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1. INTRODUCTION

1.1 Background

Whitman's Pond is a publicly owned water body located entirely within the Town of Weymouth, Massachusetts. It covers an area of approximately 205 acres in a residential part of the town and is considered a significant resource. The pond is listed as a Class "B" water body and consists of a large main basin and two shallow sub-basins. The southern sub-basin, called South Cove, supplements the drinking water reservoir for the Town of Weymouth. As necessary, water is treated and pumped over to Great Pond which is the Town' s main reservoir. The main basin is classified as an emergency water supply.

The pond provides a wide range of recreational activities. The shoreline of the pond is mostly residential. There are four public access points, public parking and a public beach on Lake Street. A gravel boat ramp is available for small boats on Middle Street. Fishing and bird watching are also activities supported by the pond, as is ice-skating, ice fishing, and ice boating in the winter.

Over the last several years the pond has grown eutrophic and the depth of silt on the bottom has increased. The beach has been closed during the past few summers due to high coliform bacteria counts, and "swimmer's itch," a parasite that now persists in the pond. Aquatic weeds choke some areas of the pond, and anoxic conditions exist at the lower depths. Overall, the water quality has been significantly degraded over several years.

A diagnostic study was conducted by Metcalf and Eddy during April 1980-March 1981 to determine the major contributing factors to the eutrophication and silting. The study concluded that urban stormwater runoff provided a large percentage of excess nutrient and sediment contribution.

1.2 DEM Lakes and Ponds Grant

The South Cove of Whitman's Pond is used as a drinking water supply for the town and is therefore the most sensitive portion of the waterbody. In the spring of 1996 Ambient Engineering prepared a Stormwater Management Plan for the South Cove. The plan identified two outfalls on the South Cove where the influence of stormwater treatment would be most effective, and recommended catch basin inserts be installed. The inserts are designed to trap oil and grease, and sediments which contain a significant portion of nitrogen and phosphorous.

The Town of Weymouth applied for a 1997 DEM Lakes and Ponds Grant to implement the recommendations of the South Cove Stormwater Management Plan. The Grant was awarded, but because the South Cove is a drinking water supply, the Town was barred from using the grant money in that portion of Whitman's Pond. The grant money was earmarked for recreational water bodies and drinking water reservoirs were excluded.

Ambient Engineering then conducted a survey of stormwater outfalls into the remaining portions of Whitman's Pond to evaluate the relative contributions of sediment and nutrients entering from each. The results of the survey identified thirteen catch basins where inserts would be placed. Four inserts were placed in storm drains on Lake Street in the vicinity of the Lake Street Beach; five were placed along Middle Street along the lakeshore; and four were placed in the Department of Public Works yard and police station parking lot where sand and oils were known to accumulate.

The Lakes and Ponds grant proposal was for funds to purchase, install, monitor and evaluate the recommended stormwater treatment devices. After installation, Ambient Engineering conducted an evaluation to rate the effectiveness of the inserts. The results of this evaluation are presented in two sections:

- An evaluation of the stormwater catchbasin inserts performance
- An evaluation of the inserts' overall effectiveness with respect to the Town's resources.

There are approximately 45 direct stormwater discharges to Whitman's Pond. Knowledge gained from this evaluation may be used designing future stormwater mitigation for the pond. The information gained from this study, independent of manufacturer's claims, can be utilized by other municipalities in Massachusetts grappling with similar problem lakes.

2. STORMWATER CATCHBASIN INSERTS

2.1 Selection of Treatment Devices

To select the stormwater treatment device best suited to Whitman's Pond several factors, including cost, function and ease of installation and operation were considered. The stormwater treatment device recommended would need to address excess nutrients and sediment which were identified as factors in lake eutrophication. An average of 60% of the total phosphorous present in stormwater runoff has been found to adsorb to sediment particles. Therefore addressing sediment also addresses a significant portion of the nutrient loading.

The two approaches considered by Ambient Engineering in the Stormwater Management Plan were "end-of-pipe" systems and "catch basin inserts". End-of-pipe systems are large inground devices where stormwater, collected form all catchbasins in the sub-watershed, are

treated immediately before discharge into the waterbody. Catch basin inserts treat stormwater as the water enters the system from the street before it enters the collection system.

Funding available from the Town of Weymouth was not sufficient to purchase and install a large end-of-pipe treatment device. The cost of individual catch basin inserts however, is much less. Several types of catchbasin inserts were therefore considered on the basis of strength, durability, ease of use, and contaminant removal ability.

The recommended insert is called the Grate Inlet Skimmer and is manufactured to order by Suntree Isles Inc. of Cape Canaveral Florida. These units are sturdy, light, and collect petroleum runoff using an oil boom. Compared to other inserts, they trap a large volume of sediment. As with all such devises, periodic cleaning is required according to the rate of sediment deposition. The maintenance requirement was low, and the insert was designed to allow stormwater to bypass the filters if the basin was filled. A schematic diagram of the Grate Box Skimmer is provided in Figure 3.

The inserts could be custom designed to fit catchbasins with irregular openings and protruding pipes. After selecting the 13 catchbasins which would receive inserts, the dimensions were sent to Suntree Isles to construct inserts for each.

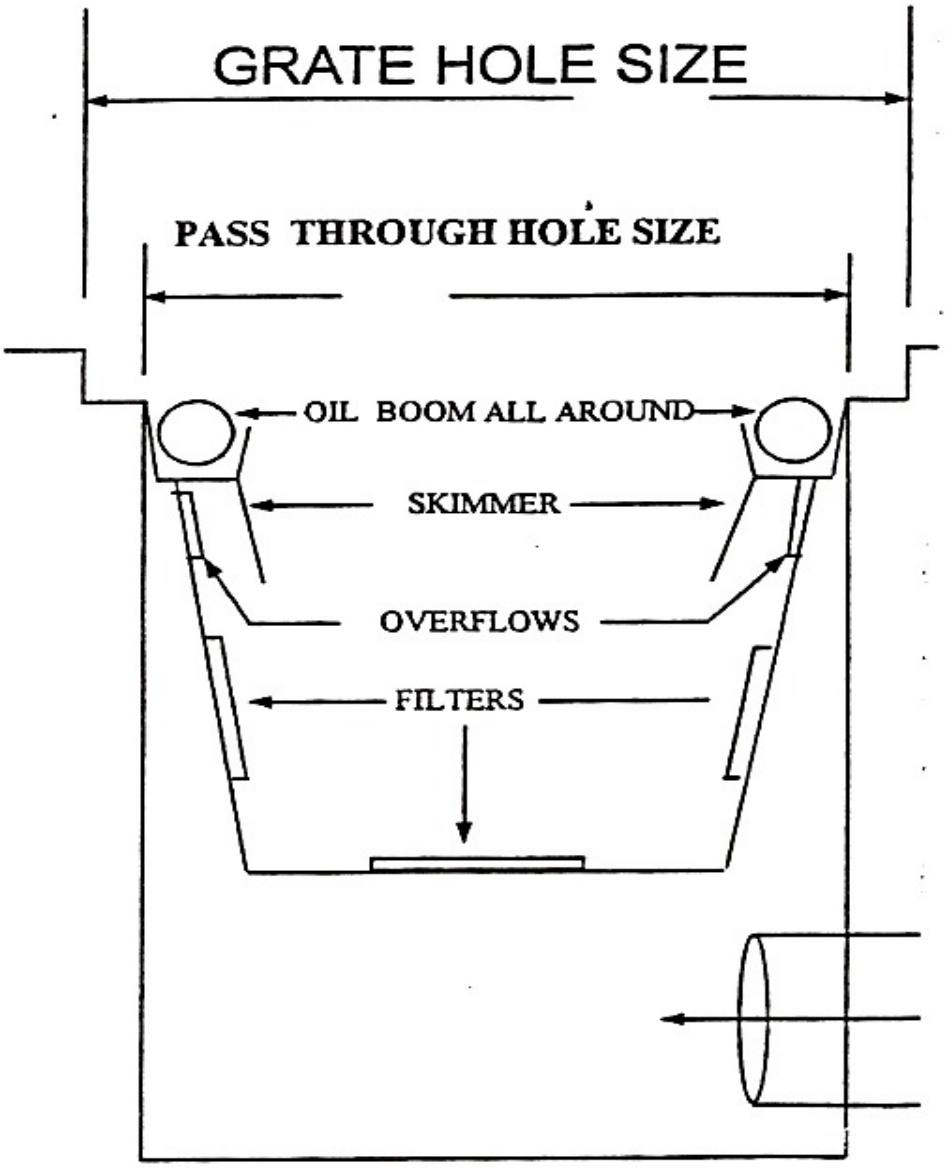
2.2 Installation of Catch Basin Inserts

The location of stormdrains entering Whitman's pond are shown in Figure 2. The location of 13 stormdrains where inserts were installed are shown in Figure 4. These catchbasins were originally given letter designations, but were later given numerical designations by the Department of Public Works.

The first three inserts were installed along Middle Street on December 3, 1997, in catchbasins Nos. 7, 8, and 9. The president of Sun tree Isles traveled to Weymouth to personally install the inserts and ensure their proper fit.

2.3 Installation Locations

After the first three inserts were satisfactorily installed the remaining ten were ordered. These ten were installed by the Weymouth Department of Public Works and Ambient Engineering on January 14, 1998. Inserts were placed in three distinct areas: Lake Street, Middle Street, and the DPW yard.



SCHEMATIC DIAGRAM CATCH BASIN INSERTS

FIGURE 3 WHITMANS POND
WEYMOUTH, MASSACHUSETTS

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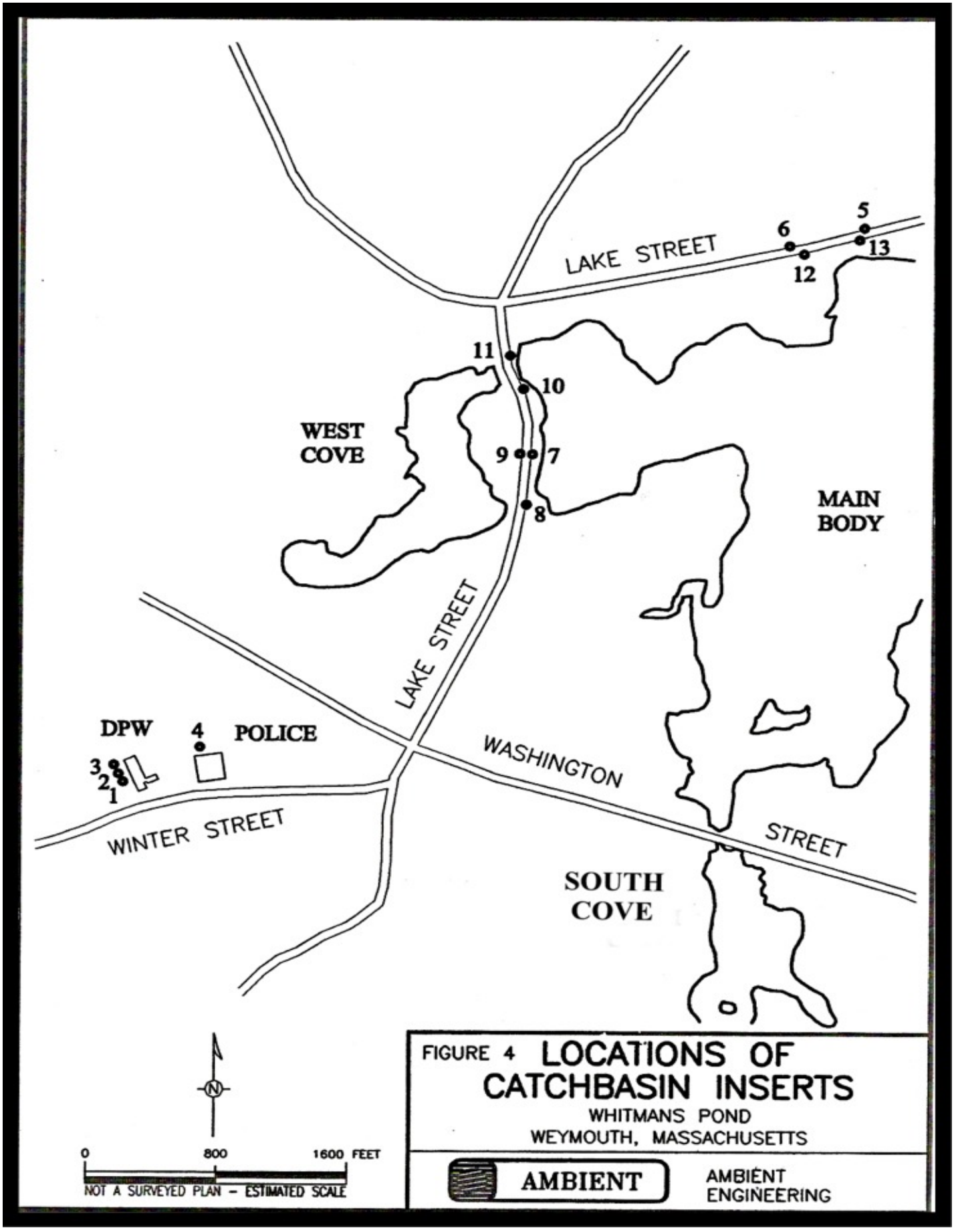

FIGURE 4 **LOCATIONS OF CATCHBASIN INSERTS**

WHITMANS POND
WEYMOUTH, MASSACHUSETTS

AMBIENT

AMBIENT ENGINEERING

3. STORMWATER INSERT EVALUATION

3.1 Criteria for evaluation

As stated above, the catchbasin inserts were evaluated for performance of units as well as for effectiveness with respect to the Town's resources. To evaluate the inserts' performance, the following criteria were considered:

- Ease of installation
- Amount of sediment removed
- Nutrient composition of the sediment removed
- Oil and grease retained
- Problems associated with operation, (e.g. hazards, ponding)

The following criteria were considered to evaluate the effectiveness with respect to the Town's resources:

. Cleaning and maintenance requirements
. Blockage by fallen leaves, vandalism, odors
· Unforeseen difficulties
· Interviews with DPW personnel

3.2 Sediment and Stormwater Sampling

Since the inserts were installed in three distinct areas around Whitman's Pond, the runoff characteristics of each these areas may also differ. Each area, Lake Street, Middle Street and the DPW Yard were each considered separately.

The volume of sediment collected from each catch basin insert was recorded at the time of cleaning. Samples of sediment were taken from each insert on May 13, 1998 and composited over each of the three areas. The sediment samples were analyzed for Total Phosphorous and Total Nitrogen. Visual assessment of the inserts was also made.

At the time of sampling, a well adjacent to gasoline pumps was pumped out into a stormdrain in the DPW yard. A petroleum odor and a sheen was noted on the water. Since more oil and grease was likely to enter the pond via the DPW yard than the Lake Street or Middle Street areas, the sediment sample from the DPW yard was also analyzed for total oil and grease.

Stormwater was also analyzed for phosphorous and nitrogen. Specialized samplers were installed in one catch basin in each area to catch a 2 liter portion of the first flush of a storm event. The sampler excluded water which entered the basin after the first flush. Runoff was shunted directly into one sampler while another sampler, installed under the catch basin insert, collected water after it had passed through. The Stormwater samplers were installed at the time the sediment samples were taken. Stormwater samples were collected on June 1, 1998,

After a period of 19 days without significant precipitation, samples of both the influent and effluent to the catch basins were analyzed for Total Phosphorous, Total Nitrogen and Total Solids. The samples obtained at the DPW yard were also analyzed for oil and grease.

Samples were collected within 24 hours of the storm event and placed on ice for transport to a Massachusetts State Certified Laboratory. Samples were analyzed using standard laboratory procedures. Copies of laboratory results are provided in Appendix A

3.3 Sediment Retained

Catch basins in which inserts were installed were originally given letter designation to differentiate them from outfall numbers. The Weymouth DPW later renamed the inserts with numerical designations. This report refers to the insert locations by the new number designations, but the corresponding letters are also listed to provide continuity with earlier Town correspondence.

Inserts Nos. 7, 8, and 9 were installed on December 3, 1997. They were first cleaned on March 25, 1998, 16 weeks later, and were found to be filled with sediment but allowed runoff to by pass the filter and did not cause ponding.

The remaining 10 inserts were installed January 14, 1998. Within 2 weeks, the inserts located at the DPW yard were filled with sediment. Soap from washing town vehicles was also reported to have clogged the oil absorbent boom and the upper tray of these inserts. During the last week in January 1998, the Weymouth DPW decided to remove the inserts because manpower was not available to clean them as necessary. In addition to the 3 DPW Yard inserts, insert No. 4 at the Police Station was also removed. The inserts were replaced 2 weeks before the time of the evaluation, May 13, 1998, when they were cleaned again.

Ponding had occurred on Lake Street and during the first week of February, leaves were found to have blocked the overflow holes on insert No.6. Insert No.6 was removed at that time.

To remove the stormwater grates and lift out the inserts the Weymouth DPW used a truck mounted hydraulic clamshell digger hoist. Lifting brackets were attached to some of the inserts and were provided separately to be attached to other ones. The inserts can also be safely lifted by placing two hooks in overt1ow holes on opposite sides of the unit. During the cleaning only one hook was applied to the side of the insert and it was lifted out rapidly. The upper rims of inserts Nos. 5 and 7 were broken when they jammed upon removal. They were also taken out of service on March 25, 1998.

The broken inserts still functioned properly however, and all seven of the inserts were returned to service on May 1, 1998. They were in service 2 weeks prior to the evaluation.

Table 1. May 13, 1998 Observations

Insert No.	Previous Letter	Location	Sediment Dimensions	Sediment Volume	Condition	Stormwater Sample	Comments
1	K	DPW	1.5x13x13 in	253.5 In^3	holding water	yes	
2	J	DPW	5x13x13	845	holding water		Observed pump out of well by gasoline pumps Into stormdraln
3	I	DPW	1x13x13	169	holding water		
4	L	DPW	1.5x13x13	253.5	holding water		
5	A	Lake St.	0.25x14x17	6			live worms noted
6	C	Lake St.	3x13x13	507	broken		Oil sock missing
7	G	Middle St	0.5x18x12	108	broken		
8	F	Middle St	3x17x17	867	holding water		pine needles, worms, butts
9	H	Middle St	1x17x17	289			0il sock missing
10	M	Middle St	0.5x13x13	84.5	pickaxe hole	yes	litter
11	N	Middle St	2x13x13	338			litter
12	D	Lake St.	0.5x12x14	84	pickaxe hole		broken pavement bypasses
13	B	Lake St.	12x9x16	1728		yes	worms

Table 2. Sediment Capture

Insert No.	Location	Installed	Weeks in Service	Volume Removed 1st Cleaning	Volume Present at Evaluation	Total Volume of Sediment Collected	Total Mass of Sediment Collected
1	DPW	1/14/98	4 weeks	2366 In^3	254 In^3	2620 In^3	70.7 kg
2	DPW	1/14/98	4 weeks	2366	845	3211	86.7
3	DPW	1/14/98	4 weeks	2366	169	2535	68.4
4	DPW	1/14/98	4 weeks	338	254	592	16.0
5	Lake St.	1/14/98	12 weeks	2142	6	2148	58.0
6	Lake St.	1/14/98	5 weeks	2366	507	2873	77.6
7	Middle St	12/03/97	17 weeks	2714	108	2822	76.2
8	Middle St	12/03/97	23 weeks	3179	867	4046	109.2
9	Middle St	12/03/97	23 weeks	3179	289	3468	93.6
10	Middle St	1/14/98	17 weeks	2028	85	2113	57.1
11	Middle St	1/14/98	17 weeks	2704	338	3042	82.1
12	Lake St.	1/14/98	17 weeks	2018	84	2100	56.7
13	Lake St.	1/14/98	17 weeks	648	648	1296	64.2

Note: Except for inserts No.4 and No. 10, all inserts were filled to capacity at the first cleaning.

The amount of sediment present in each catch basin was measured on May 13, 1998. Filled volumes of the inserts were also taken to estimate the sediment collected at the time of the first cleaning. Observations were also made as to the condition of the inserts. Some were found to be holding water, but not restricting flow to the stormdrain. Pick axe holes were noted in the bottom of two inserts, Nos. 10 and 12. (After hoisting the insert out, Weymouth DPW personnel used a pickaxe to turn the filled insert over.) The oil absorbent sock was also missing from some of the inserts' upper trays. Presumably they had been dumped into the sediment collection truck along with the sediment at the time the catch basins were cleaned. Sediment volume and observations are presented in Table 1.

Estimated sediment volumes present during the first cleaning, as well as weeks in service, are shown in Table 2. The inserts are designed to allow all additional sediment to overflow into the catch basin once the capacity of the unit has been reached. This prevents excess sediments from restricting flow into the drainage system. Therefore, it is not possible to estimate the sediment that would have been retained by each unit if it had been cleaned each time it reached capacity. The volumes listed only reflect what was actually prevented from entering the drainage system over the listed time period.

3.4 Sediment Analytical Results

Composite sediment samples were taken ITom each area and submitted for analysis. An estimate of the phosphorous and nitrogen removed ITom each area was calculated using a measured average mass of sediment of 0.027 kgfm3. Laboratory results and calculation tables are provided in Appendix A The Total Phosphorous and Total Nitrogen results are shown in Table 3 below:

Table 3. Results of Sediment Analysis

Sample Location	DPW Yard and Police	Middle Street	Lake Street
Total Kjeldahl Nitrogen (TKN)	159	195	532
Nitrates	0.064	0.064	0.064
Nitrites	<0.08	<0.08	<0.08
Total Nitrogen (mg/kg)	759	195	532
Total Phosphorous (mg/kg)	1.1	1L4	1.59
Oil & Grease (mg/kg)	21,600	NT	NT
Total Sediment removed (kg)	242	418	256
Nitrogen removed (g)	184	333	136
Phosphorous removed (g)	0.27	4.77	0.41

NT = Not tested for

Total Nitrogen is considered to be the sum of organic nitrogen and ammonia (TKN), nitrates and nitrites. The results indicate that nitrates and nitrites do not comprise a significant portion of nitrogen present in the sediment collected.

The nutrient loading from the Middle Street area appears to be significantly higher than the other two areas.

Sediment from insert No.2 was also analyzed for total oil and grease. This includes fats and non-petroleum oils. As previously noted, a well pump out from a nearby well adjacent to a gasoline pump was observed. The water, which exhibited a sheen and a petroleum odor, was discharged into catch basin No.2.

The amount of oil present in the oil absorbent boom was not determined. The presence of oil and grease in the sediment indicated that not all the water passed through the boom, or the boom did not absorb all of the oil. The results do show however, that the sediment present in the insert can provide a secondary point of oil and grease removal.

Estimating the sediment removed during the March 25, 1998 cleaning and combining it with that present at the time of evaluation, resulted in an estimate of 916 kg of sediment held by the inserts. Incorporating the analytical results shows that this mass of sediment contained 653 grams of nitrogen compounds and 5.45 grams of phosphorous.

3.5 Stormwater Sampling

To evaluate the performance of the inserts on stormwater, samples were taken of runoff entering and exiting the Suntree Isles inserts. Custom designed samplers were installed in catch basins Nos. 1, 10 and 13 to collect influent and effluent samples from each area. These samplers captured 2 liters of the first flush of the rainstorm event in which the highest concentrations of contaminants are present. The results of stormwater analysis are shown in Table 4.

Table 4. Results of Stormwater Analysis

Sample Location	DPW Yard and Police Insert No.1		Middle Street Insert No 10		Lake Street Insert No. 13	
	influent	effluent	influent	effluent	influent	effluent
Total Kjeldahl Nitrogen	98.2	3.39	7.09	12.2	38.2	13.2
Nitrates	<0.0797	0.204	<0.0797	<0.0797	<0.0797	0.184
Nitrites	0.047	0.266	0.259	0.047	0.438	0.047
Total Nitrogen (mg/l)	98.28	3.86	7.37	12.29	38.68	13.43
Total Phosphorous (mg/l)	15.8	0.548	0.898	0.259	1.93	0.55
Total Solids	1460	130	496	528	NS	18
Oil & Grease (mg/l)	110	50				

Percent Reduction

Total Nitrogen	96.07%	-66.76%	65.28%
Total Phosphorous	96.53%	71.16%	71.50%
Total Solids	91.10%	-6.45%	NS
Oil and Grease	54.55%		

NS = Not enough sample recovered

Not enough samples were obtained from the influent sampler at catch basin No.13 to perform all the analyses requested. The total solids analysis was therefore omitted. The results vary from area to area. While substantial phosphorous removal was observed at all three catch basins sampled, total nitrogen and total phosphorous were only significantly reduced at the DPW yard and Lake Street. While the percent reduction of total nitrogen and total solids appear to be negative, closer examination of the results shows that the levels detected are low, and within the range of expected sample variation. No significant reduction of total nitrogen and total soils was observed at insert No. 13. The influent and effluent values for phosphorous are closer to an order of magnitude apart and may be interpreted as a significant reduction. Although insert No. 10 was holding sediment, the presence of the pickaxe hole in the bottom may account for the poor removals.

Significant oil and grease removal occurred at insert No. 1 at the DPW Yard. The 50 mg/l present in the effluent does however indicate that sediment can clog the oil absorbent boom and allow oil from a heavy rain to bypass it. The insert is designed to direct heavy flows directly into the center of the unit to avoid flooding. A less intense rainstorm would presumably have shown a greater percent removal.

4. DISCUSSION OF RESULTS

A study of Whitman' s Pond conducted in 1986 by Metcalf and Eddy determined that phosphorous was the limiting nutrient responsible for eutrophication, and that the total stormwater loading of phosphorous to the lake, excluding input from the rivers, was 54 kg/year. In the Stormwater Management Plan for South Cove, Ambient Engineering estimated the stormwater portion of phosphorous loading over the whole pond using two different approaches. The "Simple Method" estimated that 61% of the total loading to the pond, or 496 kg P/year was due to stormwater. An alternative approach estimated that 46% of the total loading, 270 kg P/year, was due to stormwater. Averaging these two estimates to 393 kg P/year, and assuming 65% of total phosphorous is in particulate form, the filterable phosphorous loading over the lake would be approximately 250 kg/year.

Taking into account that there are 46 stormdrain outfalls entering Whitman's Pond, each outfall can be expected to contribute on the order of 5.43 kg of particu1ate phosphorous annually. Considering that the Lake Street and Middle Street catch basins serve more than one outfall, the concentrations recovered are somewhat less than expected.

The results of the stormwater influent /effluent analyses however, show significant removals from the first flush. The exception is insert No. 10, where a pickaxe hole had damaged the bottom of the unit. Although the unit continued to retain sediment, it is apparent that the performance of the unit was impaired.

Overall, the units effectively removed the pollutants tested, but a program of regular sediment removal and reasonable handling must be maintained. Presumably a significant portion of the nitrogen and phosphorous not collected in the sediment overflowed into the stormdrain after the capacity of the units were reached.

5. PERFORMANCE AND PROBLEMS NOTED

Before the inserts were installed, several questions about their strength, reliability and additional work requirement were raised. Answers to those questions were taken from discussions with Weymouth DPW Personnel and field observations.

1. Would the extra thickness of the insert under the storm grate interfere with snow plowing during the winter?

   The inserts raised the storm grates approximately 1/8 inch. This change was not enough to allow the inserts to catch on the snowplow blades.

2. Would the inserts clog with leaves and debris, causing ponding during storm events?

   This occurred in only one of the 13 inserts. The inserts are designed to bypass the same flow that enters them when the insert is filled to capacity. Two types of bypass holes were used. Some inserts were designed with rectangular, and others with round ones. The insert which was clogged with leaves had round bypass holes. Therefore the rectangular bypass holes may be less affected by leaves.

3. Are the inserts strong enough?

   The inserts are strong enough to withstand the weight of a 220 pound man jumping into them while hanging from the catch basin. There was no problem in the ability of the inserts to support the weight of sediment and water when filled to capacity, and to be lifted out of the catch basins when filled.

   Breakage did occur however, when the hydraulic winch continued to hoist units after they had jammed in the catch basin. It should be noted that those inserts continued to operate as designed. The remaining sides of the inserts provided enough support.

4. How often must the inserts be cleaned or maintained?

   Inserts Nos. 1,2 and 3 at the DPW yard filled to capacity in two weeks during the winter, while NO.4 was never seen at capacity. Monthly cleaning was suggested by Ambient Engineering at the time of installation, until the rate of sedimentation could be established. All 13 inserts can be cleaned in less than 4 hours by one operator. The Weymouth DPW does not have the personnel and time available to carry out such a program.

   The winter was mild since the catch basins were installed, and roads were not sanded as often as in other years. Over the winter it appears that the inserts would need to be cleaned monthly while those in the DPW Yard should be cleaned every two weeks. More data must be collected to determine a cleaning schedule for the rest of the year.

Aside from replacing the oil absorb socks when they become saturated, no other maintenance is required. The inserts must be cleaned regularly however, to be effective at nutrient and sediment reduction.

Aside for the blockage with leaves of subsequent ponding of catch basin insert No.5, no other problems with the units were identified.

6. CONCLUSIONS

6.1 Suntree Isles Stormwater Catch Basin Inserts performance

The Suntree Isles stormwater catch basin inserts performed well with respect to their design. With one exception, leaves and debris did not inhibit runoff from entering the stormwater system, even when the inserts were filled to capacity. The inserts' ability to prevent a significant portion of oil and grease, nitrogen, and phosphorous from entering Whitman's Pond was documented. The removal of phosphorous and nitrogen from stormwater runoff was significant during the test storm.

While the inserts are sturdy and resilient, a degree of care must be exercised during cleaning. The units are strong enough to be lifted out by the overflow holes when completely filled with sediment. However, the units are not strong enough to withstand the force of the hydraulic clamshell hoist when jammed. Damage to the screens of the unit will also hamper performance.

6.2 Overall Effectiveness of Insert Program

Discussions with Weymouth DPW personnel revealed that the inserts fill relatively quickly and must be cleaned as often as once every two weeks. The DPW does not have the manpower to implement a maintenance schedule for these inserts.

Sewage overflows into Whitman's Pond during heavy rainstorms were also cited as a major source of pollutants. Sewage overflows appear to be an unquantified source of nutrients to Whitman's Pond.

The inserts were found to be quite effective as units. The implementation of an insert program for Whitman's Pond however was not successful. Without regular sediment removal the effectiveness of the units decrease. Operator training and a commitment to long-term maintenance would be needed for successful implementation.

7. RECOMMENDATIONS

The issue of sewage overflows into the Pond must be addressed. No actual volume or concentration of sewage overflows are known. An investigation is recommended to define the nature and extent of these overflows.

The options available for the control of stormwater are:

- Allocate resources to maintain a catch basin insert program
- Install end-of-pipe treatment systems on selected stormwater outfalls
- Allocated resources for an effective catch basin sediment removal program using the clamshell digger at all catch basins.

Stormdrains are designed to trap sediment. Catch basin inserts are faster to clean than the stormdrains using the clamshell digger, but must be cleaned more often The degree of pollutant removal is greater with the inserts as the trapped sediments act as a sand filter and the boom absorbs oil and grease.

Maintenance time appears to be a critical issue to the Weymouth DPW. A larger end-of-pipe system would achieve the greatest degree of removal with the lowest time requirement for maintenance. Units themselves cost upwards of $35,000 for purchase and installation, but trap sediment, oil and grease, and require cleaning once or twice yearly.

In addition to an investigation of sewage overflows into Whitman's Pond, Ambient Engineering recommends the installation of an end-of-pipe treatment device following an investigating to determine the most appropriate site.