

liquids deposited during dry weather. The AHTG reviewed and approved the draft technical memorandum.

Cost estimates developed as part of this study validated the AHTG's assumptions that it would be most feasible to implement these controls in specific high-use or high-litter areas, and would not be cost-effective to implement throughout a drainage system. The group reviewed collected data and analyzed the most promising designs and devices. Five alternatives were studied: catch basin retrofits, side entry pit traps, storm drain inserts, a filtration device, and in-line deflection separator units. Each alternative was analyzed for its effectiveness, technical feasibility, ease of operation and maintenance, and potential costs.

For new developments with planned pedestrian areas, side-entry pit traps or catch basins with a sump and trash rack should be considered. In-line deflection separator units, just coming to market, have possibilities for locations with sufficient head. The larger in-line units, which can serve a stormwater catchment rather than a single inlet, will probably turn out to be most cost-effective. For specific high-use, high-litter areas that have intense maintenance schedules, trash screen inserts should be considered.

To control washwaters and other liquids deposited during dry weather, none of the alternatives studied were preferable over existing source control and storm drain inlet protection best management practices.

INTRODUCTION

Previous studies considered the feasibility of retrofitting catch basins to enhance removal of suspended or dissolved pollutants (Alameda County Urban Runoff Clean Water Program, 1994; King County Surface Water Management Division, et. al., 1995; Woodward-Clyde Consultants, 1997). This project considered the potential modifications to catch basins to reduce the entry of litter and debris and to capture and retain liquids that may enter during dry weather.

The project is part of the SCVURPPP's continuous improvement process, and responds to suggestions, raised during annual Co-permittee review meetings, that the Program investigate the potential use of treatment devices for removing litter and debris from stormwater. The project is part of the Bay Area Stormwater Agencies Association (BASMAA) Regional Monitoring Strategy.

BACKGROUND

An American Public Works Association 1969 study on the sources of urban stormwater pollution found that debris and contaminants from streets were the most controllable of the primary sources of stormwater pollution (Sutherland, 1999). In Australia, urban areas contribute between approximately 18 and 36 pounds (dry mass) per acre of litter and debris to stormwater drains each year (Allison et. al., 1997). Of this amount, vegetation such as tree branches and leaves comprises over 75% of the composition by mass. The remaining litter consists mostly of paper and plastic products, along with metals, cigarette items and other materials. Oil and grease can attach to the trash and debris.

Debris and vegetation can block storm drain outlets and outfalls, causing localized flooding, leaching chemicals and nutrients to water, and covering habitat. In Los Angeles County, a debris fence erected across Balloona Creek near Marina Del Ray collected 168 cubic yards of trash during the 1997-98 wet

season. Of this amount, 60% was collected in the first three storms (Hildebrand, 1998). In addition debris can be ingested by aquatic organisms and devalues the aesthetics of natural waterways. Dry-weather flows, such as those from washwaters, are also a water quality concern as they may contain pollutants.

Locations of High Debris and Litter

While vegetation makes up the greatest amount of large-sized pollutants, the quantity of street litter, including paper and plastics, is greatest in commercial areas (Allison et. al., 1997). In the Cooperative Research Centre study, Allison et al. suggests that fast food containers and cigarette butts make up a significant proportion of litter in urban streams. High-litter locations include areas with high levels of pedestrian traffic such as stadiums, streets and parking lots serving night clubs, schools, commercial downtown areas, waterfronts and malls, including fast-food corridors and street fair locations. Urban expressways, certain manufacturing facilities (e.g. wood product manufacturers) and construction sites can produce large amounts of debris in runoff. Tree-lined residential streets can produce a large amount of vegetative debris, and can carry excess organic material, fertilizers and pesticides to waterbodies.

Locations of Frequent Washwater Flows

Municipal staff note that street fairs (where food is served) often leave behind high amounts of litter and food debris, which needs to be washed from the streets. Illegal dumping of restaurant washwater is also common. In residential areas, car maintenance (car washing, changing oil, etc.) is a common source of pollutants during dry weather. Concrete-truck washing, tool cleaning, emptying of storage tanks from campers, road work, and cleanup from accidents can also result in pollutants entering storm drains during dry weather. (Novac, et. al., (no date)).

METHODOLOGY

The project scope called for the following:

- Review existing standard catch-basin designs and consider effectiveness for managing litter, debris and liquids.
- Consult with public works maintenance personnel to identify operational and maintenance concerns (catch basins vs. inlets).
- Consult with public works engineering personnel to identify engineering considerations for installation of catch basins vs. inlets.
- Identify potential design improvements that could make catch basins more effective for managing litter, debris and liquids.
- Identify elements of a management program needed to complement use of catch basins (e.g. cleaning frequency, techniques).
- Estimate planning level costs and cost differential (catch basins vs. inlets).

- Characterize areas where catch basins may be useful (e.g. commercial or high-litter areas).

Wendy Edde of the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP) convened an ad hoc task group (AHTG) comprised of municipal engineering and maintenance staff from Los Altos, Mountain View, Santa Clara, and San Jose. AHTG members collected information about their storm drain systems and maintenance practices, which supplemented a literature review conducted by SCVURPPP. AHTG members also reviewed and approved the draft technical memorandum.

Initial screening produced five alternative types of devices:

- catch basin retrofit for large debris and dry weather flows;
- side entry pit trap for large debris;
- storm drain inserts for debris;
- oil and sediment separators;
- sanitary sewer diversions for dry weather flows; and
- end-of-line deflective separation units for large debris.

The five alternative types of designs were evaluated against the baseline (existing inlets) alternative for effectiveness, technical feasibility, operation and maintenance considerations, management needs, and costs.

EVALUATION CRITERIA AND ASSUMPTIONS

Each alternative was evaluated for effectiveness and drawbacks, tendency to cause mosquito breeding, feasibility to install and operate, operation and maintenance considerations, and overall cost to install and maintain. The alternatives are reviewed based on the assumption that only high-debris/washwater areas would be retrofitted. (Retrofit of all catch basins in a municipality is not economically feasible due to the high operation and maintenance costs.)

Effectiveness

Criteria for determining effectiveness were the alternative's ability to collect litter, debris, and/or washwater. Because roughly only 20 percent of litter has been found to float in laboratory testing, effective alternatives should be able to capture litter that sinks as well as floatables. Effective designs treat the maximum amount of discharge possible, and can handle multiple storms in a day (Allison et. al., 1997).

Mosquito Breeding

If the device leaves standing water, the Santa Clara County Vector Control District may need to treat that water to control for mosquitoes. Anopheline mosquitoes, which breed in ponds and lakes, can carry malaria. However, these mosquitoes are not likely to breed in stormwater systems. *Culex pipiens* and *Culex stigmatosoma* can breed in many sites including foul waters. Neither of these species are public health vectors (Rusmiso, 1999).

Technical/Engineering Feasibility

In this section, each alternative is analyzed to determine if the technology can (a) operate without unacceptable head loss or treatment capacity; (b) can be used with existing infrastructure; (c) is appropriate for use in the Santa Clara Valley.

Operational & Maintenance (O&M) and Management Considerations

Equipment and personnel required to clean the devices, and cleaning frequency and techniques are discussed.

Costs

Except for the combined deflector system unit, all alternatives would be retrofits. The planning-level cost comparison is based on a typical block within a typical downtown commercial or street fair area (e.g. Mountain View's Castro Street, or Sunnyvale's Murphy Street or Town and Country Center parking lot). Estimates are based on six catch basins draining the one-block area. The analysis is performed over a 20-year planning period beginning in Year 2000, and assumes 5% interest. Australian prices were converted at \$1.00 Australian to \$0.70 United States.

COMPARISON OF ALTERNATIVES

Baseline—Existing Inlets

Description. Five main types of inlet designs exist. Examples of each may be found throughout the Santa Clara Valley basin. (See Attachment 1 for illustrations).

- (1) ***Curb-Opening.*** These inlets, often used in curb and gutter installations with grades flatter than 3 percent, have a curb opening that is parallel to the flow direction in the gutter. Caltrans (1995) indicates that “the curb opening is most effective with flows carrying floating trash.”
- (2) ***Grate.*** With a grate opening in the gutter or waterway, grate inlets are preferred by Caltrans over curb-opening inlets, and they are not limited by the grade of the gutter. Grate inlets can, however, be easily clogged by floating trash, and can be a hazard to bicycle traffic if bicycle-proof grates are not used.
- (3) ***Combination.*** High in capacity, combination inlets include both a grate and a curb inlet. The curb opening can either be right next to the grate, or with “sweeper inlets” the curb opening can precede the grate. Sweeper inlets intercept trash during the first portion of a storm event. Trash racks are available for combination inlets.
- (4) ***Pipe Drop.*** The most economical type of inlet, according to Caltrans (1995), the pipe drop inlets are not used in roadbeds. They are made of commercial concrete or corrugated metal pipe sections. Two types of these high-capacity inlets exist: a wall opening intake which is unaffected by grade, and a round grate intake, which can collect water coming from any direction. Wall opening intakes can be used with a trash rack.
- (5) ***Slotted Drains.*** The continuous slot on the top of the corrugated metal pipe is what gives this inlet type its name. Angle irons or grating creates the slot and provides the paving bulkhead.

This inlet may be found in medians or on the edge of a shoulder, and they can act as an alternative for a grate catch basin.

Storm drain inlets contain a box beneath the grate with the discharge outlet located at the bottom of the box. This outlet connects directly to the storm drain system.

The exact number of catch basins (which include sumps) is not known for the Santa Clara Valley. Table 1 describes the existing storm systems in use in the Santa Clara Valley.

Effectiveness. Existing inlets do not generally have significant capabilities to collect and retain large debris or dry-weather washwater flows. With the outlet pipe at the bottom of the inlet, these pollutants continue directly to the stormwater system. Larger debris that cannot pass through the outlet pipe collects and can clog the inlet if not cleaned. When an outlet pipe is partially clogged, some sediment may also collect. The cleaning of the blockage and the sediments provides the only treatment of storm water.

In Mountain View (1997), solid waste collected during inlet and catch basin cleaning is dried on an impermeable pad from which runoff discharges to the sanitary sewer. Once dried, the solids are removed to a landfill.

In fiscal year 1997-98, the City of Palo Alto (1998) cleaned 1,839-storm inlets and hydroflushed 52,385 linear feet of storm drains, which resulted in the collection 118,795 pounds of material from their storm drain system. In this same period, Los Altos (1998) inspected 11,000 inlets and cleaned 5,500. San Jose (1997), which has approximately 26,000 storm drain inlets and 2,350 curb miles of streets, cleaned 25,500 storm drains in FY1996-97.

Assuming Palo Alto is representative of debris load for Santa Clara Valley communities, the average amount of materials removed during catch basin cleaning, including storm drain hydroflushing, is 64.6 pounds per storm drain inlet. See Table 1 for information on existing storm drain inlets in the Santa Clara Valley basin.

Mosquito Breeding. Currently the County sprays methoprene or and places charcoal briquettes containing methoprene or bacillus in catch basins to control mosquitoes. Methoprene is a specific, naturally occurring chemical that keeps insects from developing from the pupae to the adult life stage. The chemical is non-toxic to mammals and has a quick half-life (Rusmiser, 1999). The dose of one charcoal tablet per month is administered from March through November each year. The vector control district finds mosquitoes a significant pest, as are drain flies and oriental cockroaches. Oriental cockroaches can thrive in storm drains, and the vector control district will spray for them in water-meter boxes, storm drains, and manholes in San Jose and Milpitas (Santa Clara Vector Control, 1999). In addition to any added cost to the vector control district, a portion of the insecticides used to control mosquitoes could find their way to the storm drain system.

Technical/Engineering Feasibility. Existing storm drain inlets are widely used throughout the Santa Clara Valley. Their feasibility is proven.

O&M and Management Considerations. Most inlets, on average, need to be cleaned at least once per year. With the outlet pipe flush with the bottom of the inlet box, excessive vegetation or debris can clog the outlet pipe or get carried into and clog the storm sewer lines. Therefore storm inlets in high-debris areas often need to be cleaned more than once per year. When cleaning, traffic control needs to

be performed. The City of San Jose estimates it can examine 50-60 inlets per day at corporation yards, and can clean approximately 10 inlets per day on major roadways.

These inlets are often cleaned using vacuum trucks. These vacuum trucks cost approximately \$250,000 and last about 10 years. They can serve about 3,675 inlet or catch basins per year (Woodward-Clyde, 1997). Cleaning is usually performed using vacuum or flush trucks, or manually. Claw-like catch basin cleaners (e.g. Hydro Clamshell or Handi-Clams) are also used to pick up debris. Storm drain pipes may be flushed with water and debris vacuumed at the downstream end. Debris collected in the vacuum trucks is typically dumped to a concrete pad, with a drain to the sanitary sewer, for dewatering of the solids. Once dewatered, solids are disposed at the landfill.

Costs. No capital costs are considered for retaining existing catch basins. Vacuum trucks cost approximately \$170,000 to \$250,000 apiece to purchase, or \$70,000 to rent for 3-4 months. In Santa Clara, the cost to dispose of leaf and litter is \$106 per bin at Newby Island in Milpitas. Different communities use different sized bins or bags to collect materials.

The City of Mountain View estimates the annual cost to maintain the estimated 1,700 storm drain inlets and 200 catch basins in the City is \$288,000. Mountain View inspects 950 inlets/catch basins per year and removed 335 cubic yards of materials using vacuum or flusher trucks in FY 1996-97. This translates to approximately \$300/inlet for the 950 inlets serviced. Assuming no differences in economies of scale between Mountain View and Palo Alto, and disregarding the existence of existing catch basins in Mountain View, the cost per pound of material removed from storm drain inlets is estimated as roughly: \$4.69/lb material removed.

See Table 2 and Appendix A for a cost analysis to maintain 6 inlets over 20 years prepared based on the Mountain View estimate of \$288,000 per year to maintain 950 of their inlets. Based on these assumptions, the expected total cost to maintain six storm drain inlets once per year for 20 years in a high-debris area is expected to be \$36,400 or \$19,100 net present value.

Catch Basin Retrofit

Description. The difference between catch basins and storm drain inlets is that catch basins have a sump below the outlet drain. A few areas in the Santa Clara Valley have old catch basins, which were originally installed to help prevent clogging of sewers with sediment, organic debris, and floatables. They also helped against oil and grease problems. Catch basins can include a hooded outlet. The hooded outlet was originally included to reduce odors from escaping sewage systems. (See Attachment 2 for illustrations). Over the second half of the century, catch basins fell out of favor among public works departments.

Effectiveness. A 1994 Alameda County Clean Water Program (ACCWP) study on “Street Sweeping/Storm Inlet Modification” reported that Brown and Caldwell (1991) claimed 30% of solids and 25% of trace metals can be removed from catchbasins with semiannual cleanings. The ACCWP (1994) also stated that results from a 1994 Watershed Protection Techniques study reported that inlets that were found in the lab to be 10-25 percent effective in removing suspended solids were not effective in trapping pollutants in the field. The study, which inspected more than 100 units in the field, found design flaws hindered effectiveness. In addition, none of the inlets inspected were being properly maintained. The study estimated that cleaning after each major storm would be necessary to achieve

optimal performance. The ACCWP (1994) concluded that “only inlets that can be inspected monthly should be retrofitted.”

Pitt (1998) found that catch basins could remove an average of 60 to 97% of the solids. Catch basins reduced chemical oxygen demand (COD) by 10-56% and biological oxygen demand (BOD) by 54-88%. Inlet strainers improved removal by about 10%. Catch basins are better at collecting larger particles, but they allow over 90 percent of the more contaminated finer particles (<100 um) to pass through the outlet (Pitt, 1998).

Pitt (1998) reported studies from the 1970's that questioned the performance capabilities of catch basins for pollutant removal and that recommended filling catch basins because of the threat of pollution from re-suspended materials. Pitt has found that the amount of catch basin sediment over time in a full catch basin was very large when compared to storm runoff yields, but not very mobile. Cleaning catch basins is important to maintain pollutant removal. Pitt did not find significant differences between catch basin supernatant and outfall water quality. However, a separate study found that catch basin supernatant water may contribute to the first flush effect, and anaerobic conditions can form rapidly in this water during dry weather. Such conditions can cause the release of oxygen demanding material, ammonium, and possibly sulfides, and can affect the bioavailability of heavy metals in flushed water (Pitt, 1998). Total and suspended solids can be reduced up to 45% for low gutter flows using catch basins, but not many pollutants are found with these courser solids.

In a three-year long study culminated in 1982 in Bellevue, Washington, Pitt (1988) found that cleaning catch basins twice a year allowed optimum capture of particulates and reduced the total residue and lead yields by 10 to 25% and COD, total Kjeldahl nitrogen, total phosphorus, and zinc by 5 to 10%.

In 1998, Pitt et. al. (1998) retrofitted an existing storm drain inlet in Stafford Township, NJ with a sump. Water was sampled before it entered the catch basin and after it passed the catch basin. Using paired samples and the Wilcoxon Signed Rank test, the results showed that the catch basin removed:

- 0-50% (average 22%) of total solids;
- 0-55% (average 32%) of suspended solids (30 to 45% of annual loadings);
- 0-65% (average 38%) of turbidity; and,
- 0-50% (average 24%) color.

Pitt (1998) indicates that catch basins with appropriately sized sumps and hooded outlets can handle extreme flows with little re-suspension, no significant changes in supernatant water and runoff quality, and minimal insect problems. Pitt recommends that catch basin sumps be constructed of concrete, plastic, aluminum or stainless steel. He cautions against using galvanized metal or treated woods.

Another impact with catch basins has to do with surges of hydrocarbons. The catch basin sump will collect hydrocarbons that float on surface of sumps. During peak flows, these may be rapidly discharged at once.

Mosquito Breeding. Because only a small number of storm inlets that would be retrofitted with catch basins, the increase in mosquito abatement costs would be insignificant.

Technical/Engineering Feasibility. Pitt (1998) indicates that catch basins will collect sediments until they reach about 60% of the total sump capacity (about 0.3 m under the outlet). At that point, re-suspension balances new deposition. The sediment trapping performance has been found to be

dependent on the flow rate passing through the catch basin and the particle sizes of the sediment; the sediment depth in the sump has a lesser effect on capture performance (Pitt, 1998). Lower flows increased the sump's ability to trap particles and larger particles are more easily trapped than smaller particles.

The USEPA recommends that the best catch basin design has the following dimensions (relative to outlet pipe diameter "D"):

- Bottom of outlet pipe should be 2.5D below street level and 4D from bottom of the sump;
- Overall height of the catch basin should be 6.5D;
- Diameter should be 4D (Pitt, 1998).

Pitt (1998) indicates that the sump volume and cleanout frequency can be estimated. For paved drainage areas of 3.3 acres, assuming 250 mg/L suspended solids concentration and 25 inches of rain per year, the sediment accumulation rate in the sump would be 3.4 cubic ft/acre of pavement per year. For the 3.3 acre paved drainage area, the accumulation would be 10 cubic ft per year. Since the catch basin sump diameter should be at least four times the diameter of the outlet pipe, the sump should be at least 40 in. if the outlet pipe is 10 inches in diameter. The annual sediment accumulation in the sump would be about 1.3 ft. If the sump was cleaned every two years, the total accumulation in the meantime would be 2.6 ft. Adding an extra foot of sump depth as a safety factor, the total sump depth of 3.5 ft is recommended. The total sump depth should not be less than 3 ft. unless the sump diameter is less than 2.5 ft. For this configuration, the sump volume is 9 cubic feet with a safety factor of roughly 1.6 (Pitt, 1998). These calculations do not take into account the additional cleaning necessary when including adverse slope inclined and bar trash screens.

An adverse slope inclined screen that covers the hooded outlet side (see Attachment 2) can be used to trap most of the trash such as cigarette butts, and suspended solids and grit. A solid top would extend from above the outlet to ensure trash does not slip into the wrong side of the screen, but allows enough room above the top of the inclined screen to allow overflow water in case the screen gets clogged. The inclined screen allows the trapped material to fall in the sump instead of being forced against the screen.

For larger trash (fast food wrappers, cups, etc), Pitt (1998) suggests adding a bar screen under the area of inlet grating in addition to the configuration described above. This is especially useful in inlets with larger curb openings. The bar screen would be installed to slope to a covered litter trap (see side entry pit traps below) in an adjacent chamber. Recommended bar spacing is 0.25 to 1 inch. The litter trap should be as large as possible, be placed above the water level, and include drain holes. A nylon net bag could be inserted in the frame to make collecting litter easier. Minimal water should flow through the litter trap.

To prevent standing water and the associated odor and mosquito impacts and for dry weather flows, weep holes can be added at the bottom of the catch basin sump so that contaminants do not enter the storm system. With the weep holes, the catch basin becomes a Storm Water Infiltration Device (SWID). The Santa Clara Valley Water District discourages the use of SWIDs, particularly for street drainage, because of the potential for groundwater contamination.

O&M and Management Considerations. The catch basin design with sump, hood, inverted screen, and trash trap will require frequent inspections and cleanups to clear partial blockages on trash bars

and to empty the pit trap according to Pitt (1998). Large amounts of leaf and vegetative matter could overload the trap. Pitt recommends requirements for such installations include commitments to inspect and clean after most storms, especially after long dry periods.

In the New York City catch basin project, National Water Main realized that existing vacuum trucks were not able to collect much of the hard-packed dirt, leaves, and large (greater than 6-8 inches) objects being found in catch basins. Therefore they created a "Hydro Clamshell" truck that contains a small crane and a 7-8 yard debris box along with a high velocity, high-pressure water system to clean lateral connections, grates and pavement (see Attachment 3). (Public Works, 1998).

Costs. In a 1997 study for Caltrans, Woodward-Clyde Consultants estimated the unit cost for retrofitting a storm drain inlet as a catchbasin on a limited access roadway at \$13,364. This cost included labor, materials, removal, and traffic control costs. Traffic control seems to be the driving cost. For Caltrans, \$2,000/day is spent "to close one lane-mile of limited access freeway during maintenance" (Woodward-Clyde Consultants, 1997). Woodward-Clyde assumes \$200/catchbasin for traffic control. Other, non-quantifiable costs associated with traffic and the resulting congestion include increased fuel use and air pollution, and decreased worker productivity. With negligible traffic control requirements, the cost could drop to \$2,750 per unit installed (Woodward-Clyde, 1997). Caltrans uses two to three workers at \$30 per person per hour to clean each storm inlet, which takes a half-hour each. The cost of debris disposal depends on the type of debris and waste removed, the disposal requirements and location area, and the dewatering requirements. Woodward-Clyde used a disposal cost of \$200 per catch basin per cleaning. Woodward-Clyde (1997) estimated a total annual maintenance cost of \$440/catchbasin for limited access freeways, and \$240 annually per catch basin for nonlimited access highways.

Table 2 and Appendix A show a breakdown of costs to retrofit 6 storm drain inlets (the typical number of inlets in a downtown commercial or street-fair block). Installation costs (including labor and materials) would be approximately \$1,000 to install, plus \$50 per foot of additional sump depth (Santa Clara, 1998). Using Pitt's recommendations and assuming a 12-inch outlet pipe, the sump depth is calculated as four feet below the outlet pipe for a total installation cost of \$1,200 per catch basin. The cost estimate assumes no new equipment is necessary to clean the catch basin sumps. It was further assumed that the cleaning frequency would be 12 times per year (once before the wet season begins, once after the first four storms of the wet season, and once per month during the wet season (October through April). It was also assumed that two workers (\$55/hour each) would require one half hour to clean each catch basin. No additional costs for equipment or supplies are assumed. Cleaning catch basins costs more than cleaning inlets because more debris is collected and more trips are required to dump the debris.

The cost for mosquito abatement, which would be performed by the Santa Clara Vector Control District, is included in the maintenance cost but has a negligible impact based on the small number of retrofits. This cost assumes that one employee at \$26/hour would deliver one \$1.00 pesticide tablet to each catch basin once per month for nine months per year. Yearly maintenance per catch basin is estimated at 0.015 hours per catchbasin per year¹ (Alameda County Vector Control District, 1999).

With these assumptions, the 20-year planning cost for retrofitting 6 catch basins in a typical downtown commercial area and cleaning each of them 12 times per year is \$971,100, or \$513,300 net present

¹ The hourly maintenance rate of 0.015 hours per catch basin per year is the mean value for the Alameda County Vector Control District over the years 1994-1998.

value The added cost to install a catch basin rather than an inlet in a new development would be roughly \$200 more per catch basin. Installation costs (labor and materials) are roughly \$50 per foot of additional sump depth and a four-foot additional sump depth is assumed (Santa Clara, 1998).

Side Entry Pit Trap

Description. This trap consists of a basket located below the entrance of storm drain inlets (see Attachment 4). The basket contains holes between 0.2 and 0.8 inches (5-20 mm) in size to allow water through. This device would not be useful for catching dry weather flows such as wash water. The device is inexpensive and meant to be easily installed at several locations. They can be used in specific areas. The device should be cleaned every four to six weeks. When installed at 192 inlets within a 124-acre catchment basin, the devices collected about 80 percent of the litter load, 65% of the total litter/debris/vegetation load. Allison, et. al. (1997) estimates that placement of these traps in half a catchment basin inlets can result in collection of two-thirds of the litter.

An Australian company, Ecosol, creates side pit entry traps for individual storm drain inlets. Ecosol's RSF 100 consists of a filtration/retention unit and a spring operated overflow bypass mechanism (Gapper et al, 1997). Upon entering the inlet, solid pollutants are carried by water across the overflow bypass mechanism to the filtration and retention units which are set back under the curb. These units capture solids greater than the aperture size of the filtration mesh (about 3mm). When the trash unit is full, pollutants back onto the overflow flap that then opens and allows for overflow. The overflow mechanism can fail only in the open position. The basket is set close to the backwall of the pit and the overflow flap is positioned below the opening inlet.

Effectiveness. Only lab testing has been completed; field-testing has not been reported. According to the Urban Water Resources Centre's independent full-scale lab test, the RSF 100 collected nearly 99% of large pollutants until the collection basket filled. The results were achieved in basins installed on-grade or in a sag. The company claims filtration of 95% of solid pollutants down to 3mm; no head-loss; a large (0.25 m³) collection capacity, no remobilization of pollutants, and no toxic fermentation.

As the flow rate increases, the volume of organic matter that stays in the basket decreased, however. In tests where the catch basin water level was high (150mm below the gutter inlet), most floatables passed through. According to the Urban Water Resources Centre, this condition will likely occur in 1% of the annual flow cases.

Technical/Engineering Feasibility. Ecosol claims the filtered stormwater does not sustain head-loss. On grades, the pollutants collected before the overflow flap activated was inversely proportional to the street grade. This is because the stormwater would carry the pollutants to the downstream face of the gutter, which resulted in the filling of that downstream side of the basket quickly and caused the overflow to open before the entire basket was full. This only occurred in tests of low or medium water levels in the catch basin. When filled, the basket would hold 0.2-m³ organic material without local flooding. Five percent of organic materials would generally escape. This would increase for a sag inlet with high water levels (all floating materials passed through). Similarly, performance was reduced for an "on-grade" inlet with relatively flat longitudinal grade when the basket was more than 90 percent full, and also reduced for an "on-grade unit" on a steep grade with a basket more than 70 percent full.

Side entry pit traps must be designed to fit the specific catch basin sites, to contain an overflow mechanism, to collect enough material to be cost-viable, and to reduce the potential for head loss. Because the trash pit is set back, enough space is necessary to install an access entry over the pit trap.

O&M and Management Considerations. “At source” debris-screening devices may reduce the possibility of debris clogging the drainage system, the cost of cleaning and repairing the drainage system, and the amount of toxins and bacteria downstream (Gapper et al, 1997). However, the cost of properly maintaining the large numbers of at-source units may be cost prohibitive. The collection basket must have enough storage capacity to minimize maintenance frequency. Two springs with different resistance tension are needed for “sag” and “on-grade” use respectively (Argue, et. al, 1996).

For the RSF100, Ecosol boasts custom designs, removable parts, corrosion resistance, and easy, cost-effective maintenance. For this study, the product is assumed to perform well over the 20-year planning period. New baskets have been designed to reduce installation time. However, because the pit trap is set back from the storm drain, suitable access beyond that provided at the grate or inlet is necessary.

Costs. The cost of the Ecosol RSF100 is assumed to be \$450 Australian or \$315 US dollars. It is assumed that no additional mosquito or cockroach abatement is needed. The product is assumed to be operational at least 20 years. The costs in Table 2 and Appendix A assume that placement of a pit trap in a new construction area would require five full time equivalent employees three hours a piece at \$55/hour to install each \$1,140 device. Costs assume that existing equipment is available to install and maintain the traps.

If the retrofit requires construction of a clean-out lid over the pit trap, then costs could be prohibitive. Richard Gapper (Ecosol, 1999) suggest SEPTS be considered only for new development or retrofits with existing access available. For this study, however, the assumed cost is for retrofit of existing inlets, which would include installation of a maintenance access cover. This retrofit is estimated to cost an additional \$1,500 per unit and three additional hours to install.

Removal of the trap at the start of each wet season (to accommodate only trash accumulated during dry weather) would be difficult. Therefore, twelve cleanings per year (after the first four major storms, monthly during the wet season, and once and just before the beginning of the wet season to collect dry weather debris) are assumed. The estimated cost of maintenance assumes each unit requires two \$55/hour employees one hour apiece twelve times per year. Additional costs may be incurred with importing this Australian product. However, the company plans to open offices in the United States. Costs to retrofit storm drain inlets with side entry pit traps , and to maintain these 12 times per year over 20 years, are \$179,200 (\$104,000 net present value).

Storm Drain Inserts for Debris and Oil/Water Separators

Description. Many companies make storm drain inserts, including the Stream Guard and the StreamSentry Litterbug. The Stream Guard was used as the example insert for analysis in this study. Stream Guards come in various versions, one made for collecting debris. The basic insert is a sock-shaped porous fabric container that tapers to and is sealed at the bottom. This is attached to a frame made of stiffer fabric that is made to fit under the catch basin grate (see Attachment 5).

Because of the tendency of storm drain inserts to clog without proper maintenance during the wet season, we examined the effectiveness of using storm drain inserts when used only during the dry period (April through August).

Effectiveness. Pitt et al. (1998) found that a 6-mm thick plastic foam screen could be used with catch basins to improve trash collection abilities, even though the device did not significantly reduce pollutants.

This analysis focuses on the use of inserts created specifically for capturing litter and debris. We also reviewed a device intended to capture oil and grease from dry weather flows (see Table 2 and Appendix A). Specific inlet devices are designed to collect specific materials. The insert designed for removal of litter would not be effective to collect spilled wash waters. Selecting the appropriate catch basin insert to capture pollutants in dry weather flows is difficult because different polymers and sorbents are used to collect different substances. Because the insert would not collect litter during the wet months, clogging of the filter would be less likely to cause deleterious effects such as localized flooding.

Technical/Engineering Feasibility. The devices are already on the market and are not difficult to install. A study in the Seattle area (King County Surface Water Management Division, et. al., 1995) recommended that catch basin inserts be used for collection of trash and debris. However, they determined that insert suitability depends on local climate and site conditions. Their recommendations are based on visual observations of tested inserts. They recognized that floatables can provide growth surfaces for bacteria and can release toxic pollutants as they deteriorate. In areas where runoff carries a lot of vegetation debris, more information is needed to determine if overflow areas can be blocked by debris.

O&M and Management Considerations. Equipment to carry the devices, and space to store the devices when not in use, would be needed. Because catch basin inserts clog so easily, they require very frequent maintenance (after each storm, or monthly) to be effective and to avoid flooding.

For use during the dry season only, the devices would need to be placed in April and removed in September or early October before the rains begin. Therefore, at least two maintenance trips per year in addition to monthly inspections during the dry season would be necessary. This results in an estimated total of seven annual maintenance inspections/cleanings per year. In addition, the inserts are assumed to require replacement once every five years.

Costs. The costs assume these units are used only during the dry season only, (see Table 2 and Appendix A). Unit costs are based on ordering by the 10-pack size. Installation is assumed to take 0.5 hour apiece by two FTE employees at a \$55/hr rate. We assumed units are placed at the beginning of the dry season (April) and removed at the end of each dry season (October). The units should be inspected monthly during the dry season, and cleaned if necessary. The oil and grease inlet is assumed to need complete replacement 75% of the time. Total costs over the planning period for dry weather oil and grease passive skimmer inserts are estimated at \$17,400 or \$10,900 present value. The total costs for the curb style trash inserts are estimated at \$12,000 or \$7,600 present value.

Diverting Dry-weather Flows to Sanitary Sewers

Description. Dry weather flows often contain high amounts of pollutants. New technologies, such as Grande, Novac, & Assoc., Inc.'s (GNA's) HydroSwitch, have been created to shunt dry weather flows

to the sanitary sewer system (See Attachment 6). HydroSwitch takes a pre-determined flow level through a sluice gate to the wastewater treatment plant. If the amount is exceeded because of a longer or intense rainfall, the sluice gate closes and re-opens when the flow drops below the specified level. This system also contains a self-adjusting baffle system to catch and retain floatables. The floatables are also directed to the wastewater treatment plant. When rain occurs, floatables are suspended in the storm water sewer and transported to the HydroSwitch. The first flush of each flow incident is diverted through the HydroSwitch. The sluice gate has a constant, adjustable discharge flow rate depending on the site needs. The sluice gate closes when the water level increases to a pre-determined level. A check valve protects against sanitary sewer system backup, and the sluice gate is activated by sanitary sewer flow backup as a secondary precaution.

For comparison purposes, we assumed that a HydroSwitch would be placed at each storm drain inlet to collect localized dry-weather flows. Larger units downline could also be installed. The device has been used in Germany and can be obtained through a Canadian firm.

Effectiveness. The first HydroSwitch was installed in a 13 ha (32 acre) area in Germany in June 1992. The Institute of Urban Water Management of Karlsruhe monitored the installation and, during an intense rainfall event, found 48% of TSS and 32% of the COD pollutant load was transferred to the sanitary sewer, while 23% of the run-off volume was transferred (Novac, et. al.). Monitoring methodology and raw data information was not provided. Four other locations in Germany have since installed the devices. This device relies on the wastewater treatment plant to accept and treat the resulting pollutant load. If the controls to prevent sanitary sewer back-up fail, raw sewage could enter the storm drain system. The likelihood of this occurring is unknown.

Technical/Engineering Feasibility. The location of storm drain inlets to be retrofitted would need to be above and proximate to the sanitary sewer lines. In addition, excess capacity (beyond planned growth allowances and normal wet weather inflow) is necessary in the sanitary sewer. The HydroSwitch would be installed in a vault on the storm sewer system. Dry weather flows enter through the open sluice gate up to the sanitary sewer capacity limit under gravity flow conditions. Using hydraulic controls, the sluice gate will close automatically if limits are exceeded or if the sanitary sewer backs up. Floatables are retained when the sluice gate is closed, and deflected to the sanitary system when the sluice gate is opened.

GSA indicates that no electricity, no electrical controls, and nearly no maintenance is required. The gate is opened and closed hydraulically. This system can also be connected to an on- or off-site central control system with either automatic or hydraulic override capabilities.

O&M and Management Considerations. GNA claims lower costs for the operation and maintenance of HydroSwitch when compared to stormwater clarifiers, minimum space requirements, and limited maintenance costs. An agreement with the local publicly owned treatment works (POTWs) would be necessary before installation of HydroSwitch or similar diverters. Additionally, POTWs would need to meet with the Regional Water Quality Control Board to discuss their pollution limits in light of their agreeing to take additional stormwater discharges. Insurance that the one-way check valve to the sanitary sewer would not fail is necessary and maintenance to ensure this over the life of the system should be considered. The technology is new and virtually untested. Therefore, this study assumes the device would need to be replaced after 15 years.

Costs. See Table 2 and Appendix A for detailed cost information. The average cost of installation in Germany is 50,000 to 70,000 DM, not including civil works costs. GSA estimates costs in North

America to be \$20,000 to \$30,000, not including civil works costs. Budget costs for the HydroSwitch unit, including equipment except for the concrete, are \$10,000 US for a six-inch diameter unit and \$20,000 US for a twelve-inch diameter unit. Costs for maintenance are not provided, but the company claims the system is completely automated so costs should be low once the technology is proven. For this study a per unit cost of \$30,000 is used to include concrete and other civil costs.

Because this is an untested technology, maintenance and monitoring is assumed to be quarterly for the first two years and twice per year thereafter. Labor cost estimates are based on two FTE employees at \$55 per hour for two hours to clean and monitor, and four FTE, two days at \$65 per hour to install. Installation includes coordination with sanitary sewer personnel. Replacements after 15 years are assumed necessary. Additional initial costs of \$2,500 to coordinate with the wastewater treatment plant personnel are assumed. This estimate does not include the additional cost to treat the extra constituents at the wastewater treatment plant. Total cost estimates over the twenty-year planning period, based on these assumptions are \$485,600, or \$304,700 present value.

End-Of-Line Units

We considered two end-of-line trash units: the Continuous Deflective Separation Device (CDS), and the Ecosol 1000. These units are installed in stormwater lines, so they collect water from several inlets. The CDS uses radial and tangential forces to trap suspended particles (see Attachment 7). Water is forced through the device in such a manner that solids are caught in a separation chamber that keeps them in continuous motion to prevent floatables from clogging the screen. Heavier pollutants fall into a sump where they are contained and removed. This allows water to pass through and continue downstream. An overflow weir allows bypass of the device during large floods.

The Ecosol RSF 1000 consists of a concrete pit and uses a filter screen basket to remove solid pollutants (see Attachment 8). Like Ecosol's side entry pit traps, this unit has an overflow mechanism that activates when the basket is full.

Effectiveness. The CDS device has been tested in Australia. The Australian field study monitored the device in a 124-acre study area containing 192 storm drain inlets (Allison, et al., 1997). The CDS device posted a 100 percent removal rate of all debris and litter over a three-month period. The company claims captures of greater than 95% of litter and debris.

Based on independent testing, Ecosol claims its RSF 1000 unit captures more than 95% of litter and large debris down to 3 mm and less. Ecosol claims captured pollutants are not remobilized, and toxic fermentation does not occur. The overflow helps prevent pipe blockage and localized flooding.

Technical/Engineering Feasibility. CDS devices are complex and expensive to install, according to Allison et al. (1997). CDS units have a small footprint and the covers do not protrude above ground level. For areas less than 2 hectares (approximately 5 acres) fiberglass units are installed. Once excavation occurs, installation of larger sizes takes two to three and a half days including installation of connection collars and diversion weirs. The largest size cast-in-place units take a longer time to construct (Howard, 1999). CDS recommends sizing the units to treat the three to six month storm events (equivalent to a half-inch of rain per hour).

The footprint diameter of the unit ranges from 4.5 to 9.5 feet depending on the size (2-22 acres impervious area treated). Sump storage ranges from 0.7 yd³ to 1.9 yd³ to control runoff flows from 1.1

cfs to 11 cfs. A diversion weir box, when pre-assembled, does not require a crane to place it. The unit is installed off the pipeline and is backfilled with gravel or sand. This reduces the compaction effort. The screen is non-blocking and non-mechanical.

The oil and grease sorbents float on the top of the sump. They do not appear to mix well in the water column. CDS devices have a design headloss that ranges from 0.31 to 0.78 feet depending on the size of the unit. The headloss could be a significant problem in the South Bay especially in municipalities such as Santa Clara that have very little elevation change. Ecosol claims its simply designed RSF 1000 does not incur head/hydraulic loss and does not affect stormwater inlet capacity. The unit can be constructed on-site and retrofitted to existing pit locations. The materials used resist corrosion.

O&M and Management Considerations. Once built, the units require cleaning about once every three months at one location in a catchment. The unit is below ground and confined space procedures may be needed or a waiver obtained. CDS recommends annual inspection and power washing of the screen, and inspection after the first storm. Pollutants should be removed from the sump when the sump is $\frac{2}{3}$ to $\frac{3}{4}$ full. If used, oil and grease sorbents should be replaced when completely discolored or coated with oil. These would likely need to be replaced more often than quarterly.

Maintenance to the Ecosol RSF 1000 can be performed using a vacuum truck or special basket liners. The filter screens can be removed easily, according to company literature.

CDS has offices in Morgan Hill, CA, and the Australian-based Ecosol is seeking to expand its operations to the United States. Both units are expected to be functional through the 20-year planning period.

Costs. Ecosol did not have cost data for the U.S. readily available.

For the CDS unit, costs are based on a \$13,200 installation cost and cleanout costs of \$300 (Howard, 1999). Labor to maintain the units are assumed to include two \$55/hour employees two hours each to clean the smallest unit. We assumed the units would be cleaned five times yearly. See Table 2 and Appendix A. The smallest CDS unit, which would serve a 25-acre catchment area (as opposed to the approximately 0.1 acre catchment area estimated for a 1-block length commercial area) was analyzed here. Based on this model and over a 20-year planning period, total costs are estimated at \$74,800 (\$50,100 net present value). This study did not examine whether larger sized units would be more cost effective to construct and maintain, although the assumption is that they would be if properly sited.

COMPARISON OF ALTERNATIVES

The best alternative for collecting trash or dry weather flows is one which is economically viable, can maximize pollutant reductions and does *not*: (a) clog and cause flooding, (b) adversely affect hydraulic head loss, (c) result in leaching of pollutants from captured materials, (d) require expensive and frequent maintenance, and (e) reduce the inlets flow capture capacity significantly, or (f) pose a public safety risk (Pitt, et. al., 1998; Gapper et al, 1997).

Table 3 provides a summary comparison of the alternatives. In terms of effectiveness, the catch basin retrofit, side entry pit trap, storm drain litter inserts and in-line deflective devices can also trap trash and debris. The side entry pit trap and the litter storm drain insert would not be useful in trapping dry weather flows. The deflection to sanitary sewer alternative would be more useful for capturing dry

weather flows rather than trash and debris. Some pollutant leaching could occur for all alternatives, although it may be less likely to occur for in-line deflective devices. Catch basins and side entry pit traps require moderate maintenance; storm drain inserts require high maintenance, and in-line deflective devices require less maintenance. Deflection to sanitary sewer may not require high maintenance but would require a high proportion of monitoring.

In terms of technical and engineering feasibility, the Deflection to sanitary sewer alternative is virtually untested. Storm drain inserts can clog easily although they and the side entry pit trap have overflow guards to protect against localized flooding. As with all the alternatives, they need to be properly maintained to be effective. The in-line vortex deflective devices may cause significant hydraulic head loss, which can severely limit their applicability within portions of the Santa Clara Valley. However, they can be sized to capture end-of-line flows, which can greatly decrease their maintenance costs in areas where head loss is not a problem. Storm drain inserts have small inlet flow capacity, and catch basins have more capacity than regular inlets due to the sump size.

The catch basin retrofit and side entry pit trap alternatives are both assumed to require 12 monitoring and/or cleanings per year per unit, whereas the in-line deflective devices need maintenance or cleaning only approximately 5 times per year. Once in place, the in-line deflective devices are quite cost-efficient in terms of maintenance because only one unit is necessary to do the work of several catch basins retrofits, side entry pit traps, or storm drain inlets. Considering the area treated, these devices are reasonably priced if the initial capital cost can be afforded. Storm drain inserts are low in price, but require high maintenance costs. The side entry pit trap and catch basin retrofit alternatives are both reasonably priced for new developments, but would be expensive for retrofits. The sanitary sewer deflection device is very high cost considering its untested.

The ability of catch basins to collect and infiltrate dry weather flows is limited by the Santa Clara Valley Water District's concerns that unlined catch basins may negatively impact ground water aquifers. Besides being untested, the deflection to the sanitary sewer device is limited by the need to have a sewer system with excess capacity in close proximity to the storm sewer.

SUMMARY AND RECOMMENDATIONS

The feasibility of using these devices, and selection of the most appropriate device, depends on site conditions, existing structures, and the maintenance capabilities of the local program.

For high-use areas in new or redeveloped projects, side entry pit traps should be considered (once the technology is easily available in the United States). Catch basin installation would also be effective in the same areas. Catch basins should include both a hood and a trash rack. (However, the trash rack increases the required maintenance frequency.) Maintenance should be conducted approximately 12 times per year, especially just prior to, and after, the first storms of the wet season.

For existing high-use areas, where reconstruction of the drainage system is not contemplated, trash-collecting inserts might be effective, but only if they can be properly maintained. For this study, they were only considered for dry weather periods. To be truly effective throughout the year, they would need to be inspected after every storm. Although generally infeasible, such a scenario could work in

specific areas (e.g. some public plazas and high-use commercial areas) where there are already resources and a commitment to very frequent maintenance for aesthetic reasons.

The in-line deflection separator units may provide the most feasible and cost effective (per-unit-area) debris removal. The units are expensive to install, but maintenance is less frequent and easier to accomplish. This alternative is recommended for areas where head-loss is not a concern.

The larger end-of-line units would trap large-size solid pollutants in runoff from larger catchment areas with lower maintenance costs, in comparison to the at-source units or smaller end-of-line units. These units are relatively expensive, and require hydraulic head, but could be practical if planned in conjunction with new or upgraded stormwater pump stations.

The HydroSwitch filtration device is a creative, interesting device, but has limited applicability in the Santa Clara Valley. Such a device could only be used in specific locations where the sanitary sewer was in close proximity and had surplus hydraulic capacity. Its implementation would raise concerns about adding to pollutant and hydraulic loads of the receiving POTW. Implementation would also require overcoming institutional hurdles to obtain approval for discharge to the sanitary sewer.

It is not recommended to use catch basins or other devices to deliberately collect wash waters and other dry water flows for later removal (e.g. during hosing or pressure cleaning of sidewalks and plazas). Allowing some dry weather flows down certain storm drains would confuse the public and undermine the “no dumping” message. Better to block the drain and remove the accumulated washwater directly from the gutter, per currently adopted BMPs.

Implementation of BMPs, education and enforcement remain the recommended method for preventing dry weather discharges to storm drains.

Recommended Next Steps

It is recommended that Program staff work with the Management Committee to identify a Co-permittee to implement a pilot project to do the following:

1. Create an inventory of high-use and high-litter areas (based on staff knowledge and maintenance records).
2. Review capital improvements projects lists and current developer-sponsored public works improvement plans and identify potential opportunities to incorporate retrofits into drainage improvement projects and street reconstruction projects.
3. Develop and prioritize a list of potential retrofit projects, which may include new installation, retrofit construction, or use of catch basin inserts.

While maintaining consistency with the pilot project recommended above, the Program should:

1. Coordinate with a Co-permittee staff ad-hoc task group to investigate and develop specific recommendations regarding inlet screen inserts.
2. Coordinate with a Co-permittee staff ad-hoc task group to work with manufacturers to develop model designs for side-entry pit traps and modified catch basins.
3. Continue to track availability and municipal experience with in-line deflection separator units.

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