and inform & gain collaboration and support. (d) Conduct field trips to observe sediment trapping incorporated in drainage systems. Hire of a bus and supply refreshments. (e) Finalise the farmers approved placement of the sediment traps.	1st July 2007	$2500	$5000
2. a) Develop an evaluation strategy in consultation with SRDC b) Develop the design of trials and methods of data collection c) Consult with NRM & DPI Innisfail to design the sediment traps and the positioning of these. d) Develop a work plan on resources required for the construction.	1st February 2008	$2500	$0
3. (a) Construct four sediment traps @$4000. (b) Construct two sediment traps @$4000. (c) Construct a series of smaller size sump sediment traps	1st October 2008	$16000 $8000 $8000	$14000 $ 7000 $ 7000
4. (a) Conduct a farmer field day to explain the finished system. (b) Carry out monitoring and collection of data at the sediment trapping sites and control sites over the 2008 and 2009 wet seasons for water quality levels and for sediment trapping outcomes by using the following methods; I. Manual sampling (turbidity) II. Rising stage (turbidity) III. Open pipe sediment capture IV. Open box sediment capture V. Dry trap inspection (c) Create a best practice booklet. (b) Final Report prepared using the template from the SRDC website.	1st August 2010	$9000	$8200
	Total	**$46,000**	**$41,200**

Table 12. Original Project plan

Picture 1.0   Class work between farmers (George Taifalos, Allan Cross, George Bilic, Pat Cassar, Fred Camileri and Ian Brooks) and department managers (Bob Stewart, Allan Dunne and Diana O'Donnell; standing)

Picture 2.0   Shed discussion at Dores' farm on Stamps Road, Tully. The Dores have carried out extensive sediment control works on their property and an outline of future works was given to field day participants.

Picture 3. Field inspection on Angelo Crema farm, Warrimi (note rock wall to control flow and sediment)

Picture 4. Field inspection of sediment trap on Angelo Crema farm, Warrimi (note curved stream design and flow restriction to control sediment)

Picture 5. Field inspection of sand trap on Angelo Crema farm, Warrimi (note curved stream design which causes sediment to stall and collect) This drain is over 2 metres deep and now full of sand.

As indicated in the report the positioning of the sediment traps was finalised. These participating farms are Allan Cross (Bundaberg Sugar Farms), Ian & Robert Brooks Farms and the Rosendall site on Spanos Road. These proposed sites are shown in the following scanned images.

Picture 6. The Cassar Road site adjacent Brooks farm.

Picture 7. The headwaters to Berryman Creek sited on the Brooks farm.

Picture 8. The Spanos Road site adjacent to Rosendall farm.

Picture 9. The main service drain site prior to its crossing the Bruce Highway.

Picture 10. Proposed shape of sediment trap overlaying an existing drain.

The white lines show the width and depth of the excavation needed. The depth is roughly 500mm below existing drain floor and the width is between 2 to 3 times the existing drain width. The rock wall sits approximately 300 mm above the floor of the existing drain which controls the discharge of water allowing sediment trapping. Excess rainfall events simply pass through unhindered but normal medium rainfalls being slowed sufficiently to trap sediment. The trapped sediment can then be removed approximately once per year.

Picture 1. Excavator work on Cassar Rd sediment trap

Picture 2. Cassar Rd sediment trap

Picture 3. Small silt trap constructed in the table drain at the beginning of main drain running toward Bruce Highway

Picture 4. Main Bruce Highway drain downstream from picture 3 with the sediment trap under construction

Picture 5. (Site 3) Sediment trap at the headwaters of Berryman creek utilizing a square design to enhance its effect by receiving water from two opposite incoming drains before exiting into Berryman creek. The excavated dirt/clay was stockpiled to allow it to dry due to it high water content. It was removed at a later date by truck and loader and used as land fill.

Picture 6. Same as above looking downstream

The progress of the project required significant ongoing communication with participating landholders. It is through this protracted communication that the agreement of six sediment traps has become the best possible outcome which we can go forward with. Landholders are interested to monitor how successful these six traps will be and look forward to analysing the effectiveness of the sediment trapping system in 2009/2010.

Photographs of the completed sediment traps

Photo 7. Bundaberg Sugar Farms (BSF) Site 5. Looking up stream from the rock wall, shows that the water is restricted from the normal fast exit through the drain system by this coarse rock wall. The trap is constructed through the widening and deepening of the existing drain. Note that an excavator has been necessary to deepen the existing drain.

Photo 8. BSF Site 5.

Photo 9. BSF Site 5 showing how the drain holds water for another 200meters from the rock wall. This is the only trap which had this effect and it is considered that the rock wall should be lowered.

Photo 10. BSF Site 5. Shows the exit of water through the rock wall directly into Buckley creek. The holding of water in this trap allows sediment particles time to settle and therefore not flow into the main creek system. Note the clarity of the water draining off.

Photo 11. BSF Site 4. The trap is constructed through the widening and deepening of the existing drain. A rock wall is used to choke the flow of water through the drain. The farmer is happy with this type of trap as it does not change the existing headlands. This drain also feeds into Buckley creek directly below the rock wall.

Photo 12. BSF Site 4.

Photo 13. BSF Site 6. This is a large square design trap which provides a much bigger holding reservoir. This is beneficial during limited heavy down pours of rain, typical of the wet tropics area. The excavation work is significant to create a trap of this size. This

trap was built on land which can not be used for cane.

Photo 14. BSF Site 6. It uses a similar rock wall to regulate water flows.

Photo 15. BSF Site 6. This trap also feeds directly into Buckley creek.

Photo 16. Brooks Farms Site 1. This design is shaped by the position of the adjacent road which runs parallel to the drain necessitating the widening of the drain to occur only on one side. The rock wall will be increased due to the higher elevation of the inlet side.

Photo 17. Brooks Farm site 1. The original drain was deepened by approx 750 mm. A large amount of clay was removed to establish this trap. The excavator digs the trap out over a one to two day period and stockpiles the clay on site to allow it to dry off after which time a loader and truck take a day to cart it away.

Photo 18. Quarry rock “Face Falls” (sizes 100mm to 400mm) stockpiled ready for placing as rock walls in the sediment traps.

Photo 19. Brooks Farm site 3. (similar to BSF site 6) receives water from two directions, the water drain on the left of the photo comes from over 32 hectares and the water drain on the right of the photo is the main Silkwood Drainage Board drain covering at least 64 hectares.

Photo 20. Brooks Farm site 2. The water from here flows directly into what is the beginning of Berryman creek.

Silkwood Drainage Board

Tour - Farm drainage

Aim: Provide information on
Sources of sediment
How drainage effects landscape hydrology
What sediment moves in a river
What is needed to trap sediment
Demonstate practical examples of solutions
Outcome: Descision by landholders on possbile actions

Time	Location	Topic	Speaker	Resources
9:00:00 AM 5 min	Sanda M Shed Silkwood	Refreshments on arrival Welcome	 Alan Dunne	tea stuff chairs
9:05:00 AM 25 min		**River Dynamics** How rivers function - what sediment does How farm drainage effects the landscape hydrology	Alan Dunne Johsntone RIT	table, OHP? water glasses
9:30:00 AM 5 min 10 20		**Soils** Composition - Sand Silt Clay behaviour in water settling times Impacts on environment	Bob Stewart FNQ NRM Ltd	soil samples turbidity tube, cylinders, Hydometer
10:05:00 AM 15 min	travel			map
10:20:00 AM 45 min		Buckley Ck site inspection	Allan Dunne	
11:05:00 AM 30 min	travel			map
11:35:00 AM 5 min 15 15	Ross Digman's Lagoon	arrive **Sediment trapping** - sources of sediment Herbert River & Mossman info - farm drain design - why all waterholes aren't good sediment traps	 Diana O'Donnell	 Photos HO -Drainage HO - Why What is Which
12:10:00 PM 30 min		LUNCH		table, sandwiches drinks, esky, ice
12:40:00 PM 35 min		**Artifical Wet lands** Why and what he has done Design of Sediment traps for WQ	Ross Digman	
1:15:00 PM 15 min	travel	LIHS - King - Houston Rd - Upper Murray Rd		
1:30:00 PM 35 min	Angelo Crema drain monitoring site	**Farm design and maintance** Battering and vegetation Rock drop structures	Angelo Crema	
2:05:00 PM 20 min	travel			
2:25:00 PM 35 min	Peter Dore's lagoon	**Artifical Wet lands** why and what he has done	Peter Dore	
3:00:00 PM 30 min	travel			
3:30:00 PM 30 min	site in silkwood	arrive SMOKO (make up time if running late)		drinks, esky, ice cake, buscuits
4:00:00 PM 30 min		site in silkwood - discuss options	Bob Stewart Diana O'Donnell	
4:30:00 PM	travel	Thanks and Farewell	Bob Steward	

Figure 1.0 Agenda for field day tour

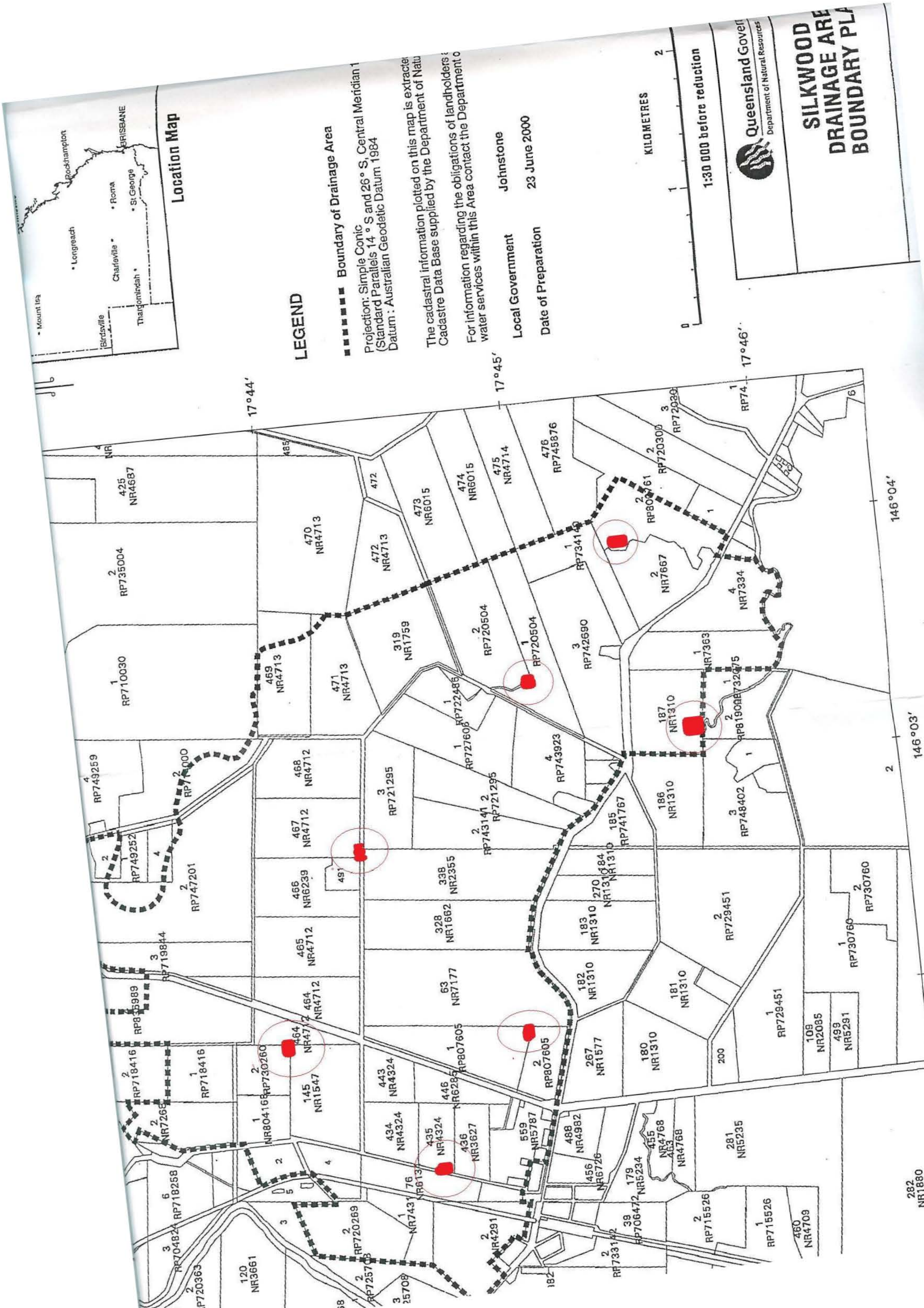


Figure 2. Registered plan of the Silkwood Drainage Board Area showing approximate positions in red of the proposed sediment trap sites.

Design and construction of the sediment traps (as recommended by NRM & DPI)

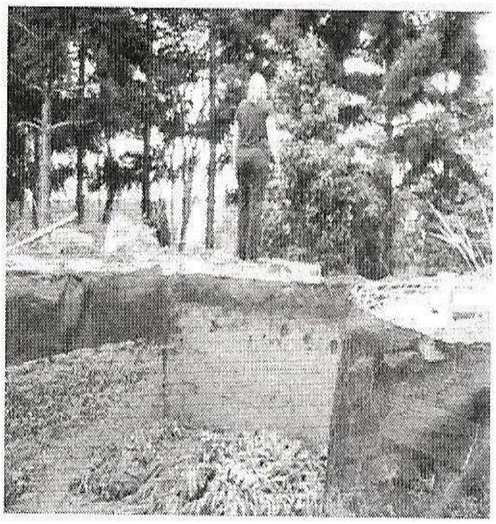
Sediment traps

Sediment traps primary role is for improving water quality by removing sediment carried in runoff water.
Economic gains are made where the extracted coarse material is spread on headlands and roads and the fines top-dressed onto paddocks (good nutrient content).

Equipment will need access for periodic sediment removal.

It greatly improves their effectiveness if trapped water drains away after several days to ensure some of the next runoff event is also captured and it's sediment allowed to settle out.

Runoff water carrying heavy sediments (sand) only needs to be slowed slightly to cause deposition of some of the coarse material. Forcing water to become almost completely still results in all sand and some of the silt fractions deposited. But to ensure that most of the fines carried by the water is deposited the water has to be held still for several days. Some clays will never settle without treatment of the water.



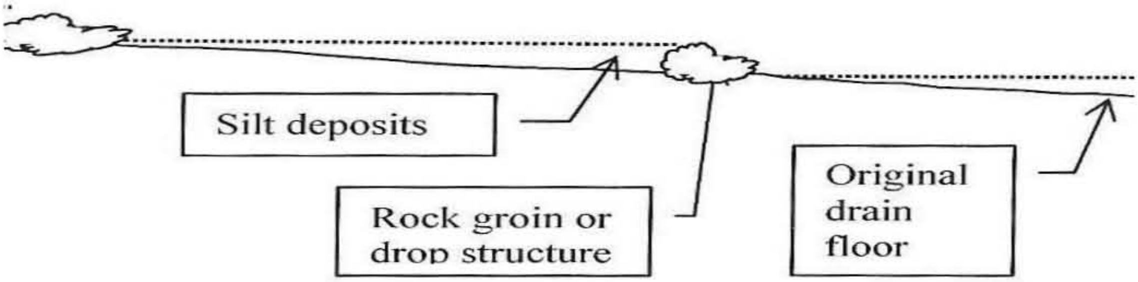
A gated pipe outlet or permeable area (rock gabian) which allows the water to slowly seep away making it possible to catch several flows a season, increasing the sediment trapped.

Figure 2. Queensland Department of Primary Industries (DPI) recommended method of sediment trap construction

Velocities are effected by the slope of the floor of the drain and the depth of water flowing in the drain. On the same slope, the deeper the water is the faster it flows.

- To reduce velocities it will be necessary to widen the drain so the same volume of water flows less deeply and therefore slower

- In areas where the drain can't be widened or on steeply sloping land it may be necessary to construct small weirs, rock groins or drop structures, effectively reduce the bed gradient to a series of steps.



Rock drop structures should have a rock toe 3 x it's height to prevent erosion as the water drops over the rocks.

The rocks also need to be keyed into the sides of the drain to ensure it is not 'avoided' or by passed.

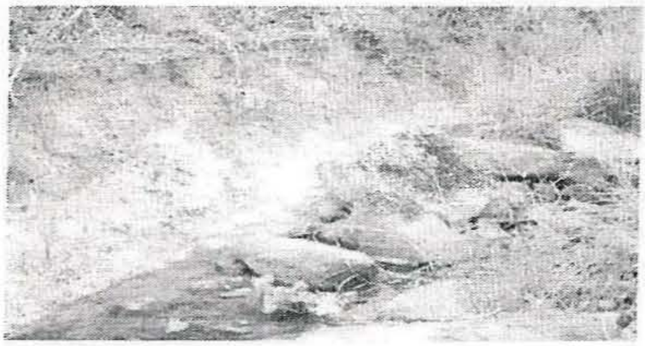


Figure 3. Queensland Department of Primary Industries (DPI) recommended method of sediment trap construction

Department of Natural Resources Mines and Water (NRMW)

Rules for construction of silt traps

If no part of the silt trap is in a watercourse then you will not need a permit for construction.

If the silt trap is within the banks of a watercourse you will need approval in the form of either a licence or permit.
- 'Riverine protection permit' if it will not increase the height of the bed level and not store more water.
- 'Licence to interfere by impoundment' if it will increase the height of the bed level and store more water.

A riverine protection permit can be obtained by completing the form "Application for Riverine Protection Permit (Water Act 2000)" Form W2F008 that is available from your NRMW office or from the NRMW web site. Riverine permits applications are free but one must be obtained each time silt is removed from the trap.

A licence to interfere by impoundment can be applied for by completing "Application for Licence to Interfere with Flow by Impounding Water" Form W2F002 and the associated Integrated Planning Act 1997 IDAS Form 1 Part K3. Each licence applications has an application cost and there is an ongoing annual charge but silt can be removed on more than one occasion as necessary.

Landowners should also contact the Environmental Protection Agency and Department of Primary Industries and Fisheries regarding any additional approvals that may be required for example a dredging permit ERA 19 or Fish Barrier permit.

Figure 4. Queensland Department of Primary Industries (DPI) recommended rules for sediment trap construction

Water Quality Monitoring Data Sheet

Rising stage sample bottles: Site : ___________ Date: _________________

Recorded by: __________________Weather event (24hrs)_________________________

Sampling Place	Depth (cm)	Temperature (C)	pH	Specific conductance (μmhos/cm)	Turbidity (NTU's)
Inlet					
Outlet					

Observed water: height above rock wall: ___________________ flow speed: ________________

Manual sampling: Site : ______________ Date: _________________

Recorded by: ____________________Weather event (24hrs)_______________________

Sampling Place	Depth (cm)	Temperature (C)	pH	Specific conductance (μmhos/cm)	Turbidity (NTU's)
Inlet					
Outlet					

Observed water: height above rock wall: ___________________ flow speed: ________________

Table 4. Water quality monitoring field data sheet (using a turbidity tube)

Acknowledgments:

The Silkwood Drainage Board would like to thank the following people and organisations that helped make this project a success;

- Mr. Bob Stewart of Natural Resource Management Innisfail acting in both capacities of board secretary and consulting scientist.
- The staff of the SRDC who showed understanding in allowing this project to be spread out over a much longer time frame than was originally planned and agreed to.
- The Grower Group Services organisation in providing encouragement and assistance
- The landholders of the Silkwood drainage Board Area who gave permission and help to let the project proceed

References:

Downing, J. (2008) Comparison of Suspended Solids Concentration (SSC) and Turbidity CAMPBELL SCIENTIFIC, INC. Copyright (C) April 2008 Campbell Scientific, Inc. http://www.campbellsci.com.au/documents/technical-papers/obs_ssc-turbidity.pdf

Drewrya, J. Newhama, L. Croke, B. (first submitted 2007) Suspended sediment, nitrogen and phosphorus concentrations and exports during storm-events to the Tuross estuary, Australia. Journal of Environmental Management 90 (2009) 879–887 http://icam.anu.edu.au/downloads/DrewryNewhamCroke2009.pdf

Queensland Department of Primary Industries (DPI) Design and construction of the sediment traps as recommended by NRM & recommended rules for sediment trap construction

Post, D.A. and Jakeman, A.J. (1995) ‘Impact of rainfall on turbidity and suspended sediment load at five sites on the Murray River between Albury and Swan Hill and possible relationships to catchment attributes’. http://www.mssanz.org.au/MODSIM95/Vol%201/Post.pdf

Stewart, B. at Terrain-Natural Resource Management-Innisfail. E-mail bobs@terrain.org.au

Bureau Of Metrology Queensland (2010) Rainfall records from South Johnstone Station http://reg.bom.gov.au/climate/dwo/201003/html/IDCJDW4108.201003.shtml

Waterwatch Victoria Methods Manual 1999. A Community Water Quality Monitoring Manual for Victoria; http://www.vic.waterwatch.org.au/file/inform/Methods%20Manual%20June99.pdf