AN INNOVATIVE STORMWATER SOLUTION FOR A WORLD HERITAGE AREA

Mike Hannah & Nick Vigar (Stormwater 360)
Dr Niels Munksgaard & Dr Bernd Lottermoser (James Cook University)

Abstract

Queensland Roads of Australia is planning for an upgrade to a four-lane surface route on the 14km section of the Kennedy Highway between Cairns and Kuranda (known locally as Kuranda Range Road) in Far North Queensland.

The road links the coastal plains of Cairns to the Northern Tablelands, and part of it goes through the Wet Tropics World Heritage Area. The catchment of the Kuranda Range road runs through drains to the Coral Sea, which is the water body that contains the famous Barrier Reef

Water quality testing in the catchment has shown the streams are in pretty good condition with the exception of a few upland tropical streams which receive runoff from the existing road. As expected these streams are showing signs of heavy metal and PAH contamination

The sensitive and unique tropical environment has required a unique approach to upgrading the road. It is proposed to build the majority of the road on bridges, to provide minimum disturbance of the forest canopy and excavation. The purpose of the bridges is also to allow for connectivity for upland animal species.

The environment and alignment of the road also provides many challenges to implementing stormwater treatment. It is proposed to provide treatment to the bridge structure with an innovative treatment train.

An Enviropod filter, detention system and a StormFilter cartridge have all been located in a small Steel box with dimensions 1.4m long x 0.7m wide x 1.4m deep. It is intended that this treatment train “in a box” be bolted to the side of the bridge structures. This paper examines the performance treatment train in a box in this sensitive environment.

Key Words: Stormwater Treatment, Treatment Train, Highways, Heavy Metals, World Heritage, Wet Tropics.

Introduction.

The Kuranda Range road is in great need of an upgrade to allow for sustainable growth in the region. Its location in a unique and sensitive environment has required an innovative approach to upgrading the road and minimising the environmental impacts from stormwater.

A literature survey by Lottermoser (2005) indicated that treatment of stormwater should focus on dissolved contaminants, suspended particulate matter and fine-grained particles because these contaminant fractions would transport much of the contaminant load. It was concluded that a treatment train approach should be pursued.

Stormwater 360 formally Ingal Environmental Services was approached by James Cook University (JCU) to assist in the design, field trial and performance evaluation of an innovative stormwater treatment solution, the Enviropod Stormfilter Treatment Train (SFEP).

The proposed upgrade of the road is to incorporate extensive use of bridges to minimise environmental effects. The proposed design of the SFEP considers the wide range of contaminants in stormwater. The SFEP incorporates removal mechanisms that mimic natural processes in a packaged solution that can be located on the bridges.

In March of 2005 a SFEP consisting of a steel gullypit, Enviropod filter and a Stormfilter cartridge was installed on the Kuranda Range Road. This paper describes the innovative solution and the how this solution mimics natural process in its design. The paper also discusses the laboratory and field testing to date.

Back Ground

Far North Queensland is one of the more rapidly grown regions of Australia; however at present the region is relatively undeveloped and because of this is home to many unique flora and fauna. North Queensland is home to two world heritage area the Barrier Reef and the Wet Tropics Rainforest.

Regional growth strategies have identified the Atherton tablelands as an area for growth that will have less environmental impact than the development of coastal areas. However the road (the Kuranda Range road) that provides access to the tablelands has a poor alignment causing many accidents and does not have the capacity for the intended future development.

The Kuranda Range Road is the local name for a section of the Kennedy highway in Northern Queensland. The road links the township of Smithfield on the Cairns coastal plane with Kuranda on the Northern Atherton Table lands

The road dissects the world heritage Wet Tropics Rainforest. The Wet Tropics Rainforest is the oldest rainforest in the world which provides an unparalleled living record of the ecological and evolutionary processes that shaped the flora and fauna of

Australia over the past 415 million years. The Wet Tropics rainforest is home to over 3000 species of plants and over 600 species of mammals, birds and reptiles.

The unique and sensitive environment that the road is located in has required an innovative approach to the design and layout of the road. The environmental design of the project incorporates extensive use of bridges to reduce works in important creeks and ridge lines which protect plants and maintains fauna connectivity. The use of bridges also avoids major cuttings and embankments. Further more the use of bridges has demanded an innovative approach to treating the stormwater. It is proposed to locate the innovative Storm Filter Enviropod Treatment Train on the bridge deck to prevent disturbance of the surrounding ecosystem.

Figure 1: Extensive use of bridges to minuses environmental impact.

Figure 2: Proposed layout of road at study site.

Figure 3: Smiths Creek, World Heritage Listed, Wet Topics Rainforest

The Contaminants in Road Runoff

Gross Pollutants

Gross pollutants are generally defined as particles over 5mm entrained in stormwater. This includes litter (cans and paper etc), vegetation (leaves and branches) and inorganic material (roading chip, car chassis wear). Gross pollutants are not inherently toxic, how ever they can break down in receiving waters releasing more toxic contaminants. Gross pollutants can wash of in large volumes and are ascetically unpleasing. A high loading of gross pollutants can easily render a stormwater treatment device ineffective or clog up a receiving waterway.

Removal of Gross Pollutants by Nature from Surface Water.

Gross pollutants are naturally screened from surface water by vegetation. Mangroves or rushes are good examples of natural gross pollutant screens. Grasses and plants in stormwater treatment technologies such as swales and bio-filtration also screen gross pollutants as they dissipate energy from the surface water reducing the flow velocity and immobilising entrained gross pollutants. Dissipation of energy is also fundamental in improving the efficiency of secondary forms of treatment in a treatment train such as sedimentation.

In nature the bulk of gross pollutants that are screened from surface water are stored dry out of the receiving water body. This prevents the degradation and release of contaminants into waterways

The proposed stormwater treatment system for the Kuranda Range upgrade will include a dry screening method with a large storage volume.

Sediment and Suspended Solids

Sediment and suspended solids are organic and inorganic particles greater than 0.45 micron and less than 5mm. The bulk sediment that is transported in stormwater is coarse (1mm to 5mm). Coarse sediment tends to travel in the stormwater system by salutation. Coarse sediment is often called bed load.

Excessive sediment in surface water prevents light transmission though water, clogs fish gills, affects filter-feeding shellfish, smother benthic organisms and can change benthic habitats. Fine sediment is associated with more toxic contaminates such as heavy metals.

Removal of Sediment and suspended solids by Nature from surface water.

In nature coarse sediment entrained in fast flowing streams drop out of the flow when they encounter large reservoirs of water such as ponds. As water enters these reservoirs the horizontal flow velocity lowers and gravitational forces allow the sediment to settle.

The amount of sediment that will settle out of the water column is dependent on:

- Specific gravity of sediment
- Particle size
- Horizontal velocity
- Size of the reservoir.

Often fine organic sediment will not readily settle. Fine organic sediment has a high affinity with other more toxic contaminates such as heavy metals. In nature fine sediment is effectively removed from surface water through filtration by soils and/or sands.

For the Kuranda road upgrade the proposed treatment option will incorporate a reservoir of water to assist in dropping the coarser and heavier particles as well as a filtration component to remove finer particles.

Hydrocarbons, Oil and Grease.

Hydrocarbons in stormwater may be in the form of a free slick, oil droplets, and oil emulsion. Hydrocarbons are naturally occurring substances and as such they naturally breakdown in nature. Oil and grease typically exist in road runoff in low concentrations attached to sediment or are emulsified. Oil and grease causes the most environmental damage when it is in high concentrations such as a spill.

The conventional method of lowering high concentration of hydrocarbons is by oil separation. Oil separation is usually involves the use of baffles. Water in made to pass under baffle. The free oil floats to the surface and is contained by the baffle. The stormwater design incorporates a baffle section with approximately 200 litres of free oil storage.

Heavy Metals

Many of the most toxic contaminants in stormwater arise from brake and tyre wear. This wear leaves not only a particulate residue but also a potentially soluble residue of heavy metal compounds. Of particular environmental significance are zinc from tyres, and copper and cadmium from brake linings.

These contaminates are warn from vehicles and deposited on the road surface for example metallic copper (I in figure below) in brake linings oxidize and dissolve in acidic highway run-off forming positively charged ions (II) . When it rains these metal ion becomes hydrated, however the hydrated metal ion in the water column **(III in the figure below)** is a short-lived species. It will rapidly sorb to any suspended particulate matter such as insoluble mineral particles **(IV, in the figure below)**, effectively becoming suspended sediment despite being a soluble species. Also present in the water column will be significant quantities of dissolved or colloidal organic species such as the various humic substances. These species are polymers formed from the breakdown of organic matter such as celluloses, proteins and other biological molecules. They are of varying molecular weight and structure which gives them varying degrees of solubility. The most significant property of these polymers is the presence of various mildly acidic functional groups along the branched chains. These manifest as negatively charged regions to which the positively charged metal ions are strongly attracted by electrostatic interactions. Whilst any metal ions will be attracted in this manner, those that are multiply charged (*e.g.* Ca^{2+}, Mg^{2+} and most heavy metals such as Zn^{2+}, Cu^{2+} and Cd^{2+}) tend to become preferentially bound to the humic substance because they can interact with more than one of the available negative charges; a process known as chelation. Thus, these organic components tend to aggressively sorb heavy metal ions forming complexes **(V, in the figure below)** which are soluble, colloidal or particulate in nature, depending upon the molecular weight of the humic substance. In fact, given time to equilibrate the predominant species involve complex interactions with both colloidal humic substances and mineral particulates **(VI, in the figure below)**.

All of these species are either suspended or dissolved in the water column. Hydrated metal ions are completely dissolved. Any species involving particulate is fully insoluble. Ions attached only to humic substances may be either dissolved, colloidal or (suspended) particulate, depending upon the molecular weight (size) of the humic substance.

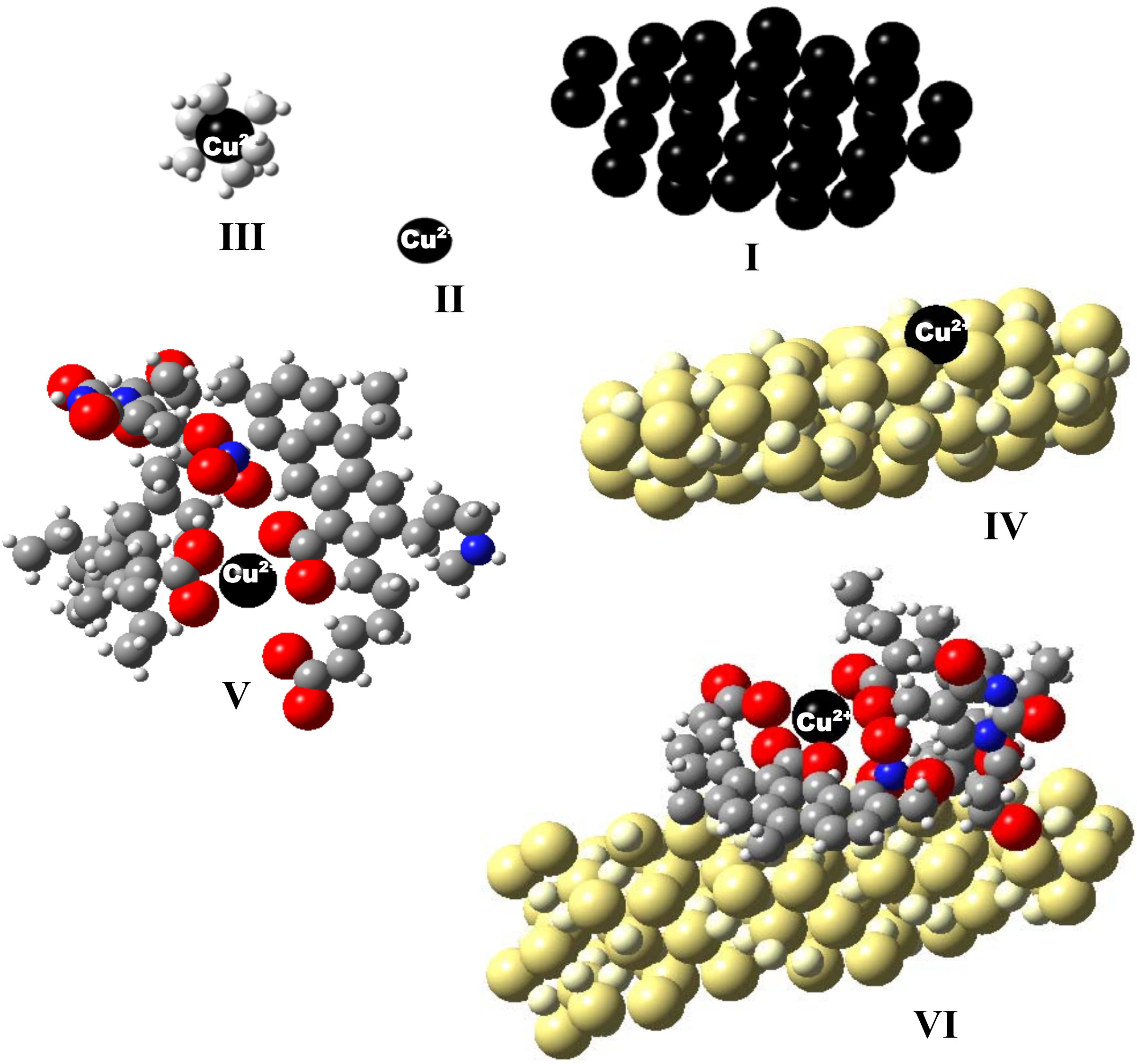


Figure 4: Example of Particulate and Dissolved Species of Copper

Bioavailability of Metals

Many factors influence the bioavailability of metals. Essentially the free metal ion is bio-available to aquatic life. i.e. can be absorbed into the blood stream of the animal. However many factors effect weather it is free or attached to another compound these include: pH, redox potential, alkalinity and hardness. The dissolved (hydrated) metal ion is easily ingested through membrane channels in fish gills. These membrane channels are actually organic ligands similar to the humic compound (V). The membrane can compete with the humic compound for the free ion, breaking the electrostatic bond. Further ions attached to particulates that settle in sediments can easily be released into pore water if it turns anaerobic. The dynamic and complex nature of metal bio-availability suggests that effective metal removal must focus on of all species of metals in stormwater not only particulate.

Removal of Metals by Nature

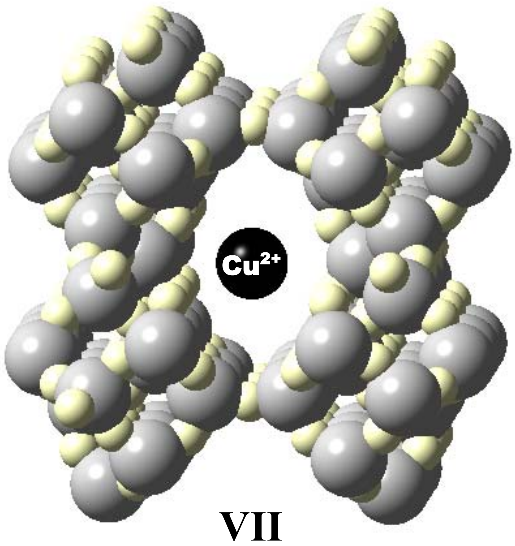
As described, all the metal species are either suspended or dissolved in the water column. Once the stormwater infiltrates the soil the same interactions determine the fate of the metal ions. Soil consists of particulate minerals (*e.g.* aluminosilicate clays) bound together with a colloidal humic component. Most clay particles possess a net negative charge and are capable of binding metal ions directly at the surface of the clay particles. As was the case in the water column, the metal ion may also sorb to the humic component, or a combination of the two. The ability of a soil to bind metal ions is commonly expressed as its Cation Exchange Capacity (CEC). It's magnitude, and whether or not the metal ions are predominantly bound to mineral or humic substances depends upon the individual soil composition. Soils derived from more negatively charged clays, and with a low humic fraction, will predominantly sorb metal ions directly to the mineral. Soils formed from neutrally charged clays, and with a high humic fraction derive the bulk of their CEC from the latter, organic component.

The above discussion shows that allowing heavy metal-contaminated run-off to infiltrate natural soils can provide good remediation. This natural process has been adopted in stormwater treatment technologies such as bio filtration, swales and infiltration systems. These treatment technologies are capable of obtaining high rates of removal as they can remove both particulate and dissolved forms of heavy metals by filtration and cation exchange.

Other stormwater management practices that involve detention and sedimentation of the contaminated runoff such as ponds and hydrodynamic separation may address issues of particulate metals but it will have minimal impact on soluble heavy metal species and may discharge unacceptable loads of metals which are potentially more toxic

Where soil infiltration is impractical, (inappropriate geology or geography) it is still possible to achieve remediation by mimicking the natural soil processes. One solution is to sorb metal ions to an analogue of the humic soil component. The use of compost filter media utilizes this approach and success has been achieved in the USA with this media. However compost filter media is not readily available in Australia or New Zealand and because of bio-security reasons can not be imported.

Another option for filter media that can be readily sourced in Australasia is zeolite and carbon. The SFEP treatment train proposed for the Kuranda Range Road utilizes a mixed sorbent containing zeolite, granulated carbon and perlite. The latter two components respectively sorb organic pollutants and filter fine sediments. The zeolite component is particularly relevant to the present discussion because it is a sorbent for metal ions, mimicking the mineral component of natural soils. Zeolites (*e.g.* clinoptilolite **(VII in figure below)**) are aluminosilicate minerals and possess a net negative charge as do most clays. Crucially, however, the crystal structure of zeolites consists of well defined cavities that link to form channels through which water and soluble species may move. Thus, where clay particles in soil may only sorb metal ions at their surface, zeolites provide a significantly larger contact area for the sorption process. Metal ions are strongly bound within negatively charged cavities throughout the mineral. The CEC of zeolites is comparable to the CEC of soils, yet without involving an organic, humic component. As such, the use of zeolite sorbents effectively mimics a particular aspect of natural soil chemistry. By omitting any organic component the problem of sorbent breakdown and subsequent metals release is avoided. The proposed stormwater system design for the Kuranda road upgrade incorporates the use zeolite as a sorbent filter media.



VII

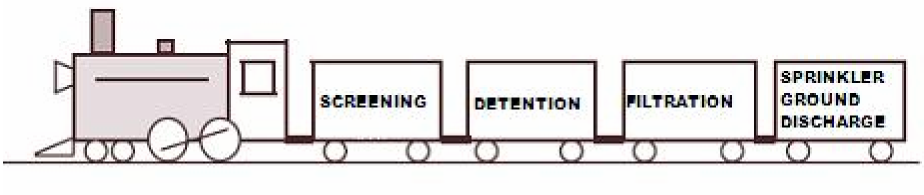
Figure 5: Zeolite molecule Capturing Copper free Ion

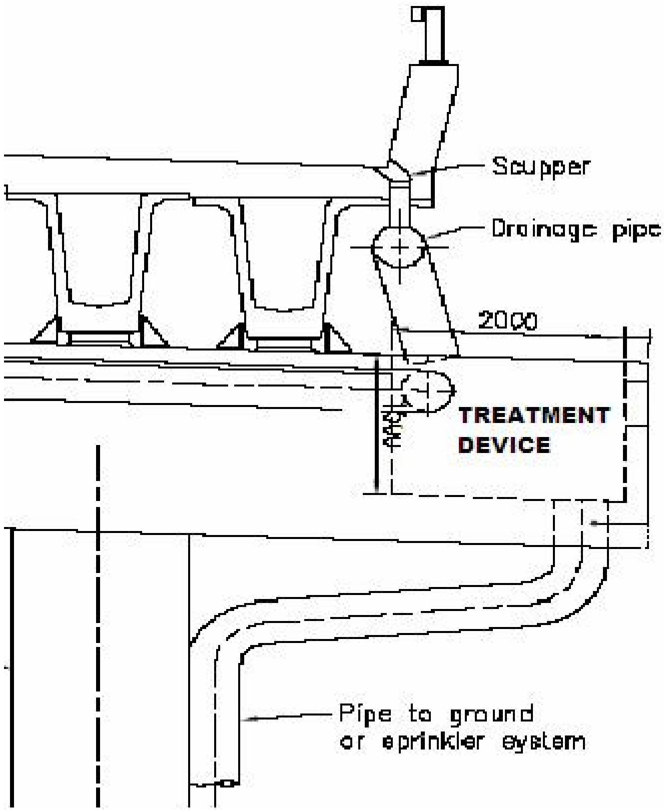
Stormwater Treatment Design

As identified above there are numerous contaminates in stormwater and it has long been agreed that the most effective method of treating stormwater is through a treatment train of best management practices with each step targeting a different type of contaminant.

With the pristine and sensitive environmental a high level of treatment is essential. However traditional approaches such as swales or wetlands are not possible with the proposed design for the road. Locating traditional treatment methods underneath the bridge would provide more environmental risk, be difficult to maintain and require considerable land. The stormwater design called for a innovative solution that could mimic natural process and capture the broad range of stormwater contaminants. The design would also have to be located on or within the bridges.

Listed below are the conceptual drawings of the proposed stormwater treatment solution Brisbane City Councils, water quality guidelines for stormwater treatment were adopted as a surrogate treatment objective for the project. The guideline recommends 75% removal of gross pollutants, 65% of sediment and 65% of total metals.





The SFEP Treatment Train –Stormfilter/Enviropod Gullypit.

Proprietary systems tend to be smaller than traditional approaches for treating stormwater. James Cook University approached Stormwater 360 (formally Ingal Environmental Services). Stormwater 360 has a range of treatment device designed to target a range of stormwater contaminates, from gross pollutant to dissolved metals.

The SFEP gullypit system is a 1.4m L x 0.7m W steel vault. Integrated into the vault is an Enviropod filter and a stormfilter cartridge. The Enviropod filter consists of a 200 micron nylon filter bag with supporting frame work. The Enviropod filter is a high flow screening device that holds retained contaminants dry. The stormfilter cartridge is a siphonic radial media filter configured to operate at 0.95l/sec. It is proposed to use a zeolite perlite activated carbon mix (ZPG) as the filter media. This media combination is readily available in the region and targets dissolved metals as well as fine particulates. The SFEP also has a scum baffle to capture oil spills and a reservoir of water to dissipate energy. The figures below show the system in more detail.

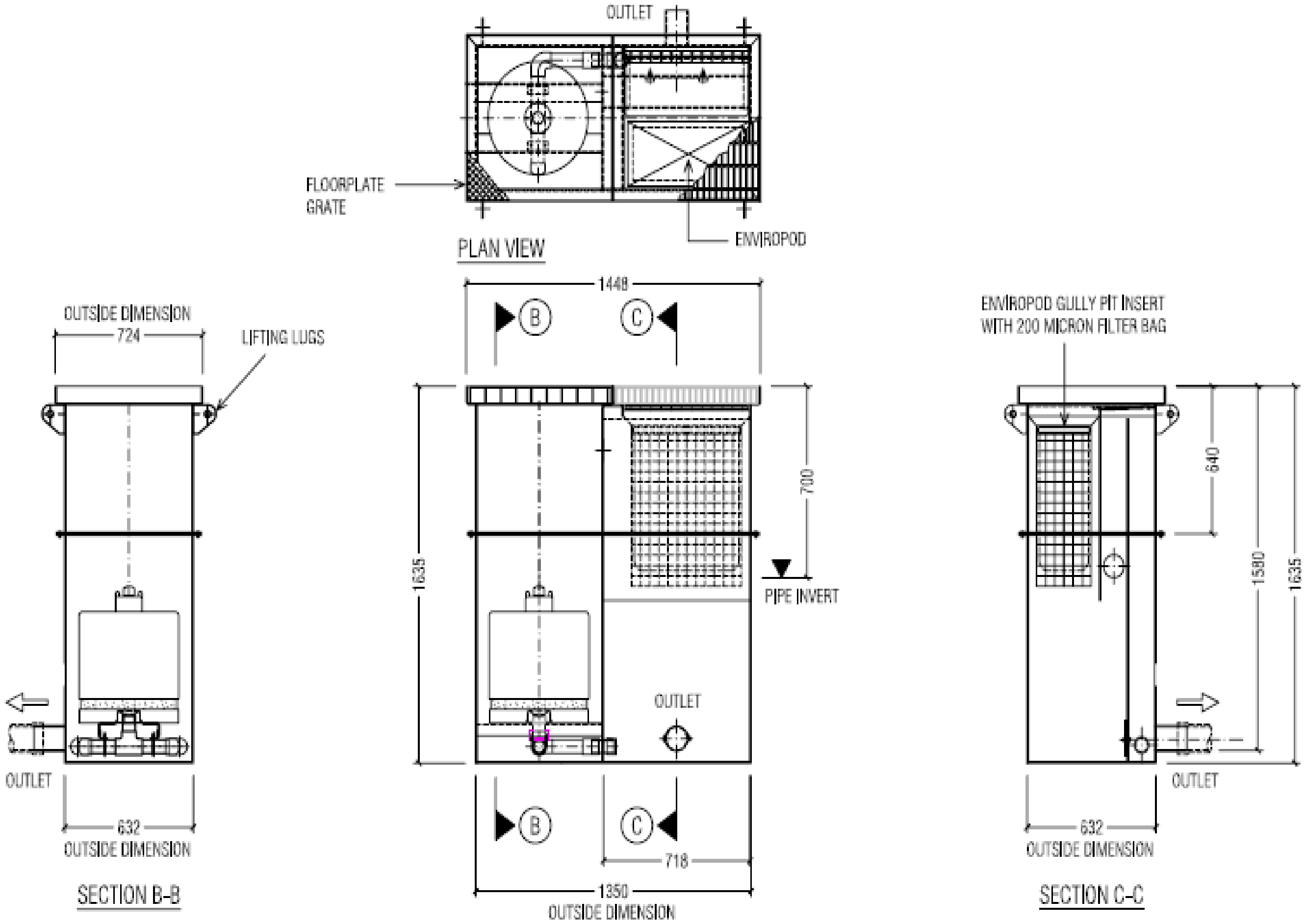


Figure 6: Construction Drawing of The SFEP Treatment Train

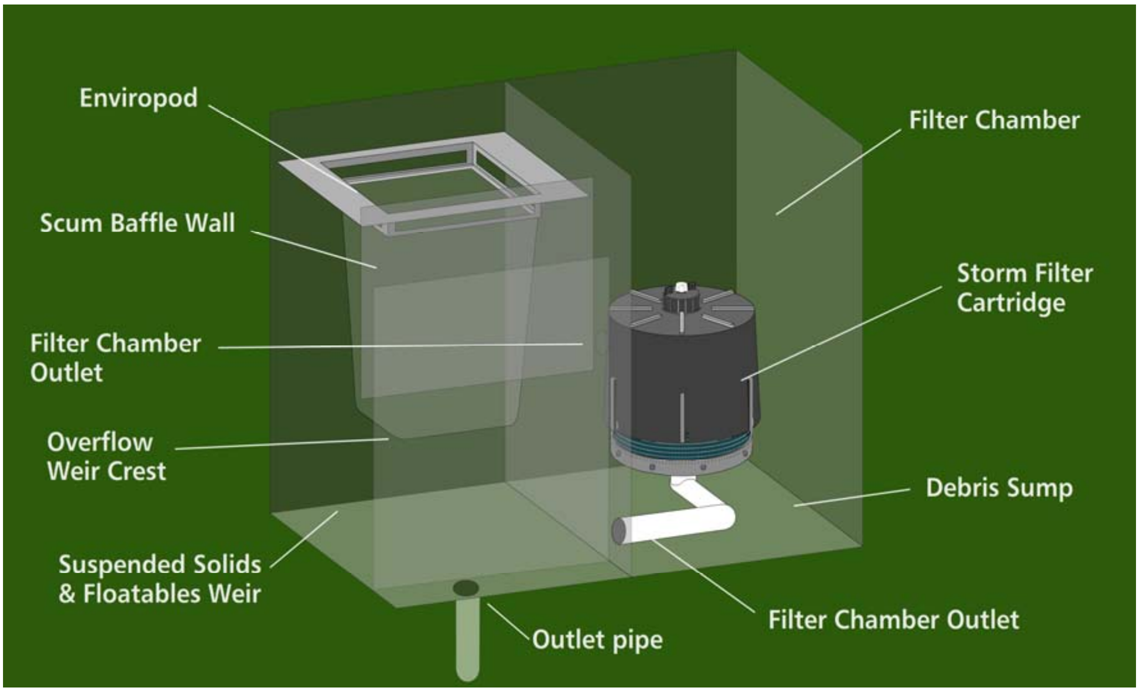


Figure 7: The SFEP Treatment Train

Laboratory and Field Testing.

Stormwater pollution is highly site specific; hydrology, geography geology and land use creates a highly variable brew of contaminants. The receiving environment of stormwater also greatly determines the effect of stormwater discharge. Because of the unique and sensitive environment of Kuranda Range the stormwater treatment system must perform. It was agreed that the system be trailed.

Laboratory Testing.

Monitoring and evaluating stormwater devices is difficult. The difficulty arises due to the variability of stormwater. One way method of evaluation that eliminates some of the variables is to trial the device in the lab.

Bench scale tests were performed at the Stormwater 360 laboratory in Auckland using 2 Horizontal Flow columns (HFC's). The HFC represents 1/24th of a stormfilter cartridge. The HFC is a perspex wedge designed to simulate horizontal radial flow as occurs in the stormfilter. A solution of synthetic stormwater was made up from metal sulphates and passed through two HFC's, one containing a New Zealand ZPG mix and the other containing Australian ZPG. The figure below is a schematic of the testing apparatus.

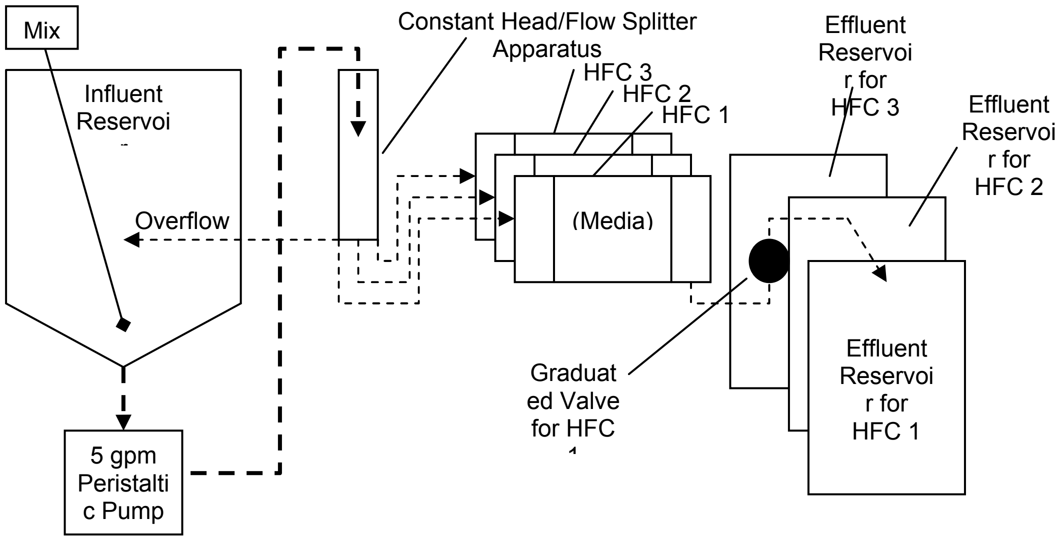


Figure 8: Schematic Laboratory Testing Apparatus

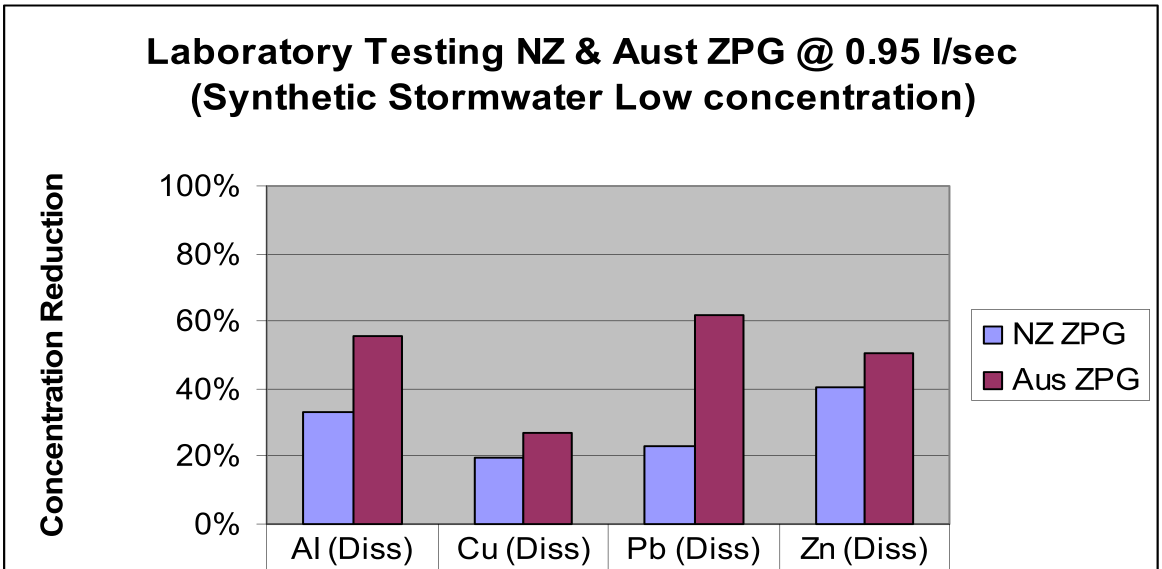
Figure 8: Laboratory Testing Apparatus

Figure 9: Horizontal Flow Column

The HFC testing only represents removal of the dissolved component of metals in stormwater. Approximately half the metals in stormwater are in dissolved form however this is highly variable. The table and figure below show results of the bench scale tests.

Element	Influent (mg/L)	NZ ZPG Effluent (mg/L)	NZ ZPG Removal Efficiency	Aus ZPG Effluent (mg/L)	Aus ZPG Removal Efficiency
Al (Diss)	0.009	0.006	33%	0.004	56%
Cu (Diss)	0.041	0.033	20%	0.03	27%
Pb (Diss)	0.013	0.01	23%	0.005	62%
Zn (Diss)	0.101	0.06	41%	0.05	50%

Table 1: Horizontal Flow Column Results



	Al (Diss)	Cu (Diss)	Pb (Diss)	Zn (Diss)
NZ ZPG	33%	20%	23%	41%
Aus ZPG	56%	27%	62%	50%

Figure 10: Laboratory Results

The results show the Australian ZPG mixture performed better than the New Zealand mixture. Considering that half of the metal component is typically particulate the results indicate the treatment objective of 65% total metals can be achieved.

Field Testing

As discussed above laboratory testing of stormwater system can give a good indication of how a methodology will perform in the field. However there are many more variables in the field. The only way to truly verify a technology can obtain the desired environmental outcomes is to monitor the device in the field. Stormwater 360 supplied a SFEP treatment train for evaluation. The SFEP was installed on the existing Kuranda Range road.

Study Site

The figure below is a picture of the site before the SFEP was installed. The catchment is approximately 300m2 of sealed road. A hot mix bund and concrete channel was constructed to capture the sheet flow and divert it into the SFEP. The pictures below show installation of the unit and the finished trial site.

Figure 11: SFEP Trial Site, Kuranda Range

Figure 12: SFEP Installation.

Figure 13: SFEP Installation

Field Trial Methodology

The figure below is a diagram of the monitoring configuration. Influent and effluent samples were collected using individual ISCO 6700 portable automated samplers. An A ISCO 750 area velocity flow module was connected to the downstream sampler for the purpose of sample pacing and flow analysis. Because of the low flows, flow was measured through a 90^o "V"-notch weir using the ISCO 750 velocity probe to measure depth.

The upstream sample intake was mounted in the invert of the formed concrete dish drain just before the SFEP. The stainless steel strainer can be seen in the photo montage below. . The downstream sample strainer was mounted in the invert of the effluent pipe up stream of the "V"-notch weir.

Samples were collected on a multi-part, volume-paced program the unit was also with an overflow detection unit. This will indicate when the stormfilter component of the SFEP is in by-pass

To insure representative and, complete data a detailed QA plan was prepared. The QA plan detailed sample handling procedures and storm qualification criteria. E.g. a minimum of 3 paired samples and 60% coverage of the storm event were required for the storm to qualify.

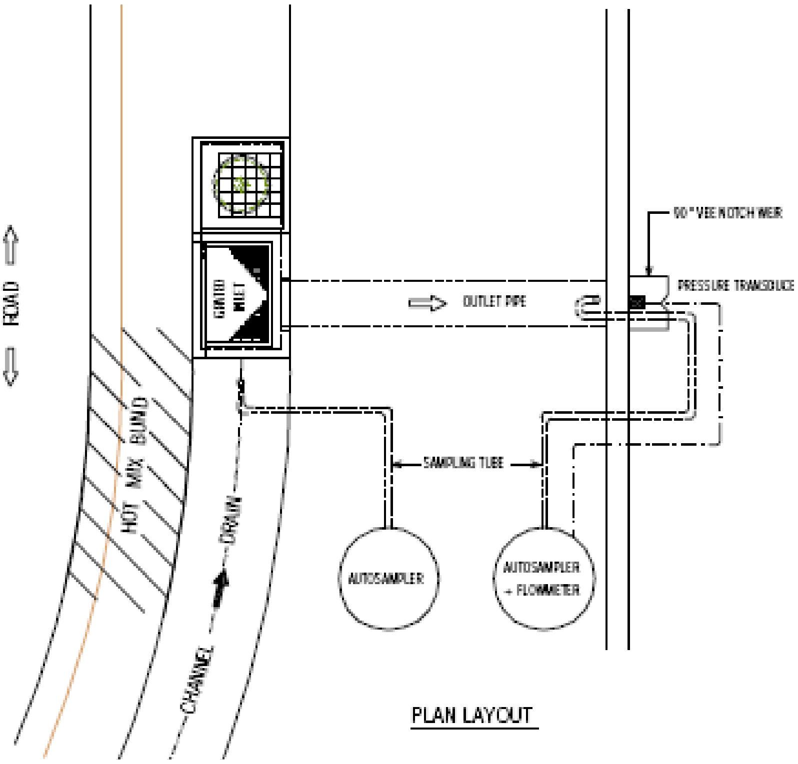


Figure 13: Field Trial Apparatus

Figure 14: Field Trial Apparatus

Preliminary Field trial Results

The table below shows the results from the 4 qualifying storms for sediment and the 3 storms for metals. Suspended sediment removal was very high with a load reduction of 89%. The picture below is of the upstream (right) and downstream (left) sample bottles. There is a noticeable difference in the sediment in the bottom of the bottles. TSS<500 microns was skewed by one bad result, more data is required to ascertain if this is an outlier.

Parameter	**Influent**					**Discrete Removal Efficiency**			**SOL Reduction**
	unit	n	Min	Max	Mean	Min	Max	Mean	
Suspended Sed.	mg/L	4	452.00	2109.00	993.34	80%	99%	88%	89%
TSS < 500 microns	mg/L	4	46.55	339.00	136.49	-27%	85%	27%	6%
TN	mg/L	3	0.25	1.70	0.92	-38%	71%	11%	32%
TP	mg/L	3	0.03	0.28	0.12	-17%	86%	50%	71%
Total Al	ug/L	3	1268.14	6835.23	3560.26	20%	89%	62%	69%
Total Ni	ug/L	3	4.18	20.10	10.09	36%	89%	67%	73%
Total Cu	ug/L	3	6.51	56.02	26.89	10%	67%	43%	54%
Total Zn	ug/L	3	29.43	402.24	177.84	-170%	65%	-32%	21%
Total As	ug/L	3	0.44	2.03	1.17	-14%	45%	22%	29%
Total Cd	ug/L	3	0.05	0.41	0.18	0%	83%	52%	67%
Total Sb	ug/L	3	0.29	1.91	1.27	-9%	22%	9%	10%
Total Pb	ug/L	3	4.45	45.97	20.77	15%	84%	54%	59%

Table 2: Field Trial Results

Figure 14: Sediment Removal

The figure below shows the discrete removal efficiency of each storm event. The bars in the figure represent the average discrete Event Mean Concentration (EMC) reduction. The lines represent the range of results. The removal efficiency of treatment devices can be highly variable this is often called flux. This is because there are many complex reactions which occur during mobilisation, transportation and removal mechanisms.

Further more treatment devices will typically have low removal efficiency at low concentration. This is because when contaminates are in low concentration in stormwater there is less possibility of contact between of an ion and another surface. The influent metal concentration observed was generally low often below ANZAC guidelines for ambient waters.

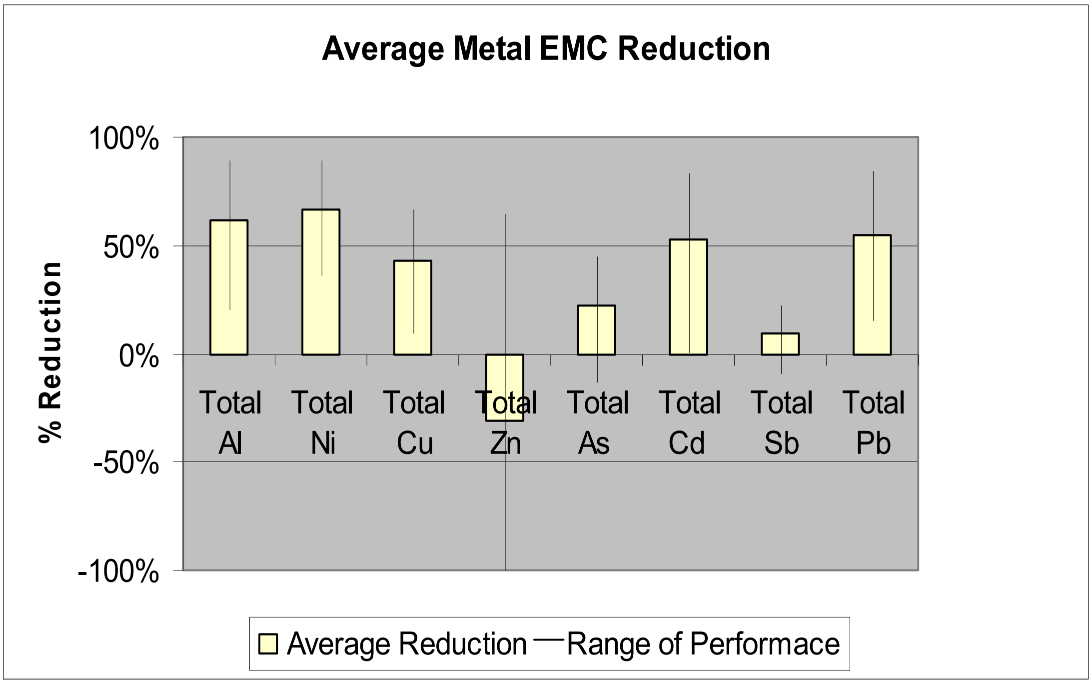


Figure 15: Average EMC Reduction

Because of the variability or flux, it is appropriate to examine the aggregate load reduction. The aggregate load reduction (or sum of loads reduction) calculated by multiplying each storms mean concentration by the flow to give a influent and effluent load. The aggregate load is the total load of contaminant exported to the receiving environment,

The figure below shows the net load reduction over the 3 events monitored to date. The results are quite different to the average EMC reduction.

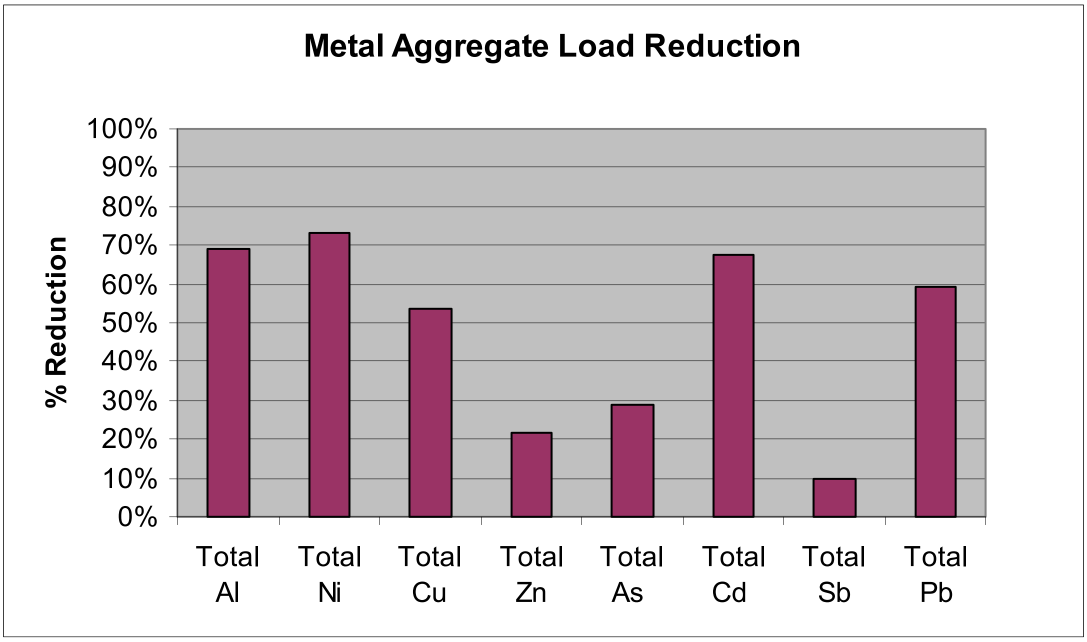


Figure 16: Aggregate Load Reductiom

Discussion

These results are only preliminary. Only 3 storms for metals and 4 storms for sediment have been analysed. Therefore no conclusions can be drawn yet, the difference between aggregate load and EMC reduction highlight the need to obtain a larger sample set. 8 to 10 more storms are needed. The difference also highlights the low removal efficiency at low influent concentration is not a concern as the bulk of contaminants will be transported in storms of high contaminant concentration

Influent concentrations encountered over the wet season were low. This observation is not surprising as frequent rainfall will prevent the build-up of contaminants on the road surface. Often influent concentrations in the wet season were below ANZAC guide lines for ambient water quality. It is anticipated that concentrations of contaminant in the road runoff will be much higher than in the less frequent storms during the dry season. It is likely that these storms will cause more environmental effect..

Considering the low concentrations and the small data set, results to date are very promising; most of the principle contaminants of concern i.e. copper lead cadmium are equal to or near the targeted 65% reduction. These results are also consistent with the laboratory testing with the exception of zinc.

The low reduction rate of zinc is surprising. It is thought there maybe some contamination issue. The SFEP is housed in a powder coated galvanised vault. Unfortunately the powder coating has failed and is flaking from the unit exposing the galvanised metal. It is believed that this is cause of the low zinc removal. A water proof liner is to be fabricated and installed to overcome this problem.

Future Work

Sampling and Residual Solid Sampling

Sampling is to continue over the dry season and into the start of the wet season. A further 8 storms are targeted. At the end of monitoring, the residual load in the device will be removed and weighed. Samples will be collected from the Enviropod and cartridge and analysed for the metal concentration. This data will be used in a mass balance comparing the influent load and effluent load with the residual in the SFEP.

Sizing Protocol

There is no regulated sizing protocol for the design of stormwater treatment devices in Northern Queensland. The correct sizing of a treatment device is essential for its environmental outcome. Correct sizing also has considerable financial implications. Typically treatment devices are size to treat 80% of the annual runoff. A hydrological analysis will be carried out to appropriately size the SFEP considering its unique location.

Comparison with Other Best Management Practices

A statistical comparison will be carried out against other best management practices such as bio filtration and swales. An analysis will consider the performance in terms of concentration as well a load reduction.

Conclusion

The SFEP treatment train is a unique and innovative approach to treating stormwater in a sensitive environment. The SFEP targets the range of contaminates in stormwater runoff from a highly trafficked road. The unique and small design of the SFEP will allow it to be installed on the proposed bridge decks, minimising environmental impact that would be associated with installing traditional BMPs in such a sensitive environment.

The SFEP uses physical and chemical mechanisms to target gross pollutants, fine sediments and heavy metals. These mechanisms mimic the process that removes these contaminants from surface water in nature,

A prototype unit has undergone laboratory and field testing on the site of the existing road, with promising results to date. The success of this project will allow an essential piece of road infrastructure to be built with minimal environmental impact from stormwater pollution.