Stormwater Pollution in Sullivans Cove, Hobart: An Unwanted By-product of Development

J. A. Chrispijn*

*Hobart City Council, 16 Elizabeth Street, GPO Box 503, Hobart, Australia 7001
(Email: chrispijnj@mailnet.hcc.tas.gov.au)

Abstract
At-source pollutant traps are a new control measure to treat polluted stormwater. These traps have been installed and tested overseas and by some Australian Councils but not in Hobart or elsewhere in Tasmania. To determine if at-source stormwater pollutant traps were effective for Hobart conditions a trial was performed to evaluate their performance in treating Sullivans Cove, an urban and highly polluted site within Hobart. Three different at-source stormwater pollutant traps were sourced and a small number of traps from each type were installed in comparable locations in and around Sullivans Cove. Their retention of polluted materials, including litter/gross pollutants, sediment, vegetation and heavy metals was monitored over a fixed period. After six months and twenty-two days a total of 2.25 tonnes (wet weight) of polluted material was captured in the 63 traps in Sullivans Cove. Retention of polluted materials varied amongst the three different types of at-source stormwater pollutant traps, their comparative performance is discussed. Based on the results of the Sullivans Cove Trial there will be another 115 at-source stormwater pollutant traps installed throughout Sullivans Cove by July 2004 and this stormwater treatment method has now been installed in other catchments within the Hobart City Council Municipality.

Keywords
At-source stormwater pollutant traps; gross pollutant traps; litter/gross pollutants; stormwater pollution;

INTRODUCTION

Located in Hobart, Tasmania, Sullivans Cove has transformed from a historical port into a major commercial and entertainment center for the Greater Hobart region. High numbers of pedestrians walk along Sullivans Cove, visiting the cafes, restaurants, retail outlets, art galleries and markets located in the area, which includes the famous Salamanca Place. The weekly Salamanca Markets, held every Saturday, attracted over 1.3 million tourists and locals in 2000/2001. In addition, January and February sees high pedestrian movement in the area with the Hobart Summer Festival attracting 600,000 visitors in 2000/2001 (Hobart City Council, 2001). This includes the finish of the Sydney to Hobart Yacht Race and the Taste of Tasmania. Sullivans Cove also receives a high traffic load from the adjoining Davey Street and Sandy Bay Road, which have average daily totals (ADTs) of +22,000 vehicles (A Trojan 2002, pers. comm., 25 July).

Commercial use, high visitor numbers and high vehicle movements have resulted in stormwater pollution in the area, and it has associated odour and vermin problems. Unsightly pollution in the area discharging into the bay creates a poor public image for residents and visitors alike. Major stormwater pollutants found in Sullivans Cove include:

- Sediment: - both mineral and organic from road development, pavement wear and particulates from vehicle emissions;
- Vegetation: - organic material such as leaves and grass clippings;
- Litter/Gross Pollutants: - human derived material such as cigarette butts, plastics, cans, bottles and other discarded rubbish;
- Heavy Metals: - derived from vehicle emissions, i.e. zinc from tyre wear and motor oil, lead from petrol exhaust, and copper from break lining wear.

Media coverage of litter and odour complaints in Sullivans Cove in January 2000 facilitated the *Hobart Docks and Salamanca Stormwater Improvement Project*. This project, initiated by the Hobart City Council and funded in part through Coast & Clean Seas, aimed to minimise pollution

and improve water quality of the Sullivans Cove stormwater system.

Sullivans Cove Catchment

The 80-hectare Sullivans Cove catchment is built on reclaimed land with the majority of the stormwater system being tidally influenced. The catchment's 310 stormwater pits are connected to numerous stormwater branches that all discharge directly into the Derwent River. Without a central discharge point there are multiple stormwater outfalls. These are inaccessible, either tidally submerged or built over by foreshore development.

The local topography has required the majority of the stormwater system to be laid on steep grades, with the exception of pipes along Salamanca Place, which are relatively flat. The steep grade of the streets in the study area adds to the mobilisation and transportation of sediments. The stormwater pits in the catchment are typically sump-less and self-flushing, providing little retention time for pollutants to settle out so they can be removed by induction and therefore provide no stormwater quality benefits. The majority of private properties discharge stormwater to the kerb (Ingal Environmental Services, 2002).

Treating Stormwater Pollution

To treat the pollution in Sullivans Cove a Gross Pollutant Trap (GPT) was originally proposed to be installed on the outlet of one of the major stormwater branches in the project area (Andrews, 1998). However, Sullivans Cove was considered an impractical site for a GPT because of a number of site constraints. This included the many stormwater branches that each services a small catchment and stormwater outfalls that are tidally submerged or built over. Additionally, it was noted that other Councils in the Greater Hobart Area have found GPTs an expensive treatment option. Large GPTs have high installation costs (some requiring additional modifications from the proprietary design to operate in tidal environments) and high maintenance costs, incurred for litter removal (i.e. associated labour, hire of specialised lifting equipment and trucks). For example Glenorchy City Council spent ~$15,000/year spent to clean a GPT at Prince of Wales Bay (Green, 2003).

The site constraints found in the Sullivans Cove Stormwater Catchment make it unsuitable for many of the proprietary stormwater treatment systems available. An alternative option that was considered was at-source stormwater pollutant traps. These devices consist of a basket/ filter bag insert that is installed into the individual drainage entrance (State Pollution Control Commission, 1989). There are a total of 310 stormwater pits in Sullivans Cove and if fitted to all these drainage entrances, at-source pollutant traps (ASPT) could collectively provide treatment for the entire catchment. This would overcome the site constraints of having a diffuse, non-centralised stormwater drainage network.

There is currently a large range of ASPTs available in Australia. They are all designed to treat litter/gross pollutants, sediment and vegetation to varying degrees, however certain traps are promoted as having high capture rates for other stormwater pollutants including fine sediment (i.e. generally <0.1mm material retained), suspended solids, nutrients, heavy metals, oil and grease. Fine sediments and suspended solids provide an available surface for these other pollutants to bind to. The proportion and type of stormwater pollution captured in an ASPT will be dependent on surrounding land uses. For example, along a main road we would expect a high proportion of fine sediment and suspended solids to be captured in an ASPT, as well as an increased loading of heavy metals, grease and oils. Similarly, outside parks and nature reserves we would expect organic matter and nutrients to be the pollutants targeted by the traps.

All these traps have been installed and tested overseas and interstate but not in Hobart or elsewhere in Tasmania. In Hobart, different site conditions are operating which may affect the performance of the traps. Rainfall in Hobart is consistent throughout the year with little seasonal variation, on average 40 to 60mm of rainfall per month. In addition, rainfall intensity and duration in Hobart are not as high as other Australian Cities (Institution of Engineers, Australia, 2001). While having a

high attendance in the summer (January- February), the small population of the Hobart City Council (47,600 residents) would see low to moderate pedestrian densities in Sullivans Cove throughout the rest of the year compared with other larger Australian Cities where traps have been previously installed. The amount of litter generated by pedestrians therefore needed to be quantified to warrant the need for traps within the Sullivans Cove Stormwater System.

The factors listed above led to the conclusion that to select the best type of ASPT for the Sullivans Cove area would require a trial of certain traps on the market. The trial involved purchasing a small number of different traps (between 11-32 units of each type from three or four proprietary businesses) and installing them in comparable locations in and around Sullivans Cove. Their retention performance for pollutants was monitored for litter/gross pollutants, sediment, heavy metals and vegetation over a fixed period.

A thorough literature review of ASPTs was conducted using an on-line serial and Internet search engines. Traps from two private companies were selected: Enviropod NZ Ltd and Ecosol Pty Ltd, as well as a side-entry pit trap designed by the Hobart City Council in 1998. All the different traps were selected based on laboratory and/or field trials and the manufacturer's claims to efficiently remove one or more target pollutants (Andrews, 1998) (Argue *et al*, 1996) (White *et al*, 2002).

The two private companies and the Hobart City Council's Workforce were contacted to provide a quotation for supply and installation of the traps. A total of 63 ASPTs were purchased and installed for the Sullivans Cove trial, at a total cost of $40,608. A brief description of the different trap characteristics follows:

- Enviropod Filter is a gully pit insert, which comprises the following components: - a supporting framework, an overflow system and a cleanable 200-micron filter bag. For the trial, 20 units were installed;
- Ecosol RSF 100 At-Source Pollutant Filter comprise high-grade aluminium support frames, removable 3mm filtration liner and overflow mechanisms with spring components. 11 units were installed for the trial;
- Side Entry Pit Traps (SEPTs) designed by Hobart City Council's Workforce these traps are one-piece stainless steel baskets and support brackets that fit in the top of the stormwater pit, mesh size is approximately 33mm. 32 units were installed for the trial.

METHODS

The trial was conducted over six months and twenty-two days from 15 January – 6 August 2002. Reflecting the seasonal (summer-autumn-winter) variations of pollutants captured by the different traps, SEPTs, Enviropods and Ecosols were cleaned monthly. All 63 traps were cleaned on the same day to ensure that there was no build up of litter between cleanings.

Each of the 63 traps was numbered for identification. The monthly load captured from each trap was manually removed and emptied into a plastic bag with a corresponding identification number. Each bag was weighed for gross wet weight (includes vegetation, sediment and litter/gross pollutants). The gross wet weight of each bag was recorded and grouped according to the different type of trap for each month. The gross wet weight denotes how much polluted material (by weight) is captured by the different traps.

To determine retention for specific pollutants targeted by the different traps, each bag of polluted material was manually separated into two major categories: - litter and sediment/vegetation. Both fractions were weighed and the weights for each recorded to its corresponding bag then grouped according to the different type of trap for each month.

Capture loads for selected heavy metals including copper; lead and zinc were assessed for the different traps. During cleanouts between 2 May and 6 August 2003, representative sediment

samples were collected and tested at a NATA accredited laboratory for heavy metals, including lead, copper and zinc. All 20 Enviropods installed were tested for metals, while a subset of SEPTs (10 traps) and Ecosols (3 traps) were tested (it was considered that many of these traps were installed in areas where there would be low levels for heavy metals such as pedestrian areas).

RESULTS AND DISCUSSION

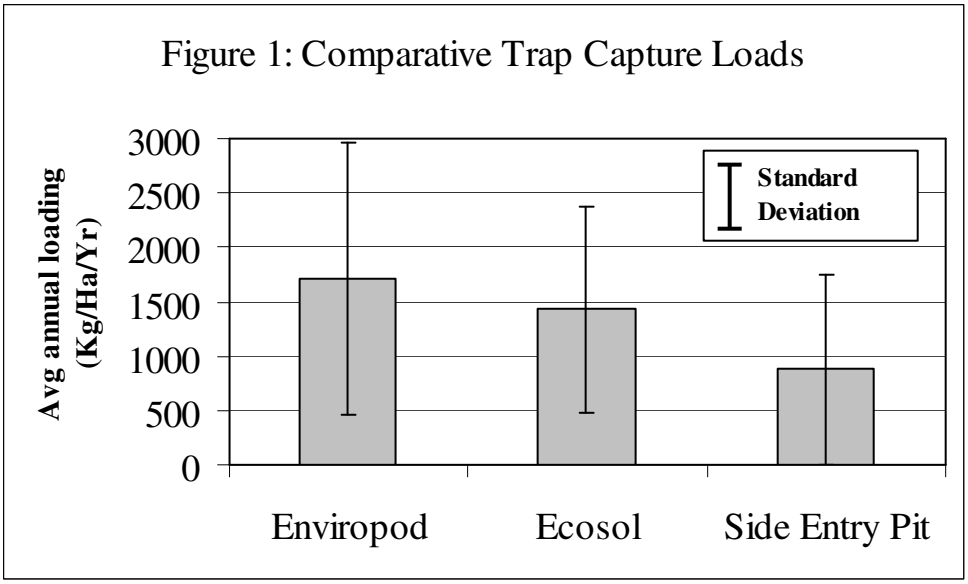
After six months and twenty-two days a total of 2.25 tonnes (wet weight) of material was captured in the 63 traps in Sullivans Cove. This equates to an annual load of 4 tonnes of material captured. Retained loads for the different traps over the 5 monitoring periods are listed in Table 1.

Table 1 Retained Loads for the Different Traps During Cleanouts

	16 Jan - 26 Mar W.W. (kg)	27 Mar - 1 May W.W. (kg)	2 May - 29 May W.W. (kg)	30 May - 2 Jul W.W. (kg)	3 Jul - 6 Aug W.W. (kg)	Total W.W. (kg)
Ecosol	108	34	25	113	38	318
Enviropod	362	94	147	340	167	1110
SEPT	302	114	81	225	96	818

Capture Loads

To determine which type trap had the highest retention of polluted material on average, mean annual loading rates, or capture loads need to be calculated. Capture loads are typically expressed as mean Kg/ha/Year. Figure 1 below shows the comparative trap capture loads for the Sullivans Cove Trial.



Both Enviropods and Ecosols had significantly higher capture loads, (1711 kg/ha/yr and 1427 kg/ha/yr respectively) compared to SEPTs, with 878 kg/ha/yr. The results were extremely variable, reflecting the seasonal variations in the data and outliers such as different land uses, illegal discharges and pollutant hotspots. Capture loads need to be calculated to take into account these differences within the catchment.

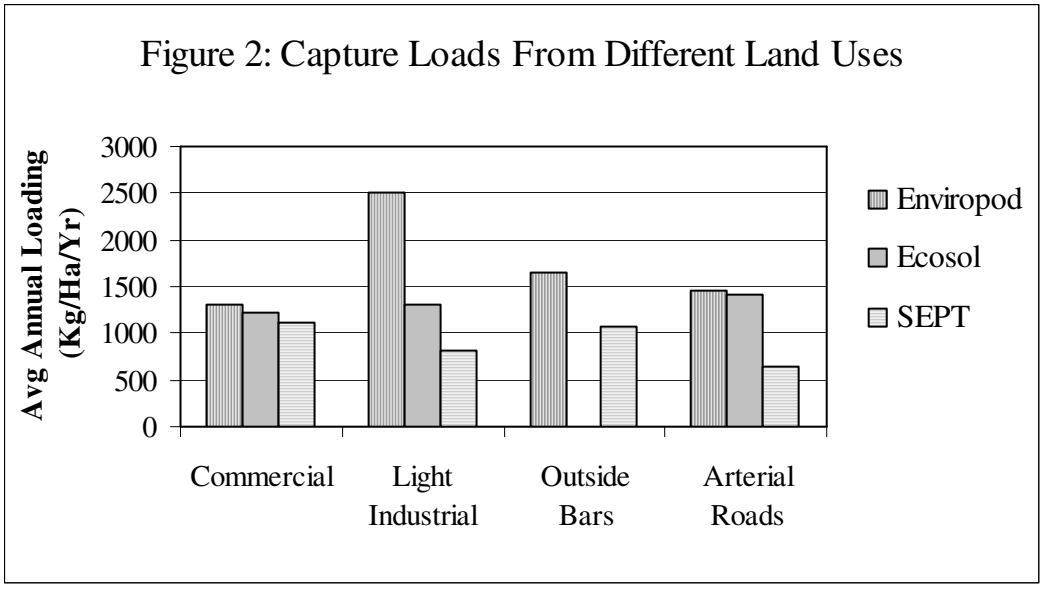
Land Use

The Sullivans Cove Area has a number of different land use activities, each of which can significantly influence capture loads. The catchment was divided into the following four classifications based on land use activities:

- Commercial: - mixed retail centre, includes Salamanca Place;
- Light Industrial Areas: - industrial areas service stations/ heavily trafficked areas;
- Outside Bars: - directly outside pubs or bars;

- Arterial Roads: - on the outskirts of the catchment.

Figure 2 compares capture loads for each type of trap in the different land use areas.



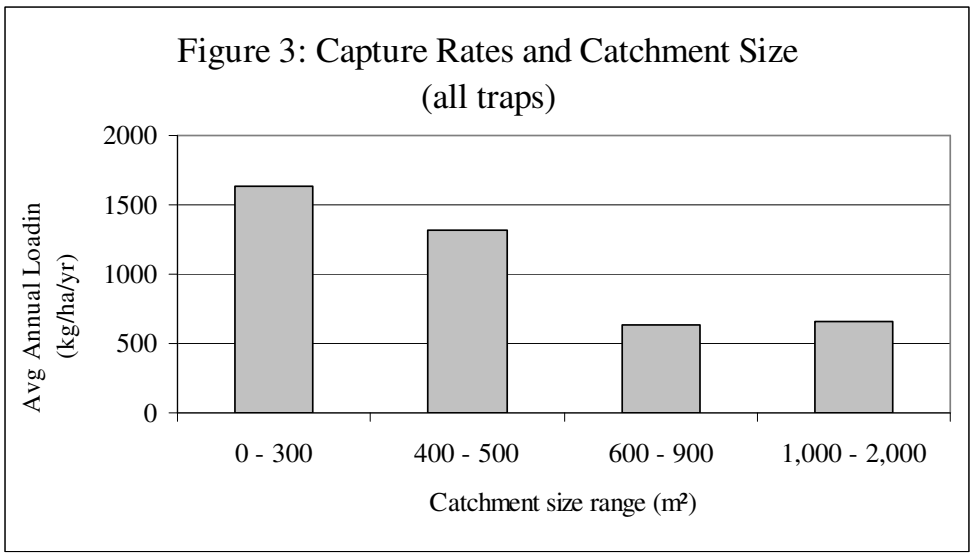
Enviropods and Ecosols collected higher capture loads for all land use types than the SEPTs. Capture loads were comparable for all three types of traps in Commercial Areas, including Salamanca Place. Enviropods and Ecosols captured less material in this area reflecting that stormwater pollution in Salamanca Place was not as significant as in other areas of the catchment.

The highest capture loads were recorded for Enviropods in the Light Industrial Areas and Outside Bars. This was expected, especially for traps located outside service stations and heavily trafficked areas. The source of the high capture loads outside bars is most likely due to the common practice for these businesses to hose down outside seating areas as a cleaning procedure. Litter and sediment from this activity invariably ends up in stormwater pits. Ecosols had high capture loads in Light Industrial Areas and Arterial Roads. Due to the limited number of Ecosols (11 units), none of these traps were installed outside bars.

Catchment Area

Each trap captured a portion of the Sullivans Cove Stormwater System. The catchment area serviced by each type trap was determined from onsite measurements so that capture loads could be calculated. Figure 3 below compares collective capture loads for all traps against the catchment size treated.

Typically smaller catchment areas of 0 - 300 m^2 had a higher capture loads for all the different types of traps, while larger catchment areas, of 600 – 2000 m^2 had a significantly reduced capture loads for all traps (in comparison 39% lower). These results suggest that in larger catchments, incoming flow is higher resulting in bypass of traps and/or remobilisation of their captured loads. It appears that to have the best capture performance, regardless of what type of trap is used, requires a high-density installation throughout the catchment.

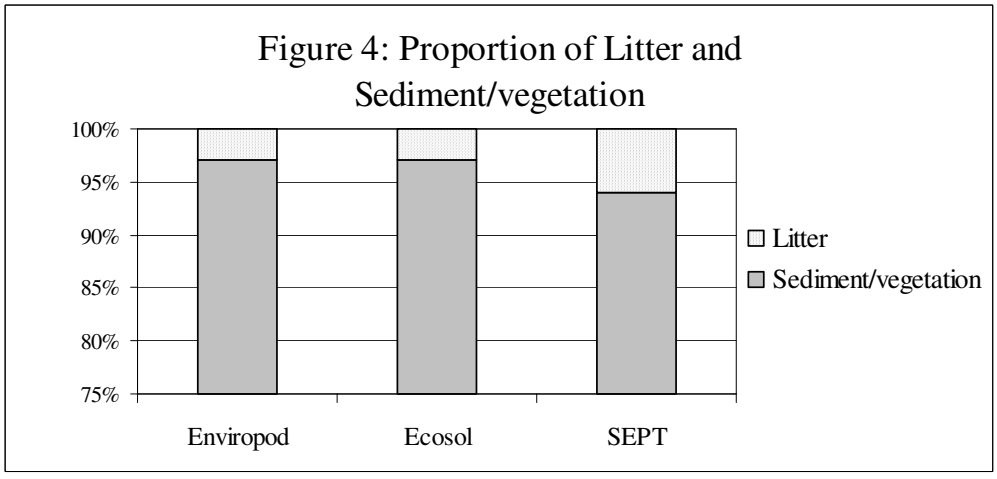


Proportion of Litter and Sediment/Vegetation

Sediment/vegetation represented 96% or 2.16 tonnes (wet mass) of all material collectively retained by the 63 traps in Sullivans Cove. Only 4% or 98 kg (wet mass) of litter was collected from all the traps in the trial.

Litter load (by weight) was lower than other at-source pollutant trials in Australia. For example in Kings Cross, South Sydney, litter (by weight) represented of the 27.8% total captured load (Ingal Environmental Services, 2002). The Great Lakes Council Trial in New South Wales, litter (by weight) represented 24.2%, of all material retained (Great Lakes Council, 2002).

The small proportion of litter captured relative to sediment/vegetation may be due to lower pedestrian densities in Sullivans Cove compared to those found in other Australian trial sites such as Sydney's Kings Cross. The results can also be attributed to the large number of deciduous trees within the Sullivans catchment. Often windy conditions help spread this organic loading to most parts of the catchment.



The proportion of litter to sediment/vegetation (by weight) varied between the SEPTs and the two other types of traps. Figure 4 above shows the percentage of litter and sediment/vegetation retained for each of the different types of traps.

Enviropods and Ecosols had the same ratio of litter to sediment/vegetation (3% litter to 97% sediment/vegetation), while SEPTs had collectively had a ratio of 7% litter to 93% sediment/vegetation. The higher litter retention levels by SEPTs were a function of the trap's

design. The mesh size of the SEPTs was coarse, approximately 33 mm, allowing the bypass of finer sediment/vegetation, especially fine sand and leaves.

Heavy Metals

Capture loads for lead, copper and zinc were calculated. The results for heavy metals from the different traps were applied to the various land uses in an effort to identify sources for these pollutants. Tables 2 - 4 show capture loads for heavy metals retained in the different traps and applied to the different land use categories.

Table 2 Copper Capture Loads Cu kg/ha/yr for Different Land Uses in the Catchment

Land Use	Enviropod	Ecosol	SEPT
Commercial	0.07	0.03	0.09
Light Industrial	0.16	-	0.31
Outside Pubs	0.21	-	0.30

Table 3 Lead Capture Loads Pb kg/ha/yr for Different Land Uses in the Catchment

Land Use	Enviropod	Ecosol	SEPT
Commercial	0.13	0.03	0.11
Light Industrial	0.28	-	0.33
Outside Bars	0.26	-	0.15

Table 4 Zinc Capture Loads Zn kg/ha/yr for Different Land Uses in the Catchment

Land Use	Enviropod	Ecosol	SEPT
Commercial	0.63	0.13	0.56
Light Industrial	1.19	-	1.17
Outside Bars	1.72	-	0.94

On average there were higher capture loads for heavy metals in Industrial Areas and Outside Bars, irrespective of what type of trap was installed. SEPTs had better capture loads for copper in all areas compared to Enviropods and Ecosols. The SEPTs tested for copper were all near parks and had a high retention of sediment/vegetation and this may have influenced results. Research has indicated that tree leaves have the ability to remove dissolved metals from stormwater passing through them. The fine heavy metal particulates are retained within the organic matter (Ingal Environmental Services, 2002).

For Industrial Areas the congregation of service stations and high vehicle movements (Davey Street and Sandy Bay Road, have ADTs of +22,000 vehicles) would produce elevated levels of heavy metals through normal vehicle wear and repair work (A Trojan 2002, pers. comm., 25 July). Likewise the predominance of taxi and vehicle parking Outside Bars in Sullivans Cove were potential sources for heavy metals in this land use area.

In comparison, the lowest capture loads for heavy metals were in Salamanca Place, a commercial retail area, where there were lower vehicle ADTs on surrounding roads and high pedestrian traffic compared to other land uses in the Catchment.

Overall, heavy metal capture loads in Sullivans Cove were comparable to levels recorded in larger Australian Cities (Ingal Environmental Services, 2002). This is surprising considering the small amount of vehicles registered in Hobart. There could be a link between the age of vehicles and the high level of heavy metal contaminants. Of the 44,082 vehicles registered in the Hobart City Council Municipality the average age is 10 years old (A Trojan 2002, pers. comm., 25 July). Vehicles generate fine particulates loaded with heavy metals through engine, brake, clutch and tyre wear. Older vehicles would generate higher amounts of heavy metals through wear compared with newer vehicles.

CONCLUSIONS

In nearly 7 months from only a small number of stormwater pits fitted with ASPTs 2.25 tonnes of polluted material was prevented from discharging into Sullivans Cove. ASPTs are an effective stormwater treatment approach for Hobart, with the Sullivans Cove Trial having comparably high results as those trials conducted overseas and by other Australian Councils (Ingal Environmental Services, 2002).

Retention of polluted materials varied amongst the three different types of ASPTs. Enviropods and Ecosols had superior treatment performance compared to SEPTs with significantly higher total capture loads, and capture loads obtained from different catchment sizes and different land uses. This can be attributed to design differences in the three ASPTs. Enviropods and Ecosols have fine mesh filter bags that are 200 micron and 3mm respectively, providing high capture efficiencies for fine sediment (40 - 60% of material <0.1mm captured) (Argue *et al*., 1996). The SEPTs one-piece stainless steel basket has coarse perforations, approximately 33 mm, allowing the bypass of fine sediment and organic material. Also the Enviropod and Ecosol filter bags have a higher storage capacity, on average 0.16 m^3 in comparison to SEPT basket that is approximately 0.045 m^3. The SEPTs smaller storage capacity would also result in remobilisation of their captured loads more frequently than Enviropods and Ecosols.

Based on the results of the Sullivans Cove Trial another 65 Enviropods and 5 Ecosols were installed in the catchment in January 2003, they are estimated at removing 7 tonnes of polluted material annually. A further 45 Enviropods will be installed in Sullivans Cove by December 2003. The 32 SEPTs from the trial will be removed and replaced with Enviropods and Ecosols. In total there will be 178 ASPTs installed throughout Sullivans Cove by July 2004 and ASPTs have been installed in other catchments within the Hobart City Council Municipality.

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