ENVIRO australis

Technical Manual

2019

Stormwater Pollution Control

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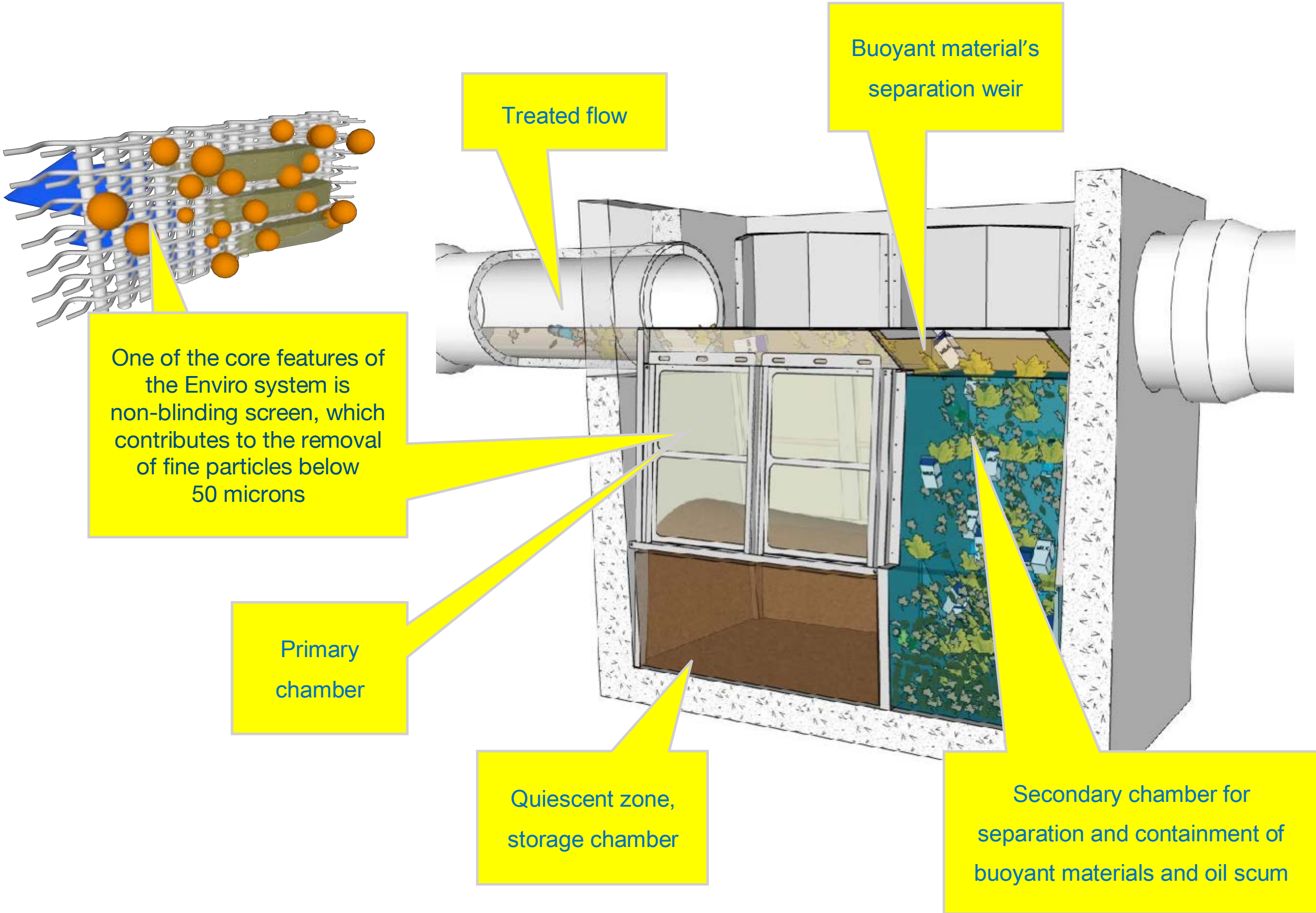
Setting New Standards in Stormwater Solutions



The Enviro E Series is proposed for Level 1 and Level 2 solutions. The E series are designed for high catchment load, which may include a broad spectrum of trash, litter, sediments and oil scum.

The defined catchment is regarded as having high catchment load as it includes residential and commercial activities, coupled with heavily trafficked roadways. The discharge will include fine toxic sediment that also includes heavy metals. These are cumulative pollutants which have already entered the Parramatta River and Sydney Harbour aquatic food chain and need to be removed from stormwater discharge.

Visit our website and use the selection guide or contact our design engineers for advice.

ENVIRO systems include:

- H series oil/water separator
- E series for high impact catchments
- G series for low impact applications

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Technical Information	08 8564 2347
Email	info@enviroaustralis.com.au
Website Enquiry	https://enviroaustralis.com.au
Urgent or After Hours	+61 419 555 514

Servicing and Maintenance

Enviro G, E and H series are designed to minimise service and maintenance costs as a result of the following features.

1. The storage chamber located below the processing chamber is designed to be easily inspected and serviced. Based on the ARQ extrapolation of $1m^3$/ann/ha from typical urban catchment, the large storage volume provides for extended service intervals. In most installations, service intervals are nominally 1 year.
2. Service is by evacuation. (Refer Fig 1). The volume of water contained in the process chamber is minimised to reduce evacuation costs. This water can be pumped out as the first stage of service, avoiding evacuation and the cost of disposal. A dry sump option is available on request.
3. All surfaces inside the Enviro series are visible from the service covers, negating the need for personnel to enter the device and perform longer term wash downs. (Refer Fig 2).
4. If required, screens can be removed manually, without entering the device. This facilitates inspection, cleaning or replacement, without additional labour or equipment. (Refer Fig 3)
5. During the construction phase, i.e. before hand over, screens can be removed allowing the device to act as a sediment trap. This enables the constructor to clean out the device and handover to the client an unused unit, eliminating disputes over device condition.

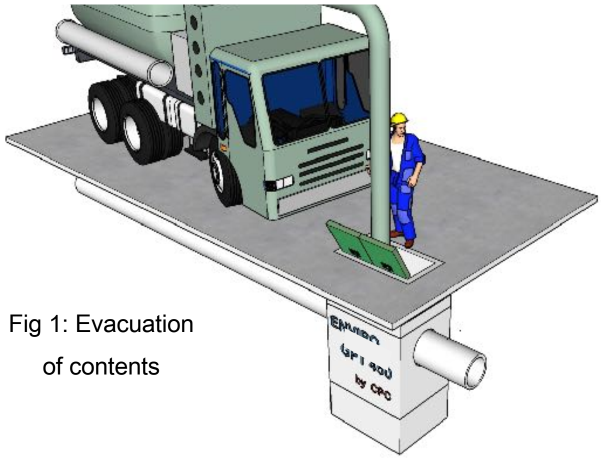


Fig 1: Evacuation of contents

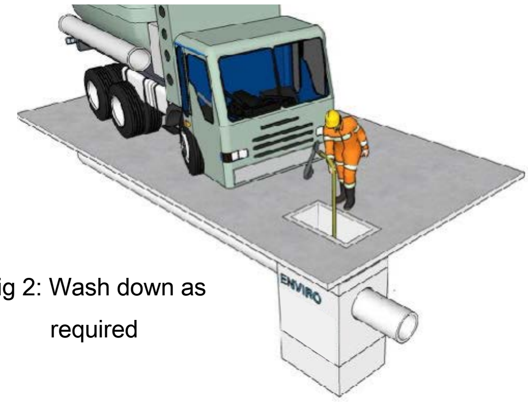


Fig 2: Wash down as required

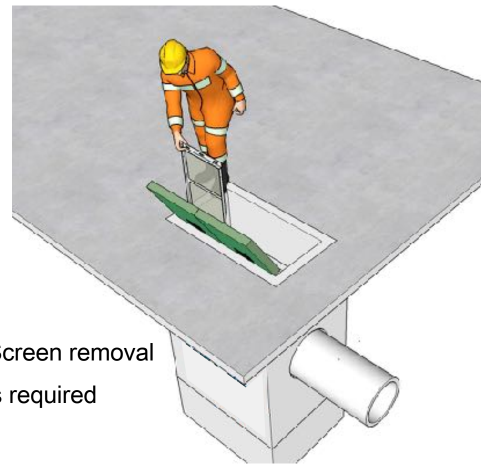


Fig 3: Screen removal as required

Design Service Life, Material Specifications and Future Upgrades

Design Service Life: 100 years

Enviro systems are designed to achieve a service life of 100 years for fixed components and 25 years for replaceable parts.

The main materials used are:

1. Precast reinforced concrete designed and manufactured in accordance with AS 3600, exposure classification table 4.3, 4(b)(i) permanently submerged in sea water.
2. Marine grade stainless steel, either 304L or 316, for the internal processing cartridge.
3. Polypropylene (PP) is used for screens, taking advantage of resistance to chemicals and fatigue. PP resists microbial attack and prevents fatigue failure from vibrate and flex under flow conditions.

Microbially Influenced Corrosion (MIC)

Stainless steel is vulnerable to MIC around heat affected zones, particularly welds.

Enviro utilises stainless steel, with no heat applied and no welding. Materials are processed by cold cutting (laser), mechanical punching and riveting. By avoiding welding and heating processes, the creation of an environment that would harbour and induce microbial attack is avoided.

Concerns with MIC date back over 30 years. In 2007, MIC was the topic of a two-day International Symposium in Perth WA when growing awareness of the nature and danger of MIC was brought to the attention of marine, mining and industrial applications of stainless steel. This conference followed a Nickel Institute 2005 paper that warned about MIC in all grades of stainless steel exposed to bacterially active waters e.g. well waters, surface waters and raw water. (NI reference book series No. 11 026, page 11).

Figure 1—Overview of pit on corroded 304L stainless steel weld

Figure 2—Closeup showing deep crevice adjacent to weld bead/base metal interface

MIC is caused by bacteria harbouring within micro cracks, where their excreta builds up and creates a localised acidic environment.

These are extracts from a publication by Susan Borenstein, August 2002.

Ms Borenstein has over 30 years of metallurgical and corrosion engineering experience for the petrochemical, utility and chemical industries.

Professional Registrations

Registered Engineer, Texas - 87474
Registered Corrosion Engineer, California - CR 1059
Registered Mechanical Engineer, Rhode Island - 6953
Registered Professional Engineer, Delaware - 11654

Austral Wright Metals

Is one of the larger suppliers of stainless steel in Australia include the abovementioned warning in their technical data.

Future Upgrades

Enviro systems can be upgraded in various ways to meet future environmental targets. These upgrades include:

- Performance monitoring
- Service alarms
- Increased performance

Figure 3—MIC-induced pitting in the weld region of a 304L stainless steel piping system.

Process and Performance Testing

Enviro Testing and Proof of Performance

The following summarises results and conclusions derived from university research and independent testing which included Ecological Consultants Australia, SESL (NATA Certified Laboratories) and Manly Hydraulics Laboratory (MHL) in Sydney (refer photo 1).

Photo 1

A full-scale model equivalent to the Enviro E45 was tested. Over 1.0 megalitre of water was processed, simulating some 38 rainfall events with varying concentrations of pollutants.

The published test results are in summary:

1. Gross pollutant removal ……100%
   Construction of the Enviro devices includes proprietary screening with apertures of 1mm or less. The entry is one-way - reverse flow is impossible - and the configuration does not allow re-suspension.
2. Sediment removal ……………86%
   Testing utilised a PSD with a bias towards fine sediment where 90% were less than 500 microns and 35% of the particles were less than 53 microns. Removal rate achieved was 81 to 86% across a range of flow rates and concentrations.
3. Nutrient removal, potentially …80%
   The fact that sediments are the major transporters of TN and TP is well established. This only varies for discharge from wetlands where release has occurred. Sydney University students researched the release rate of both N and P from catchment materials and concluded that wetted durations of greater than 10 minutes were required, to achieve significant release. These studies confirmed that early capture of particles represented a viable method of substantial nutrient export.

Enviro, in conjunction with Civilmart have established a world first testing facility, that can mimic rainfall events and provide proof of performance. (Refer photo 2 and Fig 4).

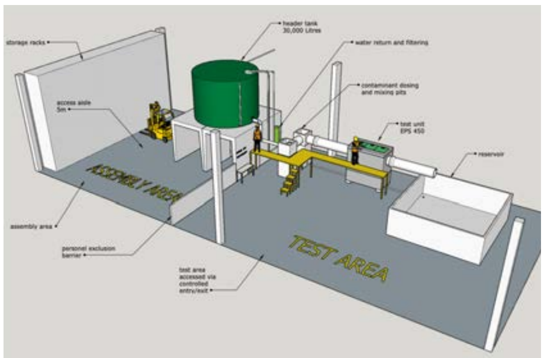
Recently, the Enviro H model was tested in accordance with EN 858-1 to confirm oil/water separation in addition to the removal of stormwater pollutants.

The tests were conducted by UniSA. These tests included continuous dosing of raw diesel oil into the influent for 20 minutes. After this duration of accumulated oil, discharge water samples were collected and tested.

The results proved that 99.95% of the oil was separated and collected. Only 4.1 ppm was detected in the out-flow samples.

Photo 2

Fig 4



Gross Pollutants – a Minor Part of the Pollutant Load

The photos included here were taken on 9 January 2019 and show the presence of gross pollutants that have bypassed any up-stream removal system.

Though removal of gross pollutants is important, this category of pollutants may represent less than 30% of the gross load discharged from a catchment.

In 2015, the Enviro Engineering Director (Leo Crasti) met with Professor Emma Johnson at the Sydney Institute of Marine Science (SIMS) to express concerns about micro-plastics and fibres. His concerns were supported by SIMS and reported on recent research that found micro pollutants were accumulating inside the gut of fish removed from Sydney Harbour (middle).

Other research also showed the presence of similar pollutants in the intestinal tract of sediment dwellers (benthic organisms) which form the base of the aquatic food pyramid.

Sediment – the Major Transporter of Toxic Chemicals and Nutrients

These photos were taken on 20 January 2019 and show the presence of limited gross pollutants, but the pond photographed is accumulating polluted sediment at a rate that could exceed 100 tonnes per annum.

Remediation, in the form of dredging will need to be carried out in the foreseeable future unless accumulation is mitigated.

Enviro can offer measures that remove sediment, reduce biological oxygen demand (BOD) and increase dissolved oxygen (DO).

Sediment and Particle Research at Sydney University

The Importance of Particle Removal

Our findings show that timely capture of fine particles is directly proportional to the retention of toxic chemicals and nutrients.

This conclusion was reached as a result of several studies in collaboration with University of Sydney students, mentored by Professor Federico Maggi. The studies included:

- Screening efficiency testing, modelling and computer analysis. (Fig 5)
- Particle column filming and creation of a 3-dimensional model. Fig 6 is a photographic image of a 40-micron particle. Fig 7 shows an animation of the particle. This research confirmed that particles are compacted micro structures and not solid. The 3D model in Fig 7 reveals a complex structure with a large surface area to volume and a high capacity to bond chemicals via electrostatic attraction, chemical and mechanical bonding.
- Field and laboratory data gathering, measuring the release rates of nutrients to solute forms.
- Field studies of wetlands and existing installations.

The research conducted supported the hypothesis, that particles exhibit an ability to retain nutrients and unwanted chemicals to a greater level than expected. This was verified by student field studies that measured the time rate of release of nutrients from accumulated bio-mass in a typical suburban catchment. These field studies were carried out in Sydney's northern suburbs.

Results confirmed that negligible release occurred for at least 30 minutes after wetting, confirming that early capture of particles, is a practical method of reducing nutrient and toxic chemical discharge in run-off water.

This research then led to a greater understanding of pollutant categories and characteristics, which led to development of the Enviro E series.

Details of this research is available on request together with an independent review by UniSA.

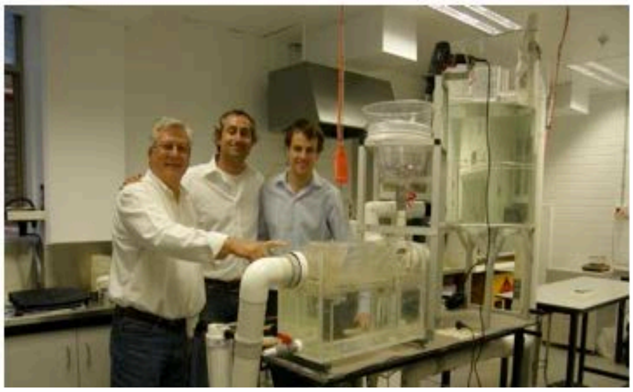


Fig 5: Laboratory modelling

AMSIIntern

An Innovative University and Industry Collaboration

The University of Sydney program supported by Leo Crasti and mentored by Dr Federico Maggi, created a laboratory simulation of rainfall and pollutant load. This led to the creation of a world first mathematics model of what is now the Enviro operating process.

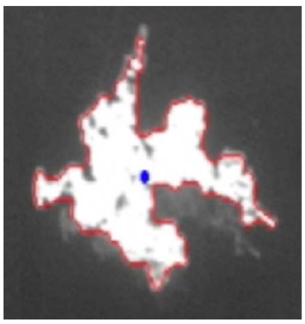


Fig 6: Photographic image of particle

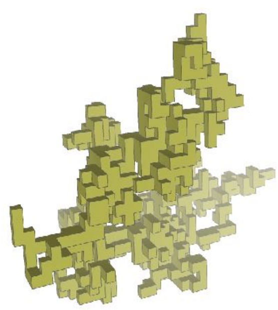


Fig 7: 40-micron particle model

Removal of Nutrients

Removal of nutrients defined as Total Phosphorous (TP) and Total Nitrogen (TN) is fundamental to improving water quality in fresh and marine ecosystems.

Environmental Protection Authorities nominate the reduction targets of:

- TN reduction 45%
- TP reduction 65%

Enviro systems are designed to comply with reduction targets by removing the major source of TN and TP; being fine particles, defined as suspended solids. It is a well-established principle that both TP and TN are primarily transported by these fine particles. Refer references:

- Email from Baden Myers, Research Fellow UniSA (below)
- Suspended solids, various articles and studies https://www.sciencedirect.com/topics/earth-and-planetary-sciences/suspended-sediment

From: **Baden Myers** Baden.Myers@unisa.edu.au
Subject: Relationship between nutrients and particles in runoff
Date: 29 June 2018 at 10:32 am
To: Leo Crasti leo.crasti@enviroaustralis.com.au

BM

Hi Leo,

As per our discussion, I can confirm that there is an understanding that stormwater particles convey phosphorous and nitrogen. Accounts vary - it is very well understood for phosphorous, but the case is not as certain for nitrogen and will be dependent on catchment characteristics.

The MUSIC manual describes the situation pretty well amongst review material which underpins how it works to simulate WSUD system treatment - see Section 7.2 of the MUSIC model user guide, attached. The understanding is strong enough such that the model developers base the removal of TN and TP on the removal of particles via the Universal Stormwater Treatment Model whenever water is in storage - there are other functions simulating water quality but the USTM is typically the main one for most treatment nodes.

Nitrogen is generally understood to be less likely to bind to particles. Broadly speaking, this is because it is assumed that nitrogen carried in stormwater is largely nitrate (NO3). The justification is that nitrogen from the atmosphere ends up as NO3. This is however being challenged. Recent literature from Queensland calls this assumption into question pretty clearly

See: https://www.sciencedirect.com/science/article/pii/S0048969717331649

(the research paper itself is attached)

Let me know if you would like more information, there is a lot floating about on the topic but these were first to come to mind! In short, phosphorous is almost certain to be particle bound but nitrogen is less certain - it would depend on the catchment characteristics, and a high or low pH has an impact on what gets bound to particles too. Recent monitoring in SA is not conclusive - we measured residential catchment runoff and found that in our unfiltered samples, total kjeldahl nitrogen (which is the sum of organic N and ammonia) was a higher proportion of the total N load. Organic N is the portion likely to be particle bound, however, we did not measure ammonia specifically, so more work required there to make a final call.

Cheers,

Baden Myers
Research Fellow
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The importance mentioned above, underpinned by a science report published in January 2015 (refer https://science.sciencemag.org) which analysed the planet's sustainability factors and identified over-nutrification having reached critical levels adjacent to many high population areas.

Enviro Engineers in developing the EPS processes referred to existing contemporary understanding and in-house research to establish a cost-effective method of removing nutrients from storm water flows and meeting the nominated reduction targets.

These reduction targets are achieved by removal of particulate matter to sizes defined as fine sediment within the Enviro multi chamber EPS. The processes included in the EPS are separation, settlement and consolidation awaiting recovery.

The following is an explanation of the development, research and principles employed as well as some reference material. Further reference material is available upon request. Alternatively, personal website research will provide more evidence.

Current accepted science is that phosphorous is mostly bonded to particles. There is little evidence that solute forms are present in stormwater discharge. Phosphorous is naturally an exotic mineral that is present in very low concentrations. Phosphorous is currently recognised as the major trigger for algal blooms and phytoplankton.

Nitrogen in its various forms, however, is readily available in the environment and there has been much concern that solute forms of nitrogen need to be removed from storm water as a priority.

Studies conducted over recent years have concluded that particle bonded nitrogen is the major form transported in storm water drains. Therefore, meeting the 45% reduction target is best achieved by removing fine particles. Refer Dissolved Organic Nitrogen https://www.sciencedirect.com/topics/earth-and-planetary-sciences/dissolved-organic-nitrogen

The eWater MUSIC model also assumes that N and P are transported by particulate matter.
Ref. MUSIC Manual Section 7.2
https://wiki.ewater.org.au/display/MD6

Further Discussion

Solute forms of nitrogen are difficult to remove as these are in the size realm of < 1 micron and more likely 0.2 microns. N O G Jorgensen has written and defined properties of N in various forms as detailed below:

> **Organic Nitrogen**
>
> N.O.G. Jørgensen, in Encyclopedia of Inland Waters, 2009
>
> Definition of Nitrogen Pools
>
> Organic nitrogen in aquatic environments consists of truly dissolved organic nitrogen (DON) and particulate organic nitrogen (PON). DON is defined as material that can pass a 0.2-μm filter, while PON is the material that is retained on the filter. This means that PON includes both dead organic matter and living organisms that are larger than 0.2 μm. The definition of DON as material being smaller than 0.2 μm is a practical, operational term rather than a biologically or chemically well-defined term. DON includes a variety of organic molecules and compounds, ranging from small molecules like urea and amino acids, to peptides and proteins, but does also include viruses and small bacteria.
>
> Another important nitrogen pool in all aquatic environments is dissolved inorganic nitrogen (DIN), which consists of ammonium, nitrate, and nitrite. Thus, the content of total dissolved nitrogen (TDN) is made up by DIN and DON.
>
> Concentrations of DON in rivers and lakes have been found to vary from 3 μM N in low-productive, oligotrophic waters to about 100 μM N in eutrophic rivers and lakes. Higher concentrations (>300 μM N) have been measured in waters receiving a high input of nitrogen such as tropical fish ponds. A large portion of DON in lakes and rivers typically originates from release by algae and phytoplankton. Since the biomass of both algae and phytoplankton varies with season and depth, DON concentrations will often show seasonal variations and will also vary with depth in lakes. Further, DON can be transported by rivers and streams into lakes and introduce large local variations in concentrations.

In nature, solute forms are readily taken up by vegetation and converted by bacteria which typically occurs in natural wetlands.

Though the application of adsorption media can reduce the level of solute forms, in practice media performance quickly declines as a result of blinding caused by the fine particles. Therefore, if adsorption media were to be used, the removal of fine sediment is a precursor.

The ARQ defines fine sediment as particles of < 62 microns. Other studies have created a definition of suspended solids as being < 500 microns. Refer Sediment and bedload discussion papers https://www.fondriest.com/environmental-measurements/parameters/hydrology/sediment-transport-deposition/

These studies point out that larger particles should be considered as bed-load and should not be taken into account as part of the totally suspended solids (TSS) reduction target which is typically 80%.

Development of Enviro Systems

Enviro has developed its systems based on a similar conclusion, being that particle removal is biased to < 500 microns. During full-scale testing at Manly Hydraulics Laboratory (MHL) the Enviro process was stress tested using sediment recovered from discharge of a sediment basin at the Blacktown Council International Sports Fields. The sediment profile was 90% below 500 microns and 35% below 53 microns. Removal rates exceeded 80%. Refer to Process and Performance Testing attached. This particle size distribution profile follows very closely the profile of particles found to be the major transporter of TN.

Prior to undertaking full-scale testing, Enviro Engineers worked closely with Sydney University to understand the particle bonding mechanism and the strength of these bonds measured in release-rate vs time.

Professor Federico Maggi has independently researched the nature of particles and constructed a method of filming microscopic particles. A 3D illustration of a 40-micron particle is shown in the previous section, Sediment and Particle Research Sydney Research. At the same time professor Maggi supervised a study of particulate matter gathered from the CBD of Sydney. Analysis of the particulate matter showed

high affinity to nutrients, heavy metals and other toxicants.

Visualisation of the particle (Refer Fig 6 and 7 previous page) grouping of sub-micro particles. This provides evidence to demonstrate that the level of particle capacity to bond with various chemical compounds is potentially far high than previously anticipated.

As the illustration shows, the particle has three levels of bonding mechanism.

1. Electrostatic attraction is high as a result of the large surface area created by aggregation of micro particles.
2. Again, driven by the large surface area is the high potential for chemical attraction.
3. Mechanical entrapment also occurs as sub-particles aggregate.

This creates understanding of why sediment beds have such a high capacity to trap and retain nutrients and toxicants.

In parallel with the particle imaging, Sydney University with assistance from Australian Mathematical Sciences Institute (AMSI) created a working model of the particle separation process and analysed the mechanism at play. A complex mathematical model was also created using known hydraulic and pore theories and compared the actual performance with the mathematical prediction.

It was demonstrated that the particle separation process was supported by known mechanisms, with the model being used as the basis for future design and is currently embedded in the modelling process used to determine Enviro system size.

Studies were conducted to determine the relationship between nutrient release into solute form vs catchment transport time. The aim was to determine whether during the relatively short time that material is wetted and transported, that nutrient would transfer from bonded to solute form.

Two studies were conducted in parallel. One focussed on phosphorous and the other focussed on nitrogen.

The results of the Nitrogen release study showed that Nitrogen remained bonded to particulate matter and concluded that the early removal of urban debris and the associated particulate matter was a means of preventing nutrification of urban waterways. (Ref Appendix 1)

The overall conclusion reached by both studies was that early capture and retention of fine particles was a reliable method of removing the majority of nutrient from storm water flows.

The final process of the Enviro system is holding of particulate matter in a quiescent state. This process utilises the entrapment observed in nature where sediment beds capture and hold nutrient and toxicants as mentioned earlier. During the MHL testing, various concentrations and flow rates were monitored while allowing captured materials to aggregate in the storage zone. This was used as a method of replicating actual (real world) conditions.

Accumulation of materials during tests that replicated 2 years of rainfall events showed no evidence of scouring, resuspension and mobilisation of captured materials. All tests were conducted using a known influent mass of pollutants while monitoring discharge water quality. At the completion of testing the collection of materials were recovered and assessed to complete the net balance of pollutant materials tested.

While developing the current Enviro multi-chamber multi-zone process reviews, analysis and prototype testing was conducted on various configurations and methods. Some of these are noted below.

Processes Considered and Rejected

Processes analysed and considered by Enviro include:

- A simple attack screen where water passes directly through a screen causing the screen to act as a sieve. As expected, the sieve principle is limited by the area and size of pores. As pores fill, the aperture reduces and

there is an accelerated tendency for the sieve to further blind.

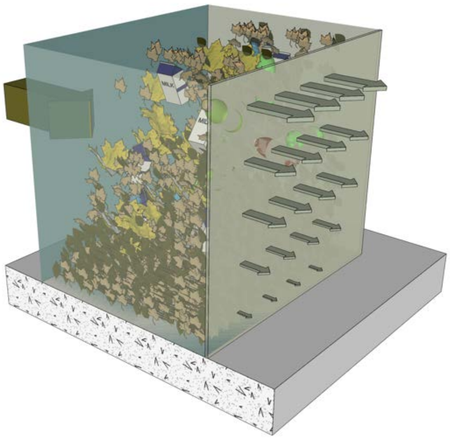


Fig 8

Fig 8 shows the principle sometimes employed with an attack screen. Though initially successful, short term blinding of the screen requires servicing immediately prior to a rainfall event. Constant churning during a rainfall event causes particulate matter to be drawn through the mesh and for organic matter to breakdown and also draw through.

- A circular screen where a cyclonic or vortex action is encouraged with materials captured on the inside of the cylinder allowing water to escape outwards. Fig 9

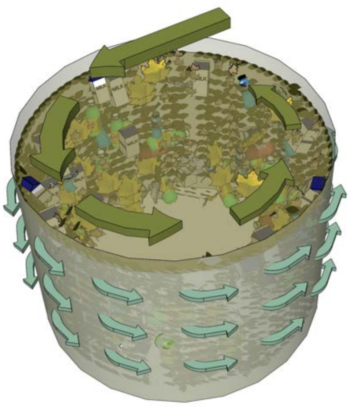


Fig 9

This process is contrary to normal centrifugal based cyclones where heavy matter is projected to the outside while clean fluid is drawn from the centre. Floatable materials contributed substantially to a grating effect causing fine sediments to pass through the screen and for organic matter particularly resident from previous rainfall events, to break down and by-pass the screen. The observation was documented by Professor Gavin Birch. Refer research article http://dx.doi.org/10.1080/15730620902807056

- Infiltration or media was also tested as a potential process in a treatment train after larger (gross pollutants) were removed. This method was discontinued as the life expectancy of media was limited and replacement caused high service costs.

The Enviro Final Design

The first separation principle discovered was that floatables needed to be separated from sediments for two reasons.

- Floatables are separated from the gross influent materials. These floatables are directed into a secondary chamber via a one-way weir preventing further breakdown and remobilisation.
- Allows sediments to be removed from the flow and retained in a separate storage sump.

The second separation principle is the screening of fine particulate matter while eliminating the tendency for screen blinding. This was achieved by Enviro after substantial hydraulic testing in both in-house testing facilities as well as university assistance. The design and construction of this remains part of intellectual property associated with EPS performance.

In summary, the process was tested and proven to reliably remove particulate matter < 20 microns without compromising screen performance. In addition to the unique design, particles are directed into a lower quiescent storage zone. Refer Fig 10

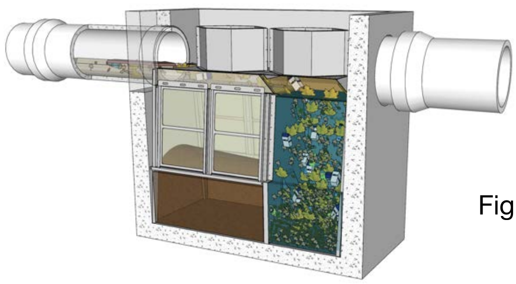


Fig 10

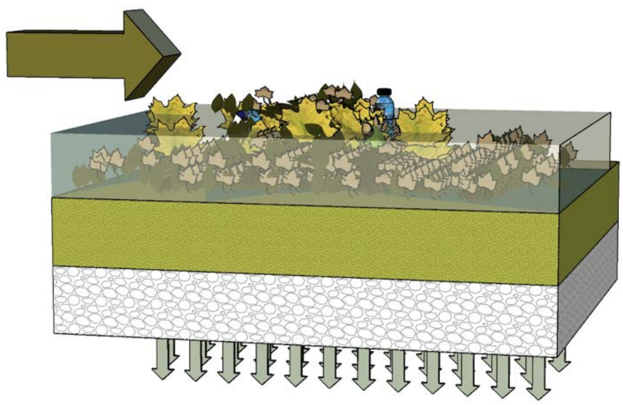
Solute forms of nutrients – removal process

Artificial or tertiary treatment methods which may be applied to removal of dissolved nutrients in particular dissolved organic nitrogen (DON), have physical limitations. DON is defined as being smaller than 0.2 microns (Ref N O G Jorgensen). It therefore follows that removal of suspended sediment is a pre curser to the implementation of DON removal media.

In simple terms, if a fine media is required that media will very quickly blind if exposed to suspended solids that are present in the influent.

The practical conclusion therefore is that removal of the prime carrier being suspended solids smaller than 500 microns is critical to both artificial methods as well as natural methods that occur in wetlands. These natural methods involve interaction between plants and bacteria where dissolved Nitrogen is a ready source of nutrient and is converted to biological material.

The illustration below demonstrates the tendency for media beds similar to those used in bio filtration to attract a layer of surface material inhibiting the infiltration process.



De-Watered Sump Alternative

Enviro Systems can be Offered with a De-Watered Sump Feature

This is important environmentally for the following reasons:

Photos 3 and 4 where taken inside 2 separate systems to demonstrate the actions of bio-digestion. The enlarged section of photo 3 shows bubbles rising to the surface generated by the decomposition of organic material in the retained water. The gas generated is similar to the anaerobic process used in waste water treatment. The output includes carbon dioxide, methane and potentially, hydrogen sulphide. Some of these gases are toxic and potentially life threatening.

Photo 3

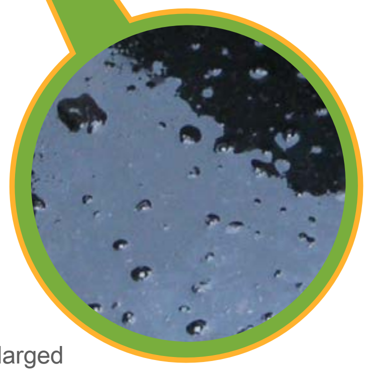


Photo 3 enlarged

Of further concern is the bacterial conversion of bonded chemicals and nutrients such as nitrogen and phosphorus into solute forms. These toxic chemicals easily enter the food chain, while over nutrification depletes available dissolved oxygen (DO).

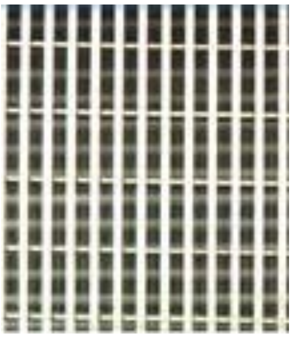
Nutrients cause spontaneous generation of algal blooms, some of which are toxic. The greater issue is that algae takes up the available DO and starves all other aquatic flora and fauna.

Often it is difficult to appreciate the importance of DO to aquatic sustainability. On Earth we live in a nitrogen atmosphere which has 20% oxygen (O_2). This is also a ready source of O_2 for the decomposition process. Transfer this into an aquatic environment, and the availability of O_2 is vastly less. DO levels vary around 10 to 15 ppm depending on temperature and other factors, therefore the conversion and breakdown of organic matter takes a long time and many exchanges of DO when compared to atmospheric exposed conversion.

Service Costs are Greatly Reduced

By eliminating the free water, service evacuation does not have to include the cost of on-site treatment if this is possible or transfer to a waste plant for final processing.

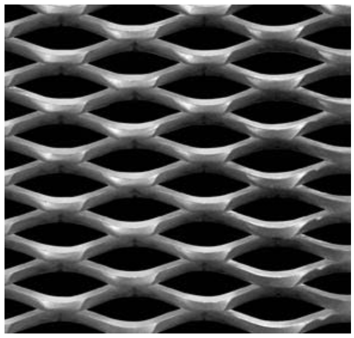
Screen Selection



1. Trapezoidal wire

2. Woven mesh

3. Punched sheet



4. Expanded mesh

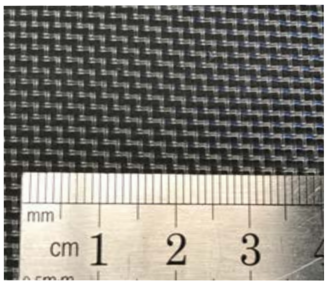
During the development of Enviro systems, substantial research and testing of screening methods and materials was conducted. All the above were analysed and discarded as unsuitable or partially suitable. Each are shown approximately at full size.

The following are summary comments only, greater detail is available upon request.

1. Trapezoidal wire often used in waste water screens is limited to aperture size.
2. Woven mesh can be used where larger apertures may be tolerated. The wire laps tend to gather fibrous materials.
3. Punched sheet is bi-directional and expensive. Flow rates are relatively slow requiring large screen surfaces.
4. Expanded mesh is limited to large apertures of 6 to 10mm. If smaller apertures are used the burred and sharp edges, together with the twisted nature of the expanding process accumulates fibrous materials.

The Enviro solution is a specially woven high strength fabric, mounted on stainless steel frames for ease of service and replacement as required. This follows common practices in many filtering applications.

The fibres are also pretreated to a smooth finish so as not to attract fibrous materials. A high resistance to bio-filming also occurs as a result of smooth surfaces.



Typical Enviro Screen

Hydraulic Process Review (1 of 2)

Enviro Hydraulic Process Review

During the development of the current Enviro multi-chamber process, various hydraulic flow control methods were trialled.

The following are some of the methods trialled. Enviro discarded most as unsuitable for broad spectrum separation and containment of pollutants.

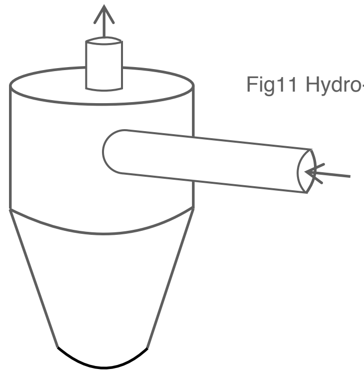
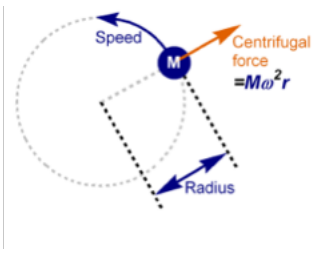


Fig11 Hydro-cyclone

Fig 12



Hydro-Cyclones

Hydro-cyclones (Fig 11) are widely used to remove sediment in pipe lines. Efficiency is directly related to flow velocity generating a centrifugal force (Fig 12), which causes materials to be thrown to the outside, while clean water flows from the centre of the vortex.

This same principal is also used in dust extractors (Fig 13). The main factors that caused Enviro to disqualify this method from serious consideration are: the variable flow velocities in a drainage system, coupled with an awkward configuration of pipe work.

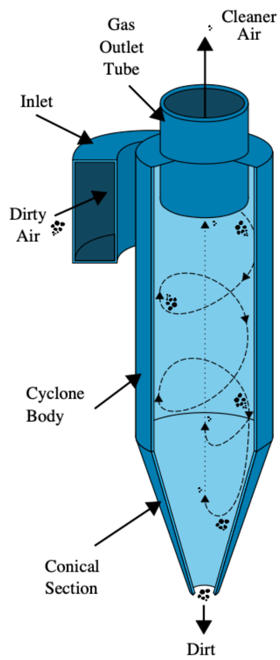


Fig 13

Inverse Vortex

Fig 14 is used by some manufacturers of stormwater devices. These systems are not true vortex/centrifuges in that retained materials are mobilised towards the screen, compromising efficiency. Other factors that limit performance are:

- The process chamber needs to be off-line, requiring a diversion weir which is subject to the hydraulic jump phenomena as water flow rates increase to 1m/sec.
- Hydraulic impedance is high, as water flow direction needs to be reversed to rejoin the main pipe conduit.
- Trickle and low flows tend to pass through the screen until sufficient flow velocity generates a vortex.

The illustration (Fig 15) shows the outcome of tests where the materials tended to orbit the chamber, either impeding flow as velocity increased or fragmenting to smaller sizes and bypassing.

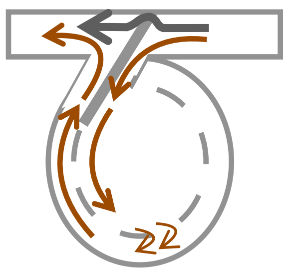


Fig 14 Inverse vortex

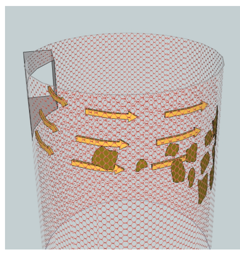


Fig 15 Illustration

Hydraulic Process Review (2 of 2)

Screened Chamber (Fig 16) shows a chamber where the flow is caused to divert vertically under a weir and pass through an attack screen. Though claims of some oil retention are possible, the main function of gross pollutant and sediment capture was limited by:

1. The weir could not cause buoyant materials to submerge. Floatables accumulated and were eventually drawn through as the volume allowed for floatables was relatively small.
2. Some heavy sediments were captured and settled; however lighter sediments were not captured ad some were retained by the screen openings. As the screen is in an attack orientation, a dramatic loss in screen-through volume compromised performance and caused pre-mature by-pass.
3. Scouring was also found to occur, with subsequent flows as materials in the sump broke down and became suspended by gaseous discharge.

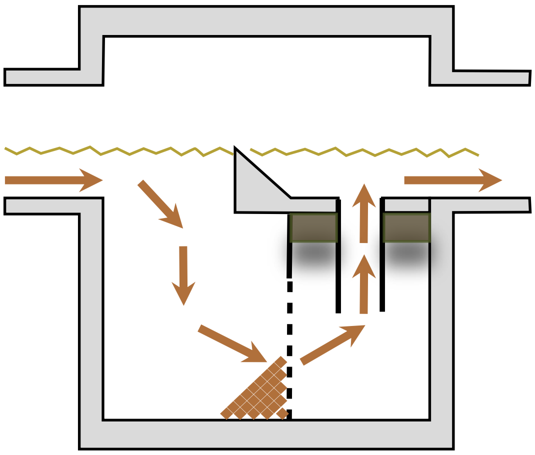


Fig 16 Illustration

The use of this principle required introduction of a primary floatable chamber or pit inserts and an extended chamber size to create extended settlement periods.
Quiescent Chamber (Fig 74) coupled with a skimming weir is the principle used in oil separators and grease arrestors. The principle was also tested for sediment and gross pollutant retention. Conclusions:

- Suitable for low flow rates and velocities only. Excessive volume and velocity create turbulence and re-suspension.
- Sediment removal occurs via settlement, which is particle size and time related. Medium to fine particles may take 1 to 2 hours to settle. This is impractical as it requires a large chamber to hold the entire catchment run-off volume to be stored for the settlement period.

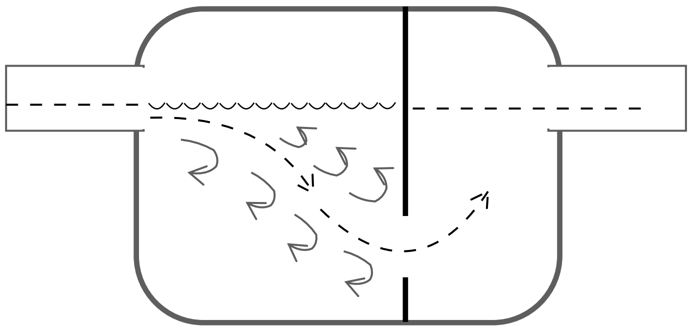


Fig 17 Quiescent Chamber

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ENVIRO systems include:

- H series oil/water separator
- E series for high impact catchments
- G series for low impact applications

Appendices

Adsorption of Nutrients to Particles in Urban Stormwater Systems (separate document)	Nicola Hayes under supervision of Federico Maggi
Enviro Process Testing (separate document)	Leo Crasti, Director BE (Mech)