A SURVEY OF INSTALLATION AND MAINTENANCE COSTS OF STORMWATER TREATMENT FACILITIES

for

By

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Preface

The New Development Committee of the Bay Area Stormwater Management Agencies Association (BASMAA) undertook this project with the objective of determining the cost impact of new permit requirements on affected local jurisdictions in the San Francisco region. The general lack of experience with stormwater treatment facilities in the Bay Area meant that the Committee had to look elsewhere for information. The survey focused on western Washington and Oregon, as many of the communities in this region have required detention and treatment in individual developments for over a decade. Unfortunately, the survey results were less than definitive. Many of the surveyed municipalities either did not maintain their treatment controls or did not collect information on the cost of doing so. When information was gathered, it was collected and reported differently by each municipality.

Despite the lack of definitive answers, the New Development Committee members felt that the results, although not what were hoped for, are the results and that as such they are informative. To avoid a similar situation developing in the Bay Area, BASMAA's New Development Committee recommends that municipalities:

- Collect information on the following costs related to treatment controls:
  - drainage review
  - construction/purchase-installation
  - operation
  - inspection
  - maintenance
- Ensure that stormwater treatment facilities are inspected and maintained

Note that the values reported in this survey are for the Pacific Northwest and do not necessarily represent the San Francisco Bay Area, the values of which are likely to be significantly higher.

Table of Contents

Tables

Attachments

The Water Quality Control Board, San Francisco Bay Region (Regional Board), is modifying NPDES permits of local jurisdictions to require detention and treatment of stormwater in new and redevelopments. The objective of the study is to determine the cost impact of the new permit requirements on affected local jurisdictions in the San Francisco region. Four costs are of interest:

- The *drainage review fee* for local government to evaluate the engineering plans for the stormwater facilities
- The cost to local governments *to inspect* installed stormwater facilities to be certain that owners are carrying out the appropriate maintenance.
- The *cost to maintain* treatment facilities
- The *cost to private development* of stormwater treatment facilities

SURVEY APPROACH

Local governments and development-engineering firms currently implementing detention and treatment requirements were interviewed by phone and email. The survey focused on western Washington and Oregon, as many of the communities in this region have required detention and treatment in individual developments for over a decade. The geographical exception is Austin, Texas. The communities were queried on fees for drainage review, and costs for post-construction inspection and maintenance. The persons contacted at each of the jurisdictions are presented in Attachment A. Consulting firms were asked to provide information on the approximate percentage of a development consumed by detention/treatment facilities, and approximate cost as a percentage of total development costs. The first question is relevant to residential developments where the detention/treatment facilities are typical on the surface. Commercial facilities are generally subsurface given the opportunity cost of the land. Additionally, the cost analysis conducted by the Regional Board as to the impact of the regulations on new development is reviewed.

DRAINAGE REVIEW FEE SURVEY

Thirteen communities were queried: eight in the Seattle area, three in the Portland area, one in eastern Washington, and Austin, Texas. Of 13 communities queried, twelve have responded. The results summarized in Table 1 indicate a wide range of fees and fee structures. There are four general rate structures:

Fixed fee: Two communities - Portland, Oregon and Clark County, Washington

Hourly rate: Three communities – Bellevue, Mountlake Terrace, and Seattle, Washington

Base fee plus hourly rate: Two communities, King County and Federal Way, Washington. For the base fee, a certain number of hours are given, most likely equal to the base fee divided by the hourly rate.

Base fee plus acreage charge: The remaining five communities include an additional charge based on number of lots, square footage, and/or length of pipe.

TABLE 1 SURVEY OF DRAINAGE PLAN REVIEW FEES

Municipalities reported a wide range of fees and fee structures.

CITY	FEE STRUCTURE	FEE VARIES WITH TYPE OF DEVELOPMENT?	COMMENTS
Austin, Tx	Fee structure by size of development: $1,270 at 0.5 acres rising to $1,765 at 10 acres. For each additional acre above 10 additional $10 per acre.		
Bellevue, Wa.	$64/hour	No	Cost can go into "thousands of dollars" depending on the development
Clark County, Wa.	$3000	Lower fee for short plats	Grading and clearing separate
Federal Way, Wa.	$600 for first 12 hours plus $50/hour per additional hour	Minimum charge less for short plats	Fee is for entire plan review (after platting process), not just drainage. Also charge $44/hour for construction inspection.
Gresham, Or.	$803 per 2,500 ft^2 of impervious surface	No	
King County, Wa.	$440 base plus $132/hour	No	Average total cost of $1,400, to $5,000 for complex developments. Clearing and grading are separate fees.
Mountlake Terrace, Wa.	$66 per hour	No	Minimum of 40 hours is typical.
Olympia, Wa.	$307 base per onsite system + $23.15 per acre plus $2.29/lf of storm drain line	No	
Portland, Or.	$98 to $196	$98 per residential, $196 per commercial	Add $114 if there is a pollutant source control review
Redmond, Wa.	Base $1400 for review of clearing, grading, and drainage plus inspection	For areas greater than 30,000 ft^2, add $9 for each additional 30,000 ft^2. For areas 5,000 to 30,000 ft^2, add $15 for each additional 5,000 ft^2.	
Seattle, Wa.	$125/hour	No	Average 6 hours per development, as most reviews are of single lot developments. $125 for first hour of inspection plus $95/hour for additional review.
Snohomish County, Wa.	Residential: $375 plus $60 per lot; Commercial: $375 plus $60 per acre. Additional charges to review revisions.		Drainage construction review fee is equal to what is charged for plan review.
Spokane County, Wa.	No response		

Given the wide disparity in charges, it is unlikely that all communities recoup their costs. Portland and Clark County charge set fees about $200 and $3,000, respectively. The significant difference in the fee is in part due to the difference in development size. Most of Portland's developments are single lot residential, whereas the less developed Clark County has large residential and commercial developments. Nonetheless, it is unlikely that the City of Portland is covering its full review costs. Bellevue and Mountlake Terrace charge $64 and $66 per hour, respectively, whereas Seattle charges $125. The latter seems high for a city employee. Few jurisdictions provided information on the number of review hours, but it appears to be on the order of 40 to 80 hours for most reviews, which are for small residential and commercial developments. Jurisdictions charge separate fees for grading and clearing review.

POST-CONSTRUCTION FACILITY INSPECTION SURVEY

The purpose of inspecting treatment facilities after commencement of operation is to ascertain if they are properly maintained. Aspects inspected include sediment level, clogging of outlet structure, integrity of fencing, integrity of access manholes and ladders for vaults, channelization and otherwise inadequate grass cover in swales. Jurisdictions have guidelines for the inspector and the owner that specify maintenance actions to occur as a function of facility condition.

The same 13 communities were queried of which twelve responded. The results are summarized in Table 2. Ten of the twelve responders have an inspection program. Only Portland and Spokane County do not. The frequency of inspection varies widely from minimal to annual. Many communities have facilities they own, inspect, and maintain. These are typically regional, serving a basin or subbasin. With some communities, the inspection and maintenance budget for the public facilities includes the cost of inspecting the private facilities. As a consequence, the budget just for inspection of private facilities cannot always be discerned. King County is unique in that it has maintained all single-family residential facilities for over a decade.

The cost to inspect a facility ranges from about $53 to $575, for the seven communities whose information was sufficient[1], with an average cost of $270. The cost for most jurisdictions is between $200 and $300. The wide range suggests differing intensities of inspection between the jurisdictions. It is possible that the actual frequency of inspection differs from the information provided by some communities. There does not appear to be an economy-of-scale; i.e., cost per facility is not less for the communities with more facilities. King County has the most experience, and therefore its costs are the most reliable. Their inspection cost per commercial facility is about $200. For planning purposes, a cost of $300 seems reasonable. The California Stormwater Quality Association (CASQA, 2003) *Stormwater Best Management Practice Handbook – Municipal* fact sheets for treatment controls list inspection activities, which more or less provide an indication of inspection costs.

STORMWATER FACILITY MAINTENANCE SURVEY

The focus is the cost to local government to maintain facilities, either those it owns or private facilities for which the local government has assumed responsibility. The data are provided in Table 2. Four communities provided sufficient information to estimate the annual cost of maintenance per facility. These are: Bellevue; ~ $130; King County, ~ $1,000; Olympia,

[1] For those communities that provided only full-time equivalent staff values (FTEs), $100,000 annual cost was assumed per FTE (Table 1).

TABLE 2 SURVEY OF INSPECTION AND MAINTENANCE OF STORMWATER FACILITIES

Wide range of inspection costs suggests differing intensities of inspection between the jurisdictions.
Maintenance costs most likely reflect the available budget, not what is necessary.

CITY	NUMBER OF FACILITIES	FACILITIES INSPECTED/YEAR	INSPECTION BUDGET	MAINTAINS PRIVATE SYSTEMS?
Austin, Tx.	No response			
Bellevue, Wa.	302 public facilities[1]	100%	$15,000	$39,000 to maintain public facilities
	1,500 private facilities	50%	2.2 FTE	No
Clark County, Wa.	~275	100%	<1 FTE	No
Federal Way, Wa.	~650	100%	2 FTE, $150,000	No
Gresham, Or.	Unknown	10 to 15% per year	No formal budget	Budget $400/year for those owned by City
King County, Wa.	1,215 SF residential 165 regional	Residential and regional: Varies with history of the facility	$350,000	Single-family residential, budget is $1,270,000
	850 commercial	Commercial: annual	$175,000	
Mountlake Terrace, Wa.	~190	Infrequent, will increase to once/2 years soon	NA	No
Olympia, Wa.	~300	50%	0.5 FTE, ~$30,000	Maintain 25 public facilities, budget $44,000.
Portland, Or.	Information not available	Information not available	Information not available	Information not available
Redmond, Wa.	~1,300	50%	1.5 FTE + $5,000 direct costs. Does not include vehicle usage cost	Yes, about 30. Cost not broken out from overall storm maintenance budget, not part of the inspection budget of private facilities.
Seattle, Wa.	~2,800	Annual to three years	1.3 FTE	Do not inspect single family residential
Snohomish County, Wa.	~300	33%	$500,000 (this includes maintenance)	Maintain ~50 facilities
Spokane County, Wa.	Information not available	Information not available	Information not available	Information not available

1. These include originally private facilities that are located in the public-right-of-way and therefore are maintained by the City.

~$1,750; and Gresham, $400. These maintenance costs are generally for publicly-owned facilities that may include a few formerly private facilities that the jurisdiction has taken responsibility for. However, in the case of King County, it maintains all single-family residential facilities. There are no shared costs between private owners and the jurisdiction. While the data are very limited, a wide difference in costs is found. It should be recognized that maintenance costs most likely reflect the available budget, not what is necessary. King County has by far the greatest range and depth of experience, and has the largest inventory (that are maintained). Therefore, its unit cost of $1,000 per year is probably the most realistic.

Generally, maintenance involves the removal of sediment and debris from outlet control structures, removal of litter from the operating area of the facility, grass mowing and related landscaping activities, fencing repairs, and the graveling and grading of access roads. The most significant item seems to be landscape maintenance. It should be noted that these maintenance costs cover three general categories: detention facilities, treatment facilities, and combined detention/treatment facilities. Most of the facilities in the current inventory are detention facilities. This is because detention requirements have been in place for nearly two decades for most jurisdictions, whereas treatment facilities have been required only since the mid-1990s. The California Stormwater Quality Association (CASQA, 2003) *Stormwater Best Management Practice Handbook – Municipal* fact sheets for treatment controls list maintenance activities, which more or less provide an indication of maintenance costs.

STORMWATER FACILITY CONSTRUCTION COSTS

Data from western Washington: Cost data (construction only) were obtained for 33 projects, a combination from this project and a previous assignment. The cost data are of development projects in western Washington. As the projects occurred over several years, the construction costs were updated to the year 2002. The data are presented in Table 3. Included with each project are the type of land use, the drainage acreage, construction cost, and the per acre cost. Land costs are not included. Both new development and retrofit projects are included in the cost analysis (as the analysis indicated no significant difference).

Generally, surface facilities (e.g., wet ponds and swales) are used in residential developments, and sub-surface facilities (e.g., vaults) are used in commercial developments, particularly retail commercial developments. Surface facilities are often used in non-retail developments (e.g., commercial office parks). The decision is driven by land cost, and the opportunity cost. Opportunity cost is the revenue lost by the businesses because the land is not available for parking. This is particularly relevant to retail businesses.

The results of the analysis are presented in listed in Table 3. The analysis indicates that the cost per acre of development varies tremendously, to the point of making it difficult to draw firm conclusions. The reasons for the significant differences within each treatment best management practice (BMP) are unclear. Placing facilities subsurface increases cost significantly. But with consideration for land and opportunity costs, the costs of subsurface are likely similar to surface facilities, depending on the land use. It is likely the opportunity cost, introduced above, is the deciding factor in choosing between a surface and subsurface facility. As for differences between the BMPs, grass swales are clearly the least expensive. The costs for ponds, vaults, and sand filters are similar when factoring in the cost of land.

The State of Washington conducted an analysis of the effects of its new manual on new developments[2]. Three scenarios were evaluated, with two treatment situations considered for one scenario. The estimated per acre construction costs (excluding land) are shown in Table 4. It is not understood why the sand filter was selected for the analysis in as much as they have seen little application in Washington. They are expensive if there is little head to drive the water (i.e. little topographical relief). The costs in Table 4 are in the range of those of projects listed in Table 3.

TABLE 3 STORMWATER TREATMENT BMP CONSTRUCTION COST

Cost per acre of development varies tremendously with the reasons being unclear.

#BMP Type	New or Retrofit	BMP Construction Cost[1]– 2002	Development Acres	BMP Cost[1]/Acre Development
1 Wet pond	New	$45,000	6.1	$7,377
31 Wet pond	Retrofit	$52,000	31.5	$1,651
32 Wet pond	Retrofit	$30,000	13	$2,308
5 Wet pond	New	$68,000	7.5	$9,067
7 Wet pond	Retrofit	$236,029	27	$8,742
33 Extended detention pond	New	$120,500	40	$3,000
2 Wet vault	New	$57,000	0.8	$71,250
3 Wet vault	New	$72,000	1	$72,000
12 Wet vault	New	$51,500	0.42	$122,619
17 Wet vault	New	$158,074	5.5	$28,741
18 Wet vault	New	$158,074	12.9	$12,254
19 Wet vault	New	$158,074	6.9	$22,909
20 Wet vault	New	$177,170	14.4	$12,303
10 Oil/water separator	Retrofit	$1,352,861	30	$45,095
11 Oil/water separator	Retrofit	$245,975	5	$49,195
21 Oil/water separator	New	$62,593	5.5	$11,381
22 Oil/water separator	New	$62,593	12.9	$4,852
23 Oil/water separator	New	$62,593	6.9	$9,071
24 Oil/water separator	New	$61,532	14.4	$4,273
25 Swale+vault+o/w	New	$222,789	5.5	$40,507
26 Swale+vault+o/w	New	$222,789	12.9	$17,270
27 Swale+vault+o/w	New	$222,789	6.9	$32,288
28 Swale+vault+o/w	New	$232,337	14.4	$16,135
8 Swale	Retrofit	$54,636	27	$2,024
13 Swale	New	$2,451	5.5	$446
14 Swale	New	$2,074	12.9	$161
15 Swale	New	$1,948	6.9	$282
16 Swale	New	$4,714	14.4	$327
6 Sand filter	New	$106,000	10	$10,600
4 Sand filter vault	New	$50,000	1	$50,000
9 Sand filter	Retrofit	$221,824	27	$8,216
29 Stormfilter	New	$31,827	5.13	$6,204
30 Vortechs	New	$35,500	7.2	$4,931

1. Land costs are not included.

[2] Washington Department of Ecology, 2001 (August), Cost Analysis: Washington Department of Ecology Year 2001 Minimum Requirements for Stormwater Management in Western Washington.

TABLE 4 WASHINGTON DEPARTMENT OF ECOLOGY ANALYSIS
Estimated costs are within the wide range of those listed in Table 3 for similar projects.

DEVELOPMENT	TREATMENT FACILITIES	BMP CONSTRUCTION COST[1] PER DEVELOPMENT ACRE
10 acre single-family residential	Wet vault	$8,600
1 acre commercial	Subsurface sand filter vault	$7,200
10 acre commercial	Surface sand filter vault	$11,200
10 acre commercial	Subsurface sand filter vault	$36,000

1. Land costs are not included.

When considering the above cost information, the climatic and regulatory differences between western Washington and the San Francisco Bay Area should be recognized. How the size of a facility is affected by rainfall patterns depends on the type of treatment BMP. Rainfall intensity controls the size of BMPs whose size is determined by peak rate such as swales. The average rainfall intensity for the San Francisco Bay area is about 25% greater than western Washington. Whether peak intensities are correspondingly greater is unknown. This difference implies that facilities in the Bay Area will be larger. However, counterbalancing the greater rainfall intensity is the lower management goal: 85% storm volume for the Bay Area, but 90% for western Washington.

Storm depth and the interevent time between storms controls the size of treatment BMPs whose size is based on volume, such as extended detention basins and wet ponds. The average storm depth of the San Francisco Bay Area is about 10% (Oakland) to 30% (San Francisco) greater than western Washington, implying larger facilities. However, the interevent time between storms is much greater in the Bay Area, by about a factor of two. Hence, the effects of these two rainfall factors tend to cancel each other, suggesting that facility size will be similar between the two regions. Furthermore, as noted above the treatment goal is lower for the San Francisco Bay Area.

Analysis of Regional Board cost estimates: The Regional Water Quality Control Board has prepared planning-level cost estimates to ascertain the impact of the new regulations on new developments. Only treatment facilities were included in the cost estimates. Each is presented below with this Consultant's analysis.

Project #1 - *Extended detention basin* [3]

Water Quality Control Board estimate

Development type: warehouse site
Development area: 5.5 acres
Total development cost: $6,674,000
Treatment system: Volume of 22,600 ft^3
Cost: construction, $18,414; land cost, $55,000; annual maintenance $33.
Added cost as a percent of development: 1.1 percent

[3] The Regional Board has subsequently questioned the results of this case study, which was conducted for them early in their process of ascertaining the impact of the new regulations on development projects.

Consultant's Analysis: This analysis suggests that the Regional Board's estimated cost for a surface basin is low. There appear to be several items missing from the estimate (see Attachment B). Furthermore, the assumed basin depth (10 feet) may not be realistic for most situations. The available elevation drop from the site to the public storm drain in the street limits operating depth. A more typical elevation drop is 5 feet limiting the operating depth in the basin to 5 feet. Reducing the operating depth from 10 to 5 feet doubles the cost of the land. Regardless, a subsurface facility appears less expensive, when considering the cost of land. For a subsurface facility, this Consultant's estimate of construction costs is $93,000. Adding 50% for engineering, permitting, and planning level uncertainty raises the cost to $140,000. Furthermore, a maintenance cost of $2,000 per year, not $33, is more realistic, for a total cost of $100,000 over 50 years (using the Regional Board's assumption in Project 2 below). These cost figures result in a cost impact of 3.6 percent of development cost. On a per acre basis, the Regional Board's analysis indicates about $25,000 for construction. This compares to $25,000 to about $75,000 for most of the wet vault projects in Table 3, suggesting the Regional Board's estimates are low. Using the figure of $75,000 per acre, the impact on the development is about 7.8%.

Project #2 *Wet basin*

Water Quality Control Board estimate

Development type: office/light industrial/R&D campus-type
Development area: 21.8 acres
Total development cost: $58,500,000
Treatment system: Volume of 61,000 ft^3, occupying 0.4 acres.
Basin cost: Construction, $68,000 to $193,000 including 25 percent for engineering; land cost, $294,000; annual maintenance $500 to $2,600/year for total of $25,000 – 130,000.
Added cost as a percent of development: 0.66 to 1.05 percent.

Consultant's Analysis: This Consultant's issue is with the initial assumption on the size of a wet basin. The technique the Regional Board used is for the sizing of extended detention basins, not wet basins. The sizing of both of these systems is based on its volume relative to the volume of the mean annual runoff event. For extended detention, the Water Environment Federation (WEF)[4] method gives a volume of about 1.5 times the mean annual runoff event, the approximate ratio used in the Regional Board analysis. It is not based on performance, but rather aggregate stormwater runoff that is captured (90%) over many storms.

However, the United States Environmental Protection Agency (USEPA) method[5] for sizing a wet basin gives a volume of about 2.5 times the mean annual event, to get 80% total suspended solids (TSS) removal. Clearly, the expectation is that an extended detention pond does not perform as well as the wet basin, given that it is much smaller. This is arguable. But, the question of what BMP to prescribe and sizing remains open. Extended detention will be very popular in California because of concerns for vector control with systems that have permanent wet pools (wet ponds and constructed wetlands). But if extended detention is a popular BMP, it should be sized such that it more closely corresponds to a wet pond size. Although not actually required now under the stormwater permits, it seems reasonable to be conservative in this regard at this time.

The costs identified by the Regional Board for their basin seems reasonable, except for the assumption of 25% for engineering, etc. Although the 25% figure was based on a reference to a

[4] WEF Manual of Practice 23, 1998, Urban Runoff Quality Management.

[5] USEPA, 1986, Methodology for Analysis of Detention Basin for Control of Urban Runoff Quality, USEPA 440/5-87-001, Washington, D.C

1991 literature review[6], actual implementation experience since then suggests that a more realistic figure would seem to be about 50%. Hence, with this factor plus 60% for a larger facility to correspond to this Consultant's view, the impact on new development is 1.1 to 1.7%. The per acre cost just for construction comes to $8,000 to $21,500, to compare with costs in Table 3.

Project #3 *Grass swales*

Water Quality Control Board estimate

Development type**:** office/light industrial/R&D campus-type
Date of estimate: October 10, 2001
Development area: 21.8 acres
Total development cost: $58,500,000
Treatment system: five grass swales**,** occupying 9,500 square feet (0.22 ac).
Swale cost: construction, $$15,200, no 25 percent for engineering; land cost, $167,100 to 330,000; annual maintenance $790/year, $39,500 over 50 years.
Added cost as a percent of development: 0.4 to 0.5 percent.

Consultant's Analysis: Swales are the least expensive best management practice (Table 3) and as noted below, historically one of the most common. The question is how representative it is to use this BMP for projecting costs for all BMPs. That swales are not used on all sites suggests there are issues besides costs that dictate the BMP selected[7].

OTHER ITEMS AND FINAL CAVEATS

The information in Table 3 is insufficient to make observations about the most commonly used treatment systems. An informal survey by the Washington Department of Ecology conducted about five years ago found that about 50% of treatment systems are swales, the rest are mostly wet ponds. Constructed wetlands are not common given land area requirements. Few sand filters exist. Most commercial facilities are subsurface. Manufactured products, in particular the StormFilter are finding considerable use in commercial developments given their small footprint in comparison to a wet vault. Vortex separators are used little in private developments as they are not yet approved by local jurisdictions in the Pacific Northwest. They are finding use in road projects.

While swales are the least expensive it is important to recognize that current design criteria being used in western Washington may result in swales that are too small, particularly if the longitudinal slope of the swale is greater than 2.5%.[8]

[6] Southeastern Wisconsin Regional Planning Commission, 1991, Costs of Urban Nonpoint Source Pollution Control Measures.

[7] A survey by the Washington Department of Ecology found that about 50% of the installed treatment devices are swales.

[8] Colwell, S., 2001, Characterization of performance predictors and evaluation of mowing practices in biofiltration swales, M.S. Thesis, University of Washington, Seattle, Washington.

ATTACHMENT A
LIST OF CONTACTS FOR TABLES 1 AND 2

Fee survey

Austin, Tx: Lucy Allathan (512) 974-2669
Bellevue, Wa.: Lisa Austin Laustin @ci.bellevue.wa.us
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Mountlake Terrace, Wa.: None
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Redmond, Wa.: Lisa Rigg, (425) 556-2758
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ATTACHMENT B
Analysis of Regional Board cost estimates

Project #1 - *Extended detention basin*

Development type: on warehouse site
Estimator: Water Quality Control Board
Date of estimate: July 11, 2001
Development area: 5.5 acres
Total development cost: $6,674,000
Treatment system: Volume of 22,600 ft^3
Basin cost: construction: $18,414; land cost, $55,000; annual maintenance $33.
Added cost as a percent of development: 1.1 percent

Analysis: This Consultant's analysis:

- Need an outlet flow control structure. With a surface facility, this is a manhole with an orifice system to control outflow rates. *Add $3,500.*
- The excavation accounts for the operating volume. Must add freeboard, increasing excavation by about 20 percent including some over-excavation, raising the excavation cost. *Add $3,500.*
- A basin of 10 feet is assumed. With freeboard and drop to the public drainage system, this requires about 12 feet of elevation, not likely available in most cases. A more likely basin depth is 6 feet, 5 for live volume and 1 foot freeboard. This doubles the land requirements. *Add $55,000.*
- The analysis appears to assume vertical walls, but the cost is not included. Either retaining walls and a concrete bottom must be added, or if left earthen, the basin walls must be sloped. Either increases excavation and land costs. Assuming an open earthen and sloped (2:1) basin, adds 20% on land requirements. *Add $22,000.*
- With a surface facility, include a fence (300 ft). *Add $6,000*.
- Include rock in pond to avoid erosion and resuspension (75 cy). *Add $1,500.*
- However, as this is a warehouse site, it is likely the facility is placed subsurface given the value of the land. If so, the above three cost items are replaced with a precast vault ($50,000), additional excavation ($20,000). Replace above three items *with $70,000.*
- Maintenance costs: King County estimates $1,400 per facility (all types) per year (Table 2). In a 1995 analysis of costs, the county estimated an annualized cost of $2,200 to maintain a vault. Bellevue recently cleaned a vault with a volume of about 80,000 ft^3 after about ten years of operation. Cost was about $50,000, giving an annual cost of about $5,000. For this estimate, assume $2,000 per year for 20 years discounted to present worth at 5 percent, which gives $15,000 in present worth. Note: the cost is not incurred each year as the vault is cleaned about every 5 years.
- Add 10% for mobilization.

ATTACHMENT C
GLOSSARY OF TREATMENT CONTROLS

(Adapted from California Stormwater Quality Association *Stormwater Best Management Practice Handbook – New Development and Redevelopment*, 2003)

Public Domain BMPs

Bioretention – The bioretention BMP functions as a soil and plant-based filtration device that removes pollutants through a variety of physical, biological, and chemical treatment processes. These facilities normally consist of a grass buffer strip, sand bed, ponding area, organic layer or mulch layer, planting soil, and plants. The runoff's velocity is reduced by passing over or through buffer strip and subsequently distributed evenly along a ponding area. Exfiltration of the stored water in the bioretention area planting soil into the underlying soils occurs over a period of days.

Constructed wetland – Constructed basins that have a permanent pool of water throughout the year (or at least throughout the wet season) and differ from wet ponds primarily in being shallower and having greater vegetation coverage.

Extended detention basin – Dry extended detention ponds (a.k.a. dry ponds, extended detention basins, detention ponds, extended detention ponds) are basins whose outlets have been designed to detain the stormwater runoff from a water quality design storm for some minimum time (e.g., 48 hours) to allow particles and associated pollutants to settle. Unlike wet ponds, these facilities do not have a large permanent pool. They can also be used to provide flood control by including additional flood detention storage.

Infiltration basin – A shallow impoundment that is designed to infiltrate stormwater. Infiltration basins use the natural filtering ability of the soil to remove pollutants in stormwater runoff. Infiltration facilities store runoff until it gradually exfiltrates through the soil and eventually into the water table.

Infiltration trench – A long, narrow, rock-filled trench with no outlet that receives stormwater runoff. Runoff is stored in the void space between the stones and infiltrates through the bottom and into the soil matrix.

Media filter – Stormwater media filters are usually two-chambered including a pretreatment settling basin and a filter bed filled with sand or other absorptive filtering media. As stormwater flows into the first chamber, large particles settle out, and then finer particles and other pollutants are removed as stormwater flows through the filtering media in the second chamber. There are a number of design variations including the Austin sand filter, Delaware sand filter, and multi-chambered treatment train (MCTT).

Multiple systems – Multiple treatment system uses two or more BMPs in series. Some examples of multiple systems include: settling basin combined with a sand filter; settling basin or biofilter combined with an infiltration basin or trench; extended detention zone on a wet pond.

Retention/irrigation – Refers to the capture of stormwater runoff in a holding pond and subsequent use of the captured volume for irrigation of landscape of natural pervious areas.

Vegetated buffer strip – Grassed buffer strips (vegetated filter strips, filter strips, and grassed filters) are vegetated surfaces that are designed to treat sheet flow from adjacent surfaces. Filter strips function by slowing runoff velocities and allowing sediment and other pollutants to settle and by providing some infiltration into underlying soils. Filter strips were originally used as an agricultural treatment practice and have more recently evolved into an urban practice.

Vegetated swale – Open, shallow channels with vegetation covering the side slopes and bottom that collect and slowly convey runoff flow to downstream discharge points. They are designed to treat runoff through filtering by the vegetation in the channel, filtering through a subsoil matrix, and/or infiltration into the underlying soils. Swales can be natural or manmade. They trap particulate pollutants (suspended solids and trace metals), promote infiltration, and reduce the flow velocity of stormwater runoff. Vegetated swales can serve as part of a stormwater drainage system and can replace curbs, gutters and storm sewer systems.

Water quality inlets (WQIs) – Also commonly called trapping catch basins, oil/grit separators or oil/water separators, consist of one or more chambers that promote sedimentation of coarse materials and separation of free oil (as opposed to emulsified or dissolved oil) from stormwater. Some WQIs also contain screens to help retain larger or floating debris, and many of the newer designs also include a coalescing unit that helps promote oil/water separation. A typical WQI consists of a sedimentation chamber, an oil separation chamber, and a discharge chamber.

Wet pond – Wet ponds (a.k.a. stormwater ponds, retention ponds, wet extended detention ponds) are constructed basins that have a permanent pool of water throughout the year (or at least throughout the wet season) and differ from constructed wetlands primarily in having a greater average depth. Ponds treat incoming stormwater runoff by settling and biological uptake.

Manufactured (Proprietary) BMPs

Drain insert – Manufactured filters or fabric placed in a drop inlet to remove sediment and debris. There are a multitude of inserts of various shapes and configurations, typically falling into one of three different groups: socks, boxes, and trays. The sock consists of a fabric, usually constructed of polypropylene. The fabric may be attached to a frame or the grate of the inlet holds the sock. Socks are meant for vertical (drop) inlets. Boxes are constructed of plastic or wire mesh. Typically a polypropylene "bag" is placed in the wire mesh box. The bag takes the form of the box. Most box products are one box; that is, the setting area and filtration through media occur in the same box. Some products consist of one or more trays or mesh grates. The trays may hold different types of media. Filtration media vary by manufacturer. Types include polypropylene, porous polymer, treated cellulose, and activated carbon.

Media filter – Manufactured stormwater media filters are usually two-chambered including a pretreatment settling basin and a filter bed filled with sand or other absorptive filtering media. As stormwater flows into the first chamber, large particles settle out, and then finer particles and other pollutants are removed as stormwater flows through the filtering media in the second chamber.

Vortex separators (alternatively, swirl concentrators) – Are manufactured gravity separators, and in principle are essentially wet vaults. The difference from wet vaults, however, is that the vortex separator is round, rather than rectangular, and the water moves in a centrifugal fashion before exiting.

Wetland – A manufactured wetland is similar to public domain stormwater wetlands. In a manufactured wetland, gravel substrate and subsurface flow of the stormwater through the root systems force the vegetation to remove nutrients and dissolved pollutants from the stormwater.

Wet vault – A manufactured wet vault is a vault with a permanent water pool, generally 3 to 5 feet deep. The vault may also have a constricted outlet that causes a temporary rise of the water level (i.e., extended detention) during each storm. This live volume generally drains within 12 to 48 hours after the end of each storm.