that would include, for example, periodically measuring groundwater levels from observation[2] wells and collecting groundwater samples from both production and observation wells for analyses of water chemistry. These data could then be used to identify trends (long-term changes [decrease] in groundwater levels), or changes to concentrations of constituents of concern or interest. Because the watershed divide is north of the White Rock boundary, much of the recharge zone is in South Surrey. Thus, the management strategy should be integrated between both the City of White Rock and Surrey where infiltration based BMP's are being considered in areas north of the City boundary.

Based on the information available, it does not appear as if observation (monitoring) wells (in addition to the production wells) have been installed within the City limits. Thus, the limits of our understanding of the hydrogeologic conditions under White Rock are based on only six production wells that are situated in four separate areas, making it difficult to adequately define zones of risk for the application of infiltration based BMPs without additional information. For example, it is clear that a well-defined clay barrier lies beneath the area of PW#1, 2 and 3. This clay layer may be correlated with the clay layer below PW#4, but may not be contiguous due to the lower lying topography in the intervening area. PW#5 begins in strata below the clay layer as it is much lower in elevation, so the southern extent of clay layer is limited by topography. Further, since the clay layer was not identified in PW#6, the eastern extent of the clay layer between PW#3 and PW#6 is unknown. Finally, there is no subsurface data east of PW#6 or west of PW#4, so the lateral extent of the clay layer is not known.

With these constraints in mind, preliminary risk zones were identified within the City limits. Drawing #3 depicts Zone A, which is inferred to have at least 3 m of the Vashon blue clay layer lying stratigraphically above the Sunnyside Uplands Aquifer, while Zone B has no overlying clay layer above the aquifer. The line was drawn at the projected stratigraphic top of the 3-m thick clay[3]. The stratigraphy is unknown in areas in the eastern and western parts of the city limits (noted by dashed lines with question marks). In these areas more work should be required to demonstrate the presence of an overlying aquitard above the aquifer. Table 4-1 provides preliminary recommendations for BMPs for the two zones. Risk zones are provided for general reference only. Site-specific information, as described in Table 4-1, must be obtained and provided to the City to confirm actual site conditions at any location.

In any case, because the hydraulic properties of the clay layer have been estimated for this report based on only desktop derived data, which could underestimate the permeability of the confining layer, a field assessment should be carried out to verify the soil characteristics and hydraulic properties of the confining layer. Further, the mapped extent of the confining layer should be verified in the field in conjunction with additional hydraulic conductivity testing. The hydraulic conductivity testing will help to confirm whether the 3 m thickness of the confining layer is adequate for aquifer protection.

[2] Observation wells are preferable to production wells to characterize static groundwater levels; this is because the water levels in production wells are intermittently under stress and not static.
[3] The 3-m thickness is the minimum thickness of the blue clay described in the boring logs of the production wells.

Table 4-1: Recommended BMPs associated with the Preliminary Risk Map prepared for use with the ISMP.

Risk Zone	Zone A	Zone B
Slopes > 2:1	No infiltration systems within 75 m of slopes > 2:1	
Slopes < 2:1, but > 4:1	If a significant low permeability unit* (e.g., compact till or clay layer ~0.5 m thick or more) is encountered within 5 m of the surface, use perforated underdrains with a low permeability liner in biofiltration-type systems within 75 m of slopes > 4:1, to convey underflow to storm sewers. Assumes no infiltration to occur.	Use perforated underdrains with a low permeability liner in biofiltration-type systems to convey underflow to storm sewers. Assumes no infiltration to occur.
	If no significant low permeability unit* (e.g., compact till or clay layer ~0.5 m thick or more) is encountered within 5 m of surface, infiltration system in biofiltration-type system recommended.	
Slopes < 4:1	if a significant low permeability unit* (e.g., compact till or clay layer ~0.5 m thick or more) is encountered within 5 m of the surface – use perforated underdrains in biofiltration-type systems to convey underflow to storm sewers	
	if no significant low permeability unit* (e.g., compact till or clay layer ~0.5 m thick or more) is encountered within 5 m of surface – infiltration system in biofiltration-type system is recommended	
Slopes < 10:1	if no significant low permeability unit* (e.g., compact till or clay layer ~0.5 m thick or more) is encountered within 2 m of surface – infiltration system in biofiltration-type system recommended	
Site-specific Investigations	Depending on the areal extent of the development, and total volume of runoff to control, perform site-specific investigations to confirm the presence of confining layers. For larger developments, this may include performing a minimum of two 5 m deep geotech borings; add one boring for every additional 15 m in swale length > 15 m. Further, conduct a minimum of three infiltration tests; add one test for every additional 15 m in swale length > 15 m.	Assumes no infiltration to occur, so design will not require identification of low permeability unit or infiltration tests.
In areas of uncertain zone delineation, demonstration of low risk conditions (i.e., existence of a laterally continuous > 3m thick low permeability unit) is required.	Depending on the areal extent of the development, and total volume of runoff to control, perform site investigations to confirm the presence of confining layers. For larger developments, this may include one 20 m deep geotech boring near the center of the proposed infiltration system, and an additional minimum of four 20 m deep geotech borings oriented radially and spaced 50-100 m distance from center of proposed infiltration system. The borings must be separated by a horizontal distance of at least 70 m. The area is considered low risk if the low permeability unit can be interpreted to be laterally continuous and identified in all five borings. The soil data obtained from each geotechnical boring should be sufficient to estimate vertical percolation (unsaturated media) and vertical/horizontal conductivities (saturated zones); this includes grain size analyses of specific hydrostratigraphic units, permeater tests on core samples, recovery tests, etc.	

*infiltration rate < 2.5 mm/hr

5 CLOSURE

The conclusions and recommendations presented in this report are in accordance with our current understanding of the Site conditions, as referenced in this report. Our interpretation of subsurface conditions is based on assumed conditions. No warranty is expressed or implied.

This report was prepared for the exclusive use of Urban Systems and the City of White Rock. Any use of this report or the material contained herein by third parties should only be done with written consent from Jacques Whitford Stantec AXYS Limited.

We trust that this information meets your present requirements. Should you have any questions or require additional information, please contact the undersigned

Sincerely,

Stantec Consulting Ltd.

Reviewed by:

Original signed by:

Heather Provost, B.Sc., CEPIT
Environmental Hydrogeologist

Original signed by:

Steve Wilbur, P.Geo
Senior Hydrogeologist

Appendix A: Drawings

HP/SW/mp

File Name and Path: [P:_CMiC Projects\1055000_to_1056000\1055860 EPP - White Rock ISMP\Hydrogeology\Report\1055860 White Rock ISMP Hydrogeological Assessment_FINAL.doc]

6 REFERENCES

BC Water Resource Atlas – http://www.env.gov.bc.ca/wsd/data_searches/wrbc/index.html

Environment Canada – http://www.climate.weatheroffice.ec.gc.ca/advanceSearch.html

Driscoll, F. G., 1986. Groundwater and Wells, 2nd ed., Johnson Division, St. Paul, Minnesota.

Freeze R.A., Cherry J.A., 1979, Groundwater, 1st ed., Prentice-Hall of Canada Ltd., Toronto.

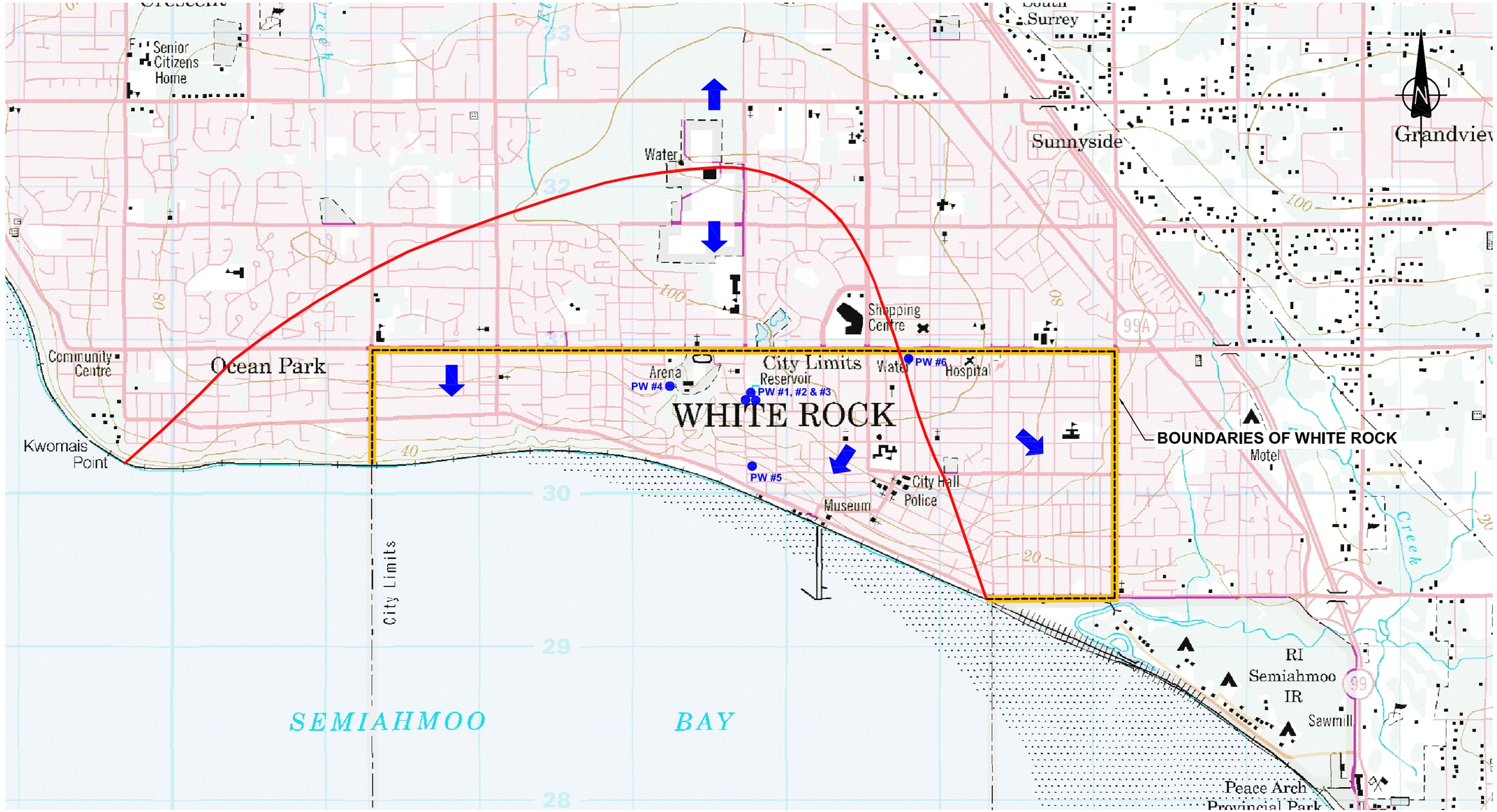
Geological Survey of Canada, Map 1484A – New Westminster West of 6th Meridian, 1:50,000 scale, 1977

Minister of Water, Land and Air Protection (MWLAP), June 2002, Guide to Using the BC Aquifer Classification Maps for the Protection and Management of Groundwater.

Williams, J.R., Ouyang, Y., Chen, J. and Ravi, V., Estimations of Recharge Rate in Vadose Zone: Application of Selected Mathematical Models, US EPA, EPA/600/R-97/128b, 1998.

APPENDIX A

Drawings



REF: Natural Resources Canada - Map 92 g02

NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A JACQUES WHITFORD STANTEC LIMITED REPORT AND MUST NOT BE USED FOR OTHER PURPOSES.

LEGEND

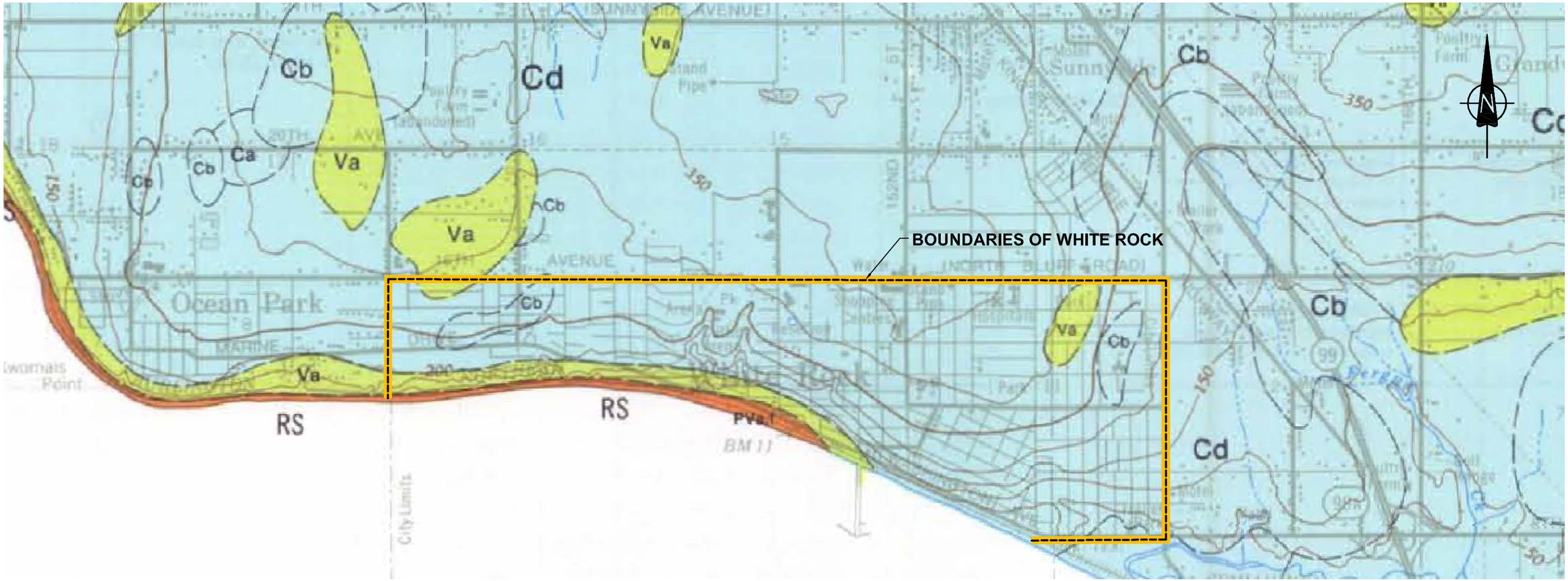
- INFERRED GROUNDWATER FLOW DIRECTIONS
- DRINKING WATER PRODUCTION WELL
- WATERSHED BOUNDARY

SCALE IN METRES
0 250 500 750 1000
1:25000

Reference:	**Job No.:** 1055860 **Scale:** 1:25,000 **Date:** 07-Dec-09 **Dwn. By:** SS **App'd By:**	**Client:** CITY OF WHITE ROCK **Site Address** WHITE ROCK, BC	WHITE ROCK INTEGRATED STORMWATER MANAGEMENT PLAN - HYDROGEOLOGY	WHITE ROCK CITY LIMITS LOCAL TOPOGRAPHY LOCATION AND DRINKING WATER PRODUCTION WELLS	**Dwg. No.:** 1

Stantec

R:\2009Fiscal\1055860_WhiteRock\CAD\WhiteRockIntergratedStormwaterManagementPlan_Hydrogeology\1055860 D01 R0.dwg PRINTED: Dec 07, 2009



Ca-e — CAPILANO SEDIMENTS *(Chronologically equivalent to Sumas Drift and Fort Langley Formation, see Lithologic Units and Environments of Deposition)*
Raised marine, deltaic, and fluvial deposits: Ca, *raised marine beach, spit, bar, and lag veneer, poorly sorted sand to gravel (except in bar deposits) normally less than 1 m thick but up to 8 m thick, mantling older sediments and containing fossil marine shell casts up to 175 m above sea level;* Cb, *raised beach medium to coarse sand 1 to 5 m thick containing fossil marine shell casts;* Cc, *raised deltaic and channel fill medium sand to cobble gravel up to 15 m thick deposited by proglacial streams and commonly underlain by silty to silty clay loam;* Cd, *marine and glaciomarine stony (including till-like deposits) to stoneless silt loam to clay loam with minor sand and silt normally less than 3 m thick but up to 30 m thick, containing marine shells. These deposits thicken from west to east.* Ce, *mainly marine silt loam to clay loam with minor sand, silt, and stony glacio-marine material (see* Cd*), up to 60+m thick. In many of the upland areas sediments mapped as* Cc *and* Cd *are mantled by a thin veneer (less than 1 m) of* Ca

Va,b — VASHON DRIFT
Till, glaciofluvial, glaciolacustrine, and ice-contact deposits: Va, *lodgment till (with sandy loam matrix) and minor flow till containing lenses and interbeds of glaciolacustrine laminated stony silt;* Vb, *glaciofluvial sandy gravel and gravelly sand outwash and ice-contact deposits*

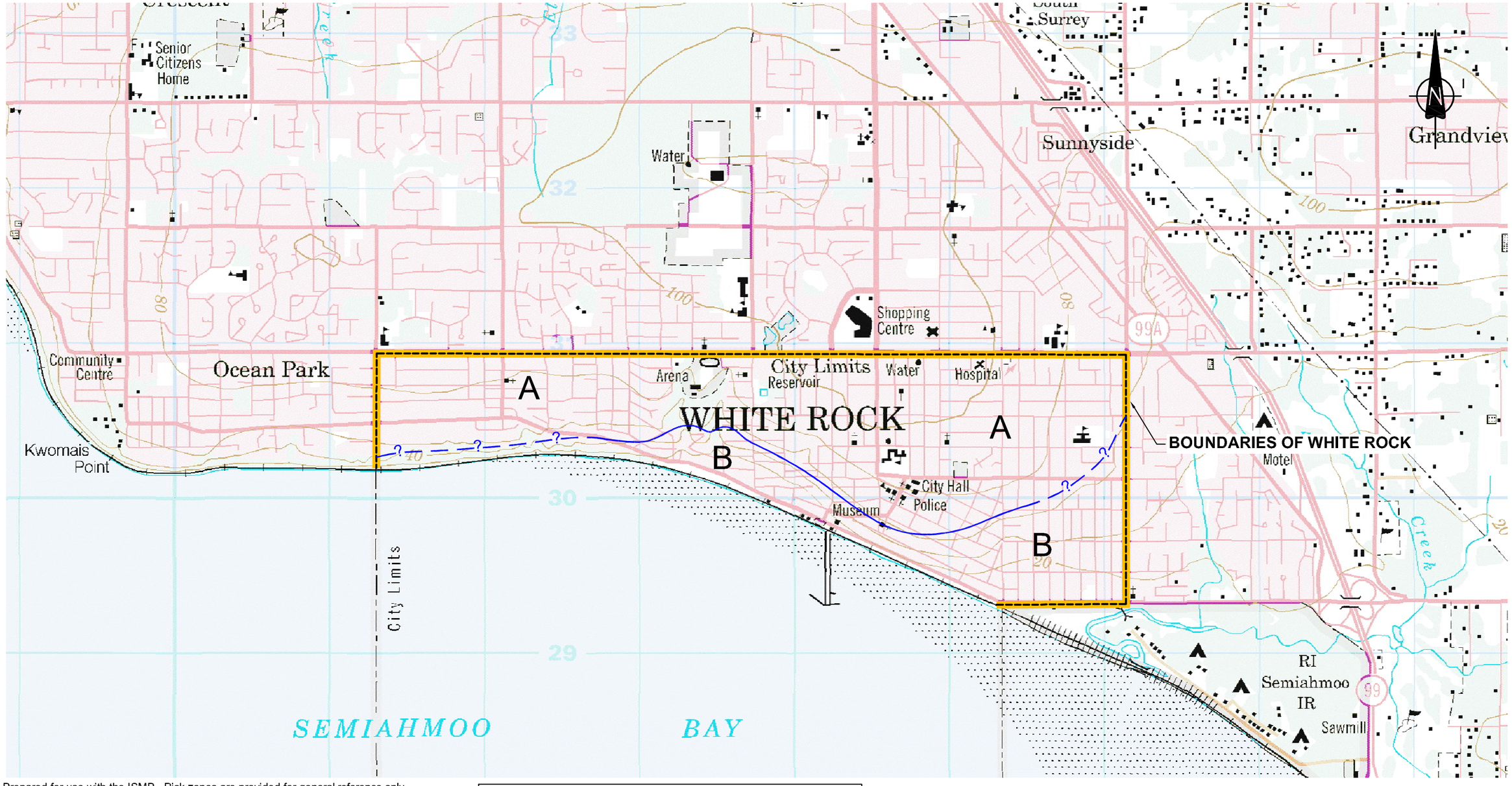
PVa-h — PRE-VASHON DEPOSITS
Glacial, nonglacial, and glaciomarine sediments: PVa, *Quadra fluvial channel fill and floodplain deposits, crossbedded sand containing minor silt and gravel lenses and interbeds;* PVb, *Quadra (?) glaciofluvial deposits, deltaic, and crossbedded sand to gravel (may be in part* Vb*):* PVc, *Quadra marine interbedded fine sand to clayey silt believed to be off shore equivalents of* PVa; PVd, *Coquitlam till, glaciomarine (?), and glaciolacustrine deposits;* PVe, *Cowichan Head fluvial, organic colluvial, and bog and swamp sediments;* PVf, *Semiahmoo till, glacio-fluvial, glaciomarine, and glaciolacustrine deposits;* PVg*, Highbury fluvial and bog and swamp deposits;* PVh*, Westlynn glaciofluvial sandy gravel*

SCALE IN METRES
0 250 500 750 1000
1:25000

NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A JACQUES WHITFORD STANTEC LIMITED REPORT AND MUST NOT BE USED FOR OTHER PURPOSES.

Reference: NEW WESTMINSTER (1484a)	**Job No.:** 1055860 **Scale:** 1:25,000 **Date:** 07-Dec-09 **Dwn. By:** SS **App'd By:**	**Client:** CITY OF WHITE ROCK **Site Address** WHITE ROCK, BC	WHITE ROCK INTEGRATED STORMWATER MANAGEMENT PLAN - HYDROGEOLOGY	SURFICIAL GEOLOGY	**Dwg. No.:** 2

R:\2009Fiscal\1055860_WhiteRock\CAD\WhiteRockIntergratedStormwaterManagementPlan_Hydrogeology\1055860 D02 R0.dwg PRINTED: Dec 07, 2009



Prepared for use with the ISMP. Risk zones are provided for general reference only. Site specific information (sec Table 4.1) must be obtained and provided to the city to confirm actual site conditions at any location.

REF: Natural Resources Canada - Map 92 g02

NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A JACQUES WHITFORD STANTEC LIMITED REPORT AND MUST NOT BE USED FOR OTHER PURPOSES.

LEGEND	
RISK ZONE	HYDROGEOLOGIC CONDITIONS
A	HAS ≥ 3m OF BLUE CLAY ABOVE AQUIFER (LINE DRAWN ON THE STRATIGRAPHIC TOP OF ~3m CLAY)
B	HAS NO OVERLYING CLAY ABOVE AQUIFER

LEGEND

RISK ZONES

SCALE IN METRES
0 250 500 750 1000
1:25000

Reference:	Job No.: 1055860 Scale: 1:25,000 Date: 07-Dec-09 Dwn. By: NP App'd By:	Client: CITY OF WHITE ROCK Site Address: WHITE ROCK, BC	WHITE ROCK INTEGRATED STORMWATER MANAGEMENT PLAN - HYDROGEOLOGY	PRELIMINARY RISK ZONES	Dwg. No.: 3

R:\2009Fiscal\1055860_WhiteRock\CAD\WhiteRockIntergratedStormwaterManagementPlan_Hydrogeology\1055860 D03 R0.dwg PRINTED: Dec 07, 2009

APPENDIX D

Water Quality

Runoff Quality

Section 1 – Context for Runoff Quality Assessment

The number of potential substances, organic and inorganic, that can be, and often are, found in urban runoff is staggering. In essence, just about anything that finds its way on to our urban surfaces, particularly impervious surfaces such as roads, parking lots and buildings, can be washed off those surfaces by rain and snowmelt and be carried into receiving water bodies as non-point source (NPS) pollution. Table D.1 provides a listing of some major NPS pollutant sources and the pollutants that they generate. Many of these pollutants can be acutely toxic at higher concentrations, although in general such toxicity is not normally associated with "typical" urban runoff. Rather, the accumulated affect of pollutant wash off over time can yield unacceptable chronic toxicity or bioaccumulation in aquatic life.

As will be described in more detail in Section 3, below, we estimated the generation and washoff of some key pollutants from the City into Semiahmoo Bay, using the model *WinSLAMM*. The pollutants simulated in the model at this time are total suspended and dissolved solids (TSS; TDS); bacteria (fecal coliforms); total and dissolved copper (Cu); total and dissolved zinc (Zn). The estimates account for the inter-event interval between storms during which pollutants build up on impervious surfaces within the City as well as the volume of runoff that the storms produce to wash off these pollutants. Because the City is not anticipated to undergo fundamental changes in land use and development density, future loads will not likely be significantly different than those generated currently.

Table D.1. Non-Point Source Urban Pollutants and Their Sources

SOURCE	MAJOR POLLUTANTS
Atmospheric deposition	From urban and rural areas: fine particles, phosphorus, ammonia, nitrate, metals, pesticides, petroleum products, and toxic organics
Litter and leaf fall	Personal and commercial debris discarded to roadway and parking lots such as plastics, paper, cans, and food; leaves and organic debris from roadside and parking lot trees that falls on paved surfaces: biological oxygen demand (BOD_5), nitrogen, phosphorus, humic organics, and metals
Residential and roadside landscape maintenance	Bacteria, phosphorus and nitrogen, pesticides and herbicides, dissolved organics from soil amendments
Transportation vehicles	Fuels, brake drum and tire wear, body rust: fine particles, metals in particular zinc, copper, cadmium, lead, and chromium; and petroleum products such as oil & grease and poly-aromatic hydrocarbons (PAH)
Pavement and pavement maintenance	Temperature modification; petroleum derivatives from asphalt; materials from abraded or degraded pavement
Pavement deicing	Chlorides, sulfates, organics from acetate deicers, coarse sediments, and cyanide
Building exteriors	Galvanized metals, chipped and eroded paints, corrosion of surfaces accelerated by acid rain, metals
Industrial businesses	Varies widely with the industry. Includes the pollutants commonly contributed by other sources but may also include those less commonly detected in general urban runoff or at concentrations greater than typically found in urban stormwater; pollutants from inappropriate connections; pollutants that may be more prevalent in stormwater from industrial areas include petroleum products, phenols, solvents, and metals
Commercial businesses	Parked vehicles; improperly disposed refuse such as discarded food, used cooking oil and grease, and packaging materials; internal drains improperly connected to the storm system: metals, BOD_5, bacteria, phosphorus, nitrogen, oil, and grease
Residential activities	Landscaping, pest control, moss control, vehicle maintenance, painting, wood preservation: pesticides and herbicides, phosphorus, nitrogen, petroleum products, zinc, and bacteria
Site development	High pH from fresh concrete surfaces; petroleum products from fresh asphalt and spills; organics and particles from landscaping materials; eroded sediment and associated constituents like phosphorus; pollutants associated with improperly disposed construction materials like fresh concrete and paints; cement from preparation of exposed aggregate concrete
Public infrastructure	Metals from galvanized stormwater drain systems; metals and petroleum products from maintenance shops; bacteria, nitrogen, phosphorus, and organics from exfiltrating or overflowing sanitary sewers

Source: Table 2.3, in G. Minton, *Stormwater Treatment: Biological, Chemical and Engineering Principles, Second Edition,* 2005

In an ideal world, one might seek to have urban runoff completely free of any NPS pollution, that is, to have the runoff as pure as it was prior to human intervention or contact. In reality, the activities that constitute urban life will always generate substances that can and likely will become NPS pollution. In British Columbia there are no specific standards or regulatory limits as to what constitutes "too much" NPS pollution in urban runoff[1]. The Federal Fisheries Act does prohibit placing, or causing to be placed, "deleterious substances" into fish-bearing waters. Again, however, there are no specific standards to determine what constitutes such substances and what level can or will be called deleterious. There are also federal and provincial guidelines for ambient water quality that establish the expected baseline conditions necessary for protection of aquatic life and use of water for other purposes. While concentrations of pollutants in urban runoff could simply be compared against these guidelines, such a comparison would not account for natural chemical, physical and/or biological processes that might render the pollutants insignificant or harmless once in the receiving water body environment. For example, mixing zones are allowed for treated sewage discharges into rivers in BC, with the recognition that various natural processes within the mixing zone will reduce concentrations to levels considered acceptable. Additional discussion of water quality issues is found in the environmental report (Appendix B).

Section 2 – Performance Targets

So how does a community decide whether and how much NPS pollution to eliminate or treat as a part of its own environmental stewardship? For the White Rock, part of the answer lies in the aquifer which is below a large portion of the City and from which the City obtains its water supply. As discussed in the hydrogeology section of the ISMP, this aquifer may be vulnerable to contamination from urban runoff generated within the City itself. Another part of the answer lies in White Rock's primary receiving water body, Semiahmoo Bay. As discussed in more detail in the environmental section of the ISMP, shellfish harvesting has been banned since 1972, due to high bacteria counts (specifically fecal coliform counts). While it has not been established that White Rock is the sole or even the most significant source of the bacteria, nonetheless, fecal coliforms are consistently present in urban runoff in large quantities.

It has become generally accepted that removal of sediments and particulate solids (or suspended solids) from stormwater is the primary key to reducing NPS pollution. There are several reasons for this. First, total suspended solids (TSS) is generally the single largest pollutant present in urban runoff, both in terms of average concentration and in terms of overall load over time. Second, many other pollutants are hydrophobic and thus become associated with TSS; removing TSS also removes many other pollutants. Third, TSS has readily visible and easily anticipated results in the environment (e.g., silted streams that suffocate aquatic life and degrade fish habitat) and in municipal storm infrastructure (e.g., clogged catch basins). Fourth, it is relatively easy to keep TSS out of runoff in the first place or, if in runoff already, it is relatively easy to remove compared to some other pollutants. Fifth, the mechanisms for removal of many other pollutants (e.g., filtration) work much better when TSS has already been removed. Thus, we recommend that White Rock establish a specific performance target for TSS in urban

[1] There are, however, performance targets for wastewater treatment; for example, the Province requires removal of total suspended solids down to 10-45 mg/L, on average.

runoff for new and redevelopment projects, and strive to meet a minimum level of TSS removal on an annual basis across the City over the coming years.

Primarily because of our urban reliance on petroleum products and on transportation based on petroleum products, oil and grease (O&G) is also ubiquitous in urban runoff. While it tends to be at relatively low average concentrations, nonetheless, O&G is one pollutant that is readily visible on water surfaces, even at very low concentrations. Further, it can have devastating effects on wildlife and aquatic life if present in sufficient quantities. Recognizing this, the City has, in more recent times, informally required the use of oil/water separators on commercial sites to capture parking lot runoff. We recommend that White Rock strengthen this general practice by establishing a specific performance target for O&G in urban runoff.

As noted, bacteria (represented by fecal coliforms) has already had a negative impact on the community, through local shellfish closures. If it were to become more serious, beach closures could occur. Further, it is possible, under certain conditions, to contaminate aquifers with bacteria. Thus, we recommend that White Rock establish a specific performance target for fecal coliforms in urban runoff for new and redevelopment projects in the City.

Bacteria are a challenge to remove from urban runoff for a variety of reasons. First, as long as there are domestic and wild animals in the urban environment, there will be fecal coliforms available for pick up in urban runoff. Unless there is a specific concern with a small number of animal species that can be targeted[2], it will be difficult to eliminate coliforms from runoff. Programs to encourage and require dog "poop pick up" help, but they are generally a drop in the bucket when considered over an entire watershed or community. Second, while some bacteria can be removed along with TSS, typical end-of-pipe treatment systems do not remove bacteria (though more natural systems which encourage contact with soil appear to). Positive elimination of bacteria generally requires the use of intensive technology, as for example chlorination and exposure to UV light used in sewage treatment plants. Thus, we recommend that the fecal coliform performance target be seen as a goal to reach over time, recognizing that it may be a challenging one to reach. It is worth noting that treatment that relies on filtration through organic soils naturally provides removal of fecal coliforms. Thus, low impact biofiltration systems will be able to meet this target.

Finally, trace metals, which are also ubiquitous in urban runoff, can be quite toxic at higher concentrations. Metals appear in both dissolved and particulate form in runoff, the ratio being a function of the metal consideration, the water chemistry of the runoff, and presence of other solids that can absorb or adsorb the element. The portion of metals that is particulate can be removed with other suspended solids; however, it is sometimes difficult to remove metals because they tend to be associated with fine particulates (smaller than a fine sand) which are harder to settle from the water column or are dissolved in the runoff. Filtration is one readily available mechanism to capture the fine particles. While performance targets could be set for all metals, we recommend setting the target for two particularly important trace metals, copper and zinc.

[2] For example, to cite one common urban problem, high concentrations of geese at urban ponds or large grassed playfields can yield very high fecal coliform counts. Some communities in the U.S. have identified this as a significant NPS issue and taken steps to remove or eliminate geese.

The purpose of these performance targets is two-fold. In terms of this ISMP, having targets allows comparison of alternate management strategies or, put differently, allows for "apples to apples" comparisons. In terms of implementing the ISMP, having targets puts all everyone (public and private alike) on an even footing with respect to what is expected for runoff quality controls.

Table D.2 provides additional background on these NPS pollutants and on the rationale for targeting them for elimination or removal from runoff.

Table D.2: Targeted Non-Point Source Pollutants

Characteristic	Pollutant			
	Total Suspended Solids (TSS)	Coliforms	Hydrocarbons	Dissolved Metals (Cu and Zn)
Considered a deleterious substance?	Yes	Yes	Yes	Yes
Potential impact on human health				
Impact on beach recreational use	No	Yes	Yes if direct contact	No
Impact on drinking water	No – N/A	No – N/A	No – N/A	No – N/A
Potential impact on marine species				
Impact on fish	Yes	No	Yes	Yes
Impact on shellfish	No (at expected levels)	No (yes for shellfish harvesting by humans)	Yes	No (at expected levels)
Impact on mammals and birds	No	No	Yes	No (at expected levels)
Potential impact on freshwater species				
Impact on fish	NA – not discharging to streams	NA – not discharging to streams	NA – not discharging to streams	NA – not discharging to streams
Impact on mammals and birds	NA – not discharging to streams	NA – not discharging to streams	NA – not discharging to streams	NA – not discharging to streams
Impacts at acute or chronic levels?	Both	Both	Both	Both
Potential sources	Runoff from roads and land (landscaping, building construction)	Animal waste (pets, wildlife), humans (cross connections or leaks in the sanitary system)	Road runoff (vehicle fuel, oil, grease)	Road runoff (vehicle wear and tear), residences (galvanized metal fences, anti-moss roof and lawn treatments)
Pollutant loading				
Estimated pollutant loading (based on existing development conditions)	52,100 Kg/year	700 trillion colonies/year	N/A	Dissolved Copper – 3 Kg/year Total Copper – 14 Kg/year Dissolved Zinc – 200 Kg/year Total Zinc – 350 Kg/year
Exceed BC Water Quality Guidelines for Protection of Aquatic Life?	No (though likely for individual samples) Annual average concentration = 43 mg/L	Yes	No (though possible for individual samples) Typical concentration < 10 mg/L	Yes Annual average concentration = 0.012 mg/L (Total Copper) Annual average concentration = 0.270 mg/L (Total Zinc)
Expected prevalence in White Rock	Yes	Yes	Yes	Yes
Indicator of other pollutants?	Yes (particulate metals)	Yes (other bacterial pathogens)	No	No
Ability to monitor	Yes	Yes	Yes	Yes

Characteristic	Pollutant			
	Total Suspended Solids (TSS)	**Coliforms**	**Hydrocarbons**	**Dissolved Metals (Cu and Zn)**
Ability to treat	Yes	Yes	Yes	Yes
Performance targets				
Performance Target	Remove or reduce 90% of the annual average load, with an average maximum concentration of 30 mg/L for any system discharging to a storm drain, ditch or the Bay	≤200/100 mL (geometric mean)	≤10 mg/L (mean)	Remove or reduce 50% of the annual average loads for both total copper and total zinc
BC Water Quality Guidelines for Protection of Aquatic Life	Maximum induced (above background) TSS in 24 hours is 25 mg/L when background up to 250 mg/L	*E coli* ≤14/100 mL (median) for shellfish harvest ≤77/100 mL (geometric mean) for primary contact recreation (swimming) ≤385/100 mL (geometric mean) for secondary contact recreation (boating)	For oil and grease in freshwater (no marine water guideline), surface water should be free of petroleum, animal or vegetable oils	For marine water (no guideline for dissolved metals): Copper (total) 0.003 mg/L maximum Zinc (total) 0.010 mg/L maximum
DFO Land Development Guidelines	During construction, maximum induced (above background in receiving stream) TSS is 25 mg/L during dry weather and 75 mg/L during storm events; no allowance when discharging to spawning areas of streams; Post-development conditions, no guideline	N/A	No (but one can infer from the guidelines that oil separator designs must remove oil droplets 60 microns or larger)	N/A
Cost-effective to meet target?	TBD	TBD	TBD	TBD
Other information to rationalize target	TBD	TBD	TBD	TBD

Section 3 – Treatment Strategies

There are three key strategies available to reduce the non-point source (NPS) pollution washed into the Bay from White Rock's urban surfaces:

- Reduce the total runoff volume;
- Reduce the total mass of pollution-generating substance(s) on urban surfaces that can be picked up by runoff; and
- Remove the NPS pollutants from urban runoff at any of several points along the conveyance path to a receiving water body.

These strategies should generally be applied in sequence, that is, the first approach should be to reduce runoff volume since it addresses at least two aspects of stormwater management, namely volume and water quality. Reducing or minimizing the impervious footprint of roads, parking lots and buildings should be considered first, followed by disconnecting impervious areas from direct discharge to storm drains and ditches. Finally, any BMP which relies heavily on evaporation, transpiration and/or infiltration will reduce runoff volume. The methods related to this strategy can generally be classified as "low impact development" (LID) BMPs.

Because White Rock is basically fully developed and will likely undergo redevelopment only over a very long time horizon, it may not be possible to achieve significant results in the short term with some of the methods noted for runoff volume reduction. Thus the next line of defense is to reduce the mass of pollutants that can potentially be washed off urban surfaces. Limits or prohibitions on pesticide and herbicide use are examples of BMPs that address this strategy.

But many of the materials that accumulate on urban surfaces (primarily impervious surfaces, but also pervious surfaces, in some cases) cannot be reduced so easily. For example, as long as the automobile remains our primary transportation mode, the minute but cumulative breakdown of brakes, tires and other components of autos along with the minute but cumulative breakdown of road surfaces will yield a significant mass of fine sediments (including trace metals) and petroleum hydrocarbon products that pollute stormwater. For such pollutants, an alternate BMP is the use of state-of-the-art, high efficiency street cleaners. If properly pursued on a frequent enough schedule, use of street cleaning could prove quite effective in keeping sediments out of runoff. Street cleaning could be applied to both public ROW as well as commercial and institutional parking lots. Not surprisingly, street cleaning does have high operating and maintenance costs attached. As an interim measure between today and a future when redevelopment has occurred sufficiently for LID to become a significant factor in controlling runoff, street cleaning may be cost effective; it will have to carefully compared with the costs of removing pollutants by other BMPs.

The final strategy, "treating" runoff at any of several points along its conveyance system from sources to receiving water bodies, includes a wide variety of LID as well as more conventional BMPs. Because some areas of the City may not support the use of infiltration (see hydrogeology appendix), LID systems such as rain gardens, planter boxes and biofiltration swales ("bioswales") can be used with perforated underdrains that overflow to storm drains

(or ditches). In that case, LID may not reduce runoff volume but will primarily act for water quality treatment. These would be placed before conveyance systems (storm drains), that is, on individual properties and in road ROW. Other types of BMPs that could be suitable for White Rock include oil/grit separators; manufactured vaults that provide primary treatment to remove sediments (and other pollutants associated with sediments); manufactured systems providing more advanced or enhanced treatment, including filtration, disinfection and absorption of dissolved pollutants such as metals; and sand and amended sand filters.

As noted in the previous paragraphs, some NPS control options could serve as interim management measures and thus their cost-effectiveness will likely be highly dependent on time horizons until lower impact BMPs can be installed. It will be very helpful on formulating a water quality management strategy for the City to give some thought to the timing for new and re-development.

Other considerations in formulating an overall water quality management strategy include:

- Public versus private installation and ownership of BMPs;
- Location and timing of other infrastructure improvements, particularly storm conveyance system; and
- Requirements for "pretreatment" of runoff that is infiltrated in locations above the City's water supply aquifer; this is especially critical for roadway runoff, which tends to be the single largest category of pollutant generator in urban areas.

The overall water quality management strategy will likely rely heavily on the long-term implementation of LID within the City, along with a mix of more "technology-dependent" BMPs that are either interim measures or are applied in hot spot areas where LID may not be suitable and/or the City wishes to retain greater control over the operation and maintenance of the systems.

Section 4 – Modeling and Assessment

Using the model WinSLAMM (Version 9.4), pollutant loads were developed for all 18 catchments within the City, for both existing and future conditions. Within the margin of error associated with the model, and given the limited overall change in land use envisioned for the City as presented in the OCP, future pollutant loads are essentially the same as existing pollutant loads. Thus, for the assessment, future conditions only were used to test several management strategies. In each case, we applied the alternative strategy uniformly across all 18 catchments in order to set "upper limits" to the potential benefits of the strategies.

WinSLAMM is a Windows-based version of the U.S. Geological Survey's model SLAMM (Source Loading and Management Model). The model was originally developed to better under the relationships that exist between sources of urban runoff pollutants and runoff quality. It has been continually expanded since the late 1970s and now includes a wide variety of source and outfall control practices.

Win SLAMM was used in a variety of notable studies such as the DuPage Watershed Plan, Humber River basin in Toronto, New York City's municipal watersheds (Kensico Reservoir, for one) and others. This model is widely

accepted by leading scientists and government agencies throughout the U.S. and was used as part of the White Rock ISMP for the following reasons:

- It emphasizes *small storm hydrology and particulate runoff rather than focusing on very large and rare rainfall events (a feature of drainage models). This was vital because empirical evidence has shown that stormwater quality problems are mostly associated with frequent and relatively small rains;*
- *Its results and assumptions are strongly based on actual field observations;*
- *It has the ability to examine a wide variety of source area and outfall control practices (BMPs); and,*
- *It has the ability to consider many stormwater controls (affecting source areas, drainage systems, and outfalls) to*gether, for a long series of rains.

In formulating strategies, the three key strategies noted above were used as a framework for identifying the alternatives for assessment. Obviously unworkable strategies were dismissed early; specifically, the use of wet ponds and stormwater wetlands in White Rock was dismissed as there is very little space available for their use. In modeling, each strategy was applied evenly over all catchments, in order to establish an upper limit for pollutant control results. The alternative treatment strategies are listed in Table D.3.

Table D.3: Treatment Alternatives for Analysis

Key Strategy	Treatment Alternative	Features
#1 - Reduce runoff volume	Use infiltration to reduce total annual runoff volume	Per provincial guidelines, capture ½ Mean Annual Rainfall (MAR), assumed to be 30mm over 24 hours
#2 - Reduce total mass of pollutants	Apply street cleaning	Use high performance street cleaning equipment, applied at four different rates (twice per year; once per month; once per week; daily)
#3 – Remove pollutants once entrained in runoff	Install "green" infrastructure throughout City	Use biofiltration systems; per provincial guidelines, capture ½ MAR; apply to all properties and ROWs
	Install end-of-pipe sediment removal systems	"Primary" or "pre-treatment" systems to remove coarse sediments and oil & grease
	Install end-of-pipe advanced filtration systems	"Higher level" enhanced treatment systems to remove sediments, oil & grease, dissolved metals and bacteria

Biofiltration systems include planter boxes, rain gardens, bioswales, as well a few proprietary systems such as the "Filterra" system (which is essentially a "tree in a box with filtration"). *Primary treatment systems* include proprietary (manufactured) systems such as "StormCeptor", "Vortechs" and "CDS". Public domain systems such as a simple concrete vault were also assumed to provide similar treatment capabilities, as long as they are designed with a hydraulic loading rate equivalent to proprietary systems and include baffles or similar oil skimming devices. *Enhanced treatment systems* also included both proprietary systems (e.g., "StormFilter") and public domain systems (multi-chambered treatment train; sand filters). In general, systems that encourage contact between the runoff and soils and/or filter media, such as activated carbon or zeolite, can provide bacteria removal. In theory both primary and enhanced treatment systems can be upgraded to provide disinfectant capabilities; however, disinfection is much more efficient when preceded by enhanced treatment.

The catchment boundaries were the same as those used in the screening report prepared in 2007[3]. Total area modeled was 472.7 hectares, of which 57.3% is impervious surfaces (mostly buildings, parking lots, driveways, sidewalks and streets). A few minor areas of the City, typically areas without storm drains, are not included in the total. Also, areas within Surrey that contribute runoff to White Rock's drainage system have been ignored. The catchment boundaries and areas are shown on Figure D.1.

Early runs showed that though land uses change slightly over time between now and the future (as represented by the City's Official Community Plan, or OCP), the overall effect is well within the margin of error of the model. Therefore, only the future conditions were assessed against the various treatment strategies. Figure D.2 shows the future land use conditions. Other land use conditions also affect the results.

Hourly precipitation records for the White Rock area (White Rock STP; Environment Canada Station 1108914) were used for model. Complete data were available, however, for only four years (2000, 2001, 2005 and 2006), so the model was run as if these were four consecutive years. The annual rainfall for these years varied between 949 mm and 1,109 mm, with a mean of 1,037 mm. According to Environment Canada, the average annual precipitation at White Rock STP for the period 1971 to 2000 is 1,102 mm; thus the four year period used in the analysis was near average if somewhat drier than normal. For purposes of the analysis, this difference is negligible. There were 638 storm, or rain, events during the four year simulation period. An inter-event dry period of at least six (6) hours was used to determine whether a new event was occurring.

The Mean Annual Rainfall (MAR) is 57.8 mm in 24 hours, again based on the period 1971 to 2000; the MAR is a standard measure referenced by the Province in its stormwater guidelines. Upwards of 90% of the annual volume of rainfall occurs in events less than the MAR.

The model includes a number of loading factors for pollutants. With minor modifications, these factors were used as is.

[3] Urban Systems, Ltd., "Water Quality Screening Assessment, Draft Report", September 2004, for City of White Rock.

Some of the other conditions within the City accounted for in the model are:

- Multiple land uses (See Table D.4)
- Connected versus disconnected impervious surfaces (see Table D.5 and Figure D.3)
- Pitched versus flat roofs (see Table D.6)
- Both streets (arterial; collector; local) and alleyways/lanes (see Table D.7)
- Variable soils infiltration rates (see Table D.8)

For purposes of modeling, the presence of catch basins, some of which may have sumps for capturing grit, was ignored.

One treatment strategy focuses on providing biofiltration systems within the City's streets and alleyways/lanes; however some of these are quite steep and may not be suitable for such systems. Figure D.4 shows all ROWs within the City that have a profile slope of less than or equal to 6%; it is assumed that biofiltration can be utilized on these streets. The figure also shows areas of the City with more or less than overall grade of 10%. Even though a street may have a profile less than 6%, the overall topography, if steep, may place space limits on biofiltration.

Runoff inflow from Surrey was ignored in the analysis; thus sizing of end-of-pipe treatment systems are slightly undersized with respect to treating runoff from both the City and its neighbor. When the City decides to implement installation of facilities that could treat runoff from Surrey, appropriate coordination and re-engineering will be required.

The model functions in English units, rather than metric, thus all input and output were carefully checked to ensure consistency.

Results from all simulations, by catchment, can be found at the end of this appendix. Figures D.9(a) shows the estimated annual total suspended (TSS) loadings for future conditions without the application of a treatment strategy while Tables D.9(b) through (k) show the loads for each of the treatment strategies as well as providing the estimated construction and O&M costs; Table D.10 summarizes the results across all catchments for the alternative management strategies.

Cost estimates were made for all the treatment strategies. Costs for construction (i.e., capital cost) and for operation and maintenance (as well replacement in the case of street sweepers) were estimated at a Class D level. Capital costs include construction cost plus engineering and administrative costs (20% of construction cost) and contingency (35% of construction); for the street sweeper alternatives, only administrative costs (5%) and contingency (35%) were added under the assumption that engineering-related costs would be negligible. Operation and maintenance costs were generally estimated based on a percentage of the capital costs, based on literature values for use of best management practices.

Table D.10 summarizes the estimated costs. TSS has been used as the focus for assessing the cost per pollutant removal, although any of the targeted pollutants could have been used.

Section 4 – Recommendations

Based on the analysis of runoff quality and potential strategies for treating urban runoff pollution in White Rock, we recommend the following overall runoff quality strategy for the City:

For public infrastructure:

- Provide low impact biofiltration systems and, where feasible, narrower streets and/or porous asphalt parking lanes, for as many streets and lanes as possible within the City, as shown on Figure D.6; and

- For the catchments identified in Figure D.6, provide end-of-pipe enhanced treatment to remove suspended sediments, coliforms and oil & grease, along with metals and other pollutants associated with the sediments. End of pipe systems should meet the performance standards discussed earlier in this appendix. The targeted catchments are characterized by high density development, including commercial and multi-family.

For new and redevelopment:

- For single family residential, at minimum, provide 300 mm of amended topsoils and discharge roof leader to the ground (rather than to storm drains) or to a biofiltration system; and

- For commercial, institutional and multi-family residential, provide 300 mm of amended topsoils in grassed areas and use low impact BMPs to provide treatment and infiltration (where allowable).

In addition, we encourage retention of existing and planting of new trees wherever possible, throughout the City. Large, mature trees, especially native coniferous trees, provide significant runoff reduction benefits, which in turn mean less pollution is washed into the City's storm systems.

Some areas of the City have been identified as unsuitable for infiltration of runoff (Zone B, as shown in the hydrogeology appendix). In these areas, low impact BMPs may be used, but only when provided with a perforated underdrain system. The underdrains intercept runoff before it is infiltrated and redirect it to the City's storm drains. While this means that runoff volume will not be significantly reduced, it does mean that runoff will have been provided treatment through contact with soil prior to eventual discharge to the Bay.

It is absolutely critical that whatever systems are finally implemented be maintained and replaced over time in order to obtain the desired runoff quality treatment.

CITY OF WHITE ROCK

Legend

- Outfall
- Catchment Boundary
- General Catchment Outflow Direction

Catchment #	Hectares
1	16.45
2	31.65
3	20.60
4	11.08
5	7.90
6	26.50
7	30.89
8	6.72
9	55.78
10	8.40
11	18.08
12	63.30
13	4.66
14	13.63
15	24.95
16	23.70
17	44.72
18	63.65

Semiahmoo Bay

Integrated Stormwater Management Plan

Catchment Boundaries

URBANSYSTEMS.

0 250 500 1,000

Meters

Figure D.1

U:\Projects_VAN\1325\0061\01\D-Drafting-Design-Analysis\GIS\Projects\mxds\ReportFigures\2009_12_03_FigureD1_CatchmentBoundaries.mxd Last revised by: bpauls on 03/12/2009 at 3:44:53 PM

CITY OF WHITE ROCK

Legend

- Catchment Boundary

Official Community Plan

- Single Family Residential
- Multi-Family Residential
- Commercial
- Comprehensive Development
- Land Use Contract
- Open Space, Parks and Recreation

Semiahmoo Bay

Integrated Stormwater Management Plan

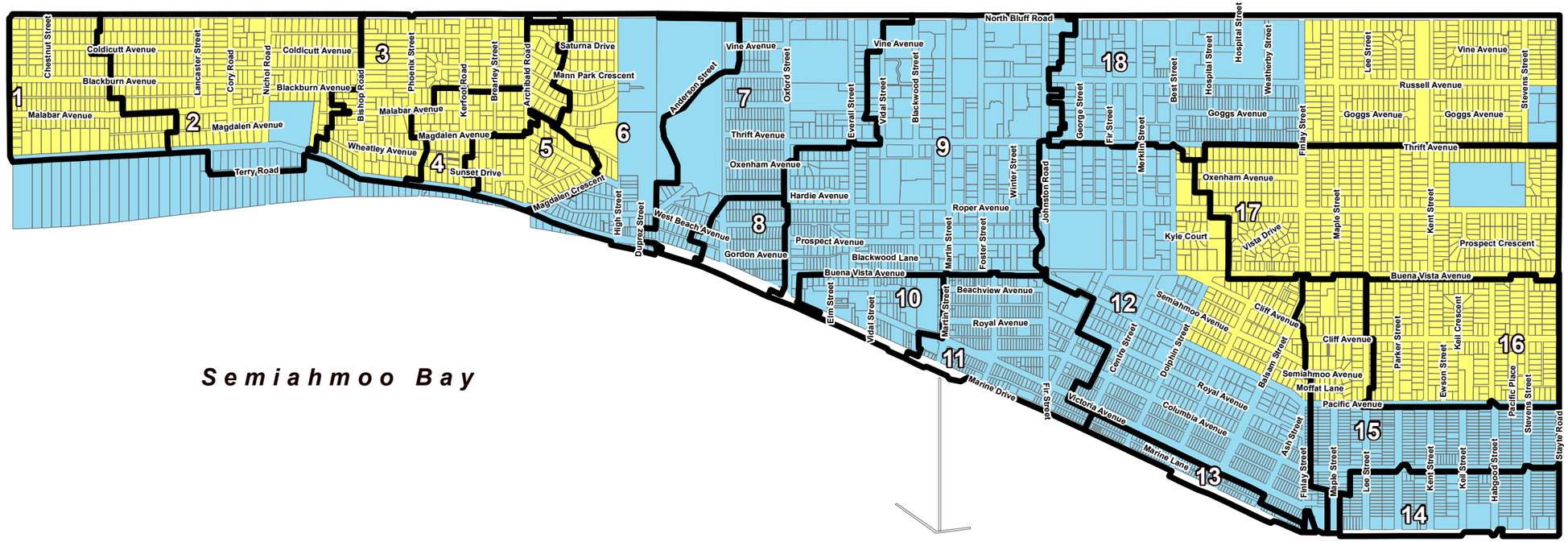
Future Land Use

Figure D.2

0 250 500 1,000

Meters

U:\Projects_VAN\1325\0061\01\D-Drafting-Design-Analysis\GIS\Projects\mxds\ReportFigures\2009_12_03_FigureD2_FutureLandUse.mxd Last revised by: bpauls on 03/12/2009 at 4:12:33 PM



CITY OF WHITE ROCK

Legend

- Catchment Boundaries
- Zone of Roof Leader Connections to Storm Drain
- Zone of Roof Leader Disconnects

Note: Zone designation based on "Comprehensive Drainage Study - 2004 Update"

Integrated Stormwater Management Plan

Roof Leader Connection Specified Areas

Figure D.3

URBANSYSTEMS.

0 250 500 1,000

Meters

U:\Projects_VAN\1325\0061\01\D-Drafting-Design-Analysis\GIS\Projects\mxds\ReportFigures\2009_12_03_RoofLeaderConnectionSpecifiedAreas.mxd Last revised by: bpauls on 03/12/2009 at 2:58:37 PM

CITY OF WHITE ROCK

Legend

- Streams
- Road Slope: 0 to 3 %
- Road Slope: 3 to 6 %
- Topography With Slope Less Than 10%
- Catchment Boundaries

Integrated Stormwater Management Plan

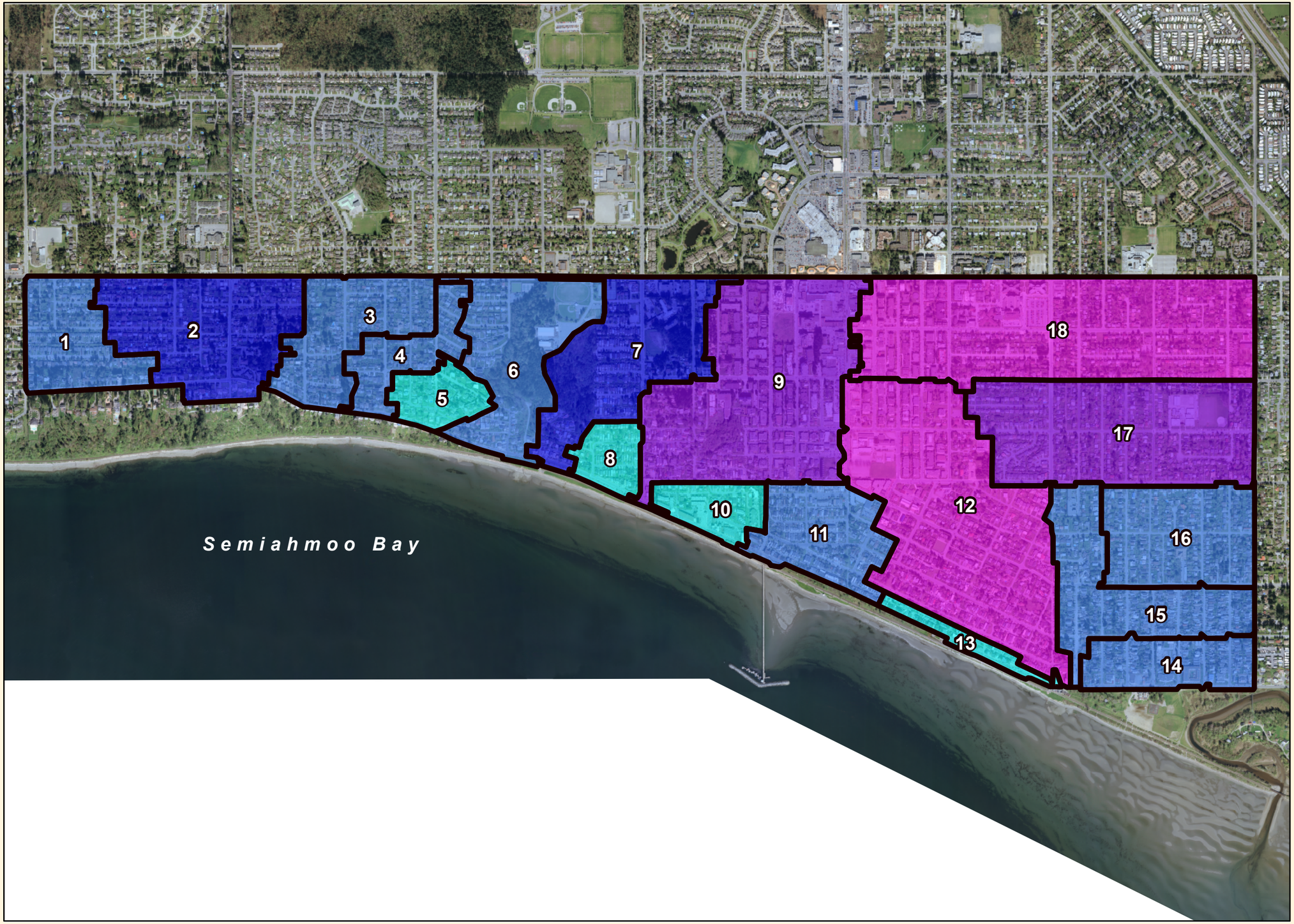
Streets Potentially Suitable for Biofiltration Systems

Figure D.4

Semiahmoo Bay

0 250 500 1,000
Meters

U:\Projects_VAN\1325\0061\01\D-Drafting-Design-Analysis\GIS\Projects\mxds\ReportFigures\2009_12_03_FigureD4_StreetsSuitableForBiofiltration.mxd Last revised by: bpauls on 07/12/2009 at 11:47:43 AM



CITY OF WHITE ROCK

Legend

Catchment Boundary

TSS Loads (kg / year)

- < 15000
- 15000 - 30000
- 30000 - 45000
- 45000 - 60000
- > 60000

Integrated Stormwater Management Plan

Annual TSS Loads by Catchment

URBANSYSTEMS.

0 250 500 1,000

Meters

Figure D.5

U:\Projects_VAN\1325\0061\01\D-Drafting-Design-Analysis\GIS\Projects\mxds\ReportFigures\2009_12_03_FigureDX_AnnualTSSLoads.mxd Last revised by: bpauls on 07/12/2009 at 4:23:49 PM

CITY OF WHITE ROCK

Legend

- Streams
- Roads for ROW Biofiltration Systems - Recommended
- Roads for ROW Biofiltration Systems - More Study Required
- End-of-Pipe Enhanced Treatment - Recommended
- Catchment Boundaries

Integrated Stormwater Management Plan

Potential Water Quality Infrastructure

Figure D.6

0 250 500 1,000

Meters

U:\Projects_VAN\1325\0061\01\D-Drafting-Design-Analysis\GIS\Projects\mxds\ReportFigures\2009_12_03_FigureD4_StreetsSuitableForBiofiltration.mxd Last revised by: bpauls on 07/12/2009 at 11:47:43 AM

Table D.4 - Impervious Area by Catchment and Land Use Type

NOTE: Areas listed in ACRES

Future Conditions - City of White Rock

Catchment No.	Commercial	Institutional	Residential	Roads	Total Impervious	Total Catchment Area (acres)	Pervious Area (acres)	% Impervious
1	0.000	0.105	13.399	7.69	21.191	40.6490	19.4576	52.13%
2	0.904	0.248	25.382	14.40	40.937	78.2108	37.2741	52.34%
3	0.000	0.000	16.782	9.36	26.142	50.9002	24.7587	51.36%
4	0.000	0.000	8.556	5.20	13.755	27.3806	13.6251	50.24%
5	0.000	0.000	5.972	3.80	9.772	19.5128	9.7405	50.08%
6	0.000	12.238	21.047	6.73	40.017	65.4832	25.4664	61.11%
7	0.000	9.099	15.816	12.24	37.160	76.3426	39.1831	48.67%
8	0.000	0.000	4.691	4.36	9.055	16.6166	7.5612	54.50%
9	18.645	1.079	41.543	29.64	90.908	137.8305	46.9228	65.96%
10	4.028	0.000	5.472	4.82	14.321	20.7584	6.4370	68.99%
11	1.948	0.000	11.183	18.20	31.334	44.6750	13.3411	70.14%
12	5.353	4.690	38.750	51.09	99.886	156.4281	56.5416	63.85%
13	1.486	0.000	2.062	5.43	8.980	11.5073	2.5270	78.04%
14	0.001	0.824	10.112	5.79	16.725	33.6908	16.9657	49.64%
15	0.828	0.454	18.451	10.20	29.935	61.6599	31.7249	48.55%
16	0.335	0.589	18.648	12.74	32.307	58.5758	26.2686	55.15%
17	0.000	3.195	33.145	19.83	56.170	110.5021	54.3326	50.83%
18	7.048	5.720	44.991	32.58	90.335	157.2697	66.9345	57.44%
Total	40.576	38.241	336.002	254.112	668.931	1167.9932	499.0625	57.27%
								57.17%

Future vs. old

Catchment No.	Increase/decrease in impervious area	% change
1	2.451	6.03%
2	4.332	5.54%
3	2.596	5.10%
4	1.283	4.69%
5	-0.340	-1.74%
6	17.324	26.46%
7	3.318	4.35%
8	-0.698	-4.20%
9	2.062	1.50%
10	0.340	1.64%
11	-7.516	-16.82%
12	-5.499	-3.52%
13	-1.899	-16.50%
14	-2.417	-7.17%
15	-4.306	-6.98%
16	0.130	0.22%
17	5.627	5.09%
18	0.552	0.35%
Total	17.341	1.48%

Existing Conditions - City of White Rock

Catchment No.	Commercial	Institutional	Residential	Roads	Total Impervious	Total Catchment Area (acres)	Pervious Area (acres)	% Impervious
1	0.000	0.000	11.053	7.69	18.741	40.6490	21.9082	46.10%
2	0.620	0.000	21.582	14.40	36.605	78.2108	41.6056	46.80%
3	0.000	0.000	14.186	9.36	23.545	50.9002	27.3550	46.26%
4	0.000	0.000	7.273	5.20	12.472	27.3806	14.9083	45.55%
5	0.000	0.000	6.312	3.80	10.112	19.5128	9.4009	51.82%
6	0.000	7.831	8.130	6.73	22.693	65.4832	42.7906	34.65%
7	0.000	4.735	16.862	12.24	33.842	76.3426	42.5010	44.33%
8	0.000	0.000	5.389	4.36	9.753	16.6166	6.8635	58.69%
9	13.319	1.244	44.642	29.64	88.846	137.8305	48.9844	64.46%
10	4.052	0.000	5.108	4.82	13.981	20.7584	6.7772	67.35%
11	1.955	0.960	17.732	18.20	38.850	44.6750	5.8253	86.96%
12	5.089	6.155	43.048	51.09	105.385	156.4281	51.0430	67.37%
13	1.452	0.000	3.994	5.43	10.879	11.5073	0.6283	94.54%
14	0.613	1.285	11.457	5.79	19.142	33.6908	14.5487	56.82%
15	0.644	0.978	22.417	10.20	34.241	61.6599	27.4188	55.53%
16	0.000	0.911	18.531	12.74	32.177	58.5758	26.3984	54.93%
17	0.000	2.109	28.604	19.83	50.542	110.5021	59.9598	45.74%
18	4.181	2.664	50.362	32.58	89.783	157.2697	67.4868	57.09%
Total	31.925	28.872	336.681	254.112	651.589	1167.9932	516.4038	55.79%
								56.94%

change future - existing

res	com	ins	pervious
2.346	0.000	0.105	-2.451
3.800	0.284	0.248	-4.332
2.596	0.000	0.000	-2.596
1.283	0.000	0.000	-1.283
-0.340	0.000	0.000	0.340
12.917	0.000	4.408	-17.324
-1.046	0.000	4.364	-3.318
-0.698	0.000	0.000	0.698
-3.099	5.326	-0.165	-2.062
0.364	-0.024	0.000	-0.340
-6.549	-0.007	-0.960	7.516
-4.298	0.264	-1.465	5.499
-1.932	0.034	0.000	1.899
-1.345	-0.612	-0.461	2.417
-3.966	0.184	-0.524	4.306
0.117	0.335	-0.322	-0.130
4.541	0.000	1.086	-5.627
-5.371	2.867	3.056	-0.552
-0.679	8.651	9.369	-17.341

Table D.5 - Roof Leader Disconnections

Roof Leader Disconnected		Roof Leader Connected		Percentage Connected	
Catchment No.	Acres	Catchment No.	Acres	Catchment No.	Percentage Connected
1	36.44	1	2.43	1	6.26%
2	63.62	2	11.87	2	15.72%
3	46.94	3	1.70	3	3.49%
4	26.33	4	1.06	4	3.86%
5	17.77	5	1.74	5	8.91%
6	18.22	6	45.91	6	71.59%
7	0.00	7	72.79	7	100.00%
8	0.00	8	14.06	8	100.00%
9	0.00	9	135.37	9	100.00%
10	0.00	10	18.46	10	100.00%
11	0.00	11	42.10	11	100.00%
12	34.90	12	121.43	12	77.68%
13	0.00	13	8.01	13	100.00%
14	0.00	14	30.02	14	100.00%
15	19.50	15	41.59	15	68.08%
16	54.65	16	2.93	16	5.09%
17	100.70	17	8.85	17	8.08%
18	72.77	18	77.94	18	51.72%

Based on Figure from 2004 study

Table D.6 - Pitched and Flat Roofs

Catchment No.	Area in Acres Pitched	Flat	Area in Acres Pitched Connected	Pitched Disconnected	Area in Acres Flat Connected	Flat Disconnected
1	10.69	0.36	0.669055161	10.02	0.022550031	0.34
2	20.13	2.08	3.164004905	16.96	0.326220754	1.75
3	13.63	0.55	0.475327472	13.16	0.019350237	0.54
4	7.05	0.22	0.272193772	6.78	0.008419001	0.21
5	6.12	0.19	0.545615601	5.58	0.016870575	0.17
6	8.08	7.88	5.784627906	2.30	5.641309732	2.24
7	14.83	6.77	14.8281	0.00	6.7691	0.00
8	5.23	0.16	5.2271	0.00	0.1617	0.00
9	26.69	32.51	26.6947	0.00	32.5107	0.00
10	2.99	6.17	2.9871	0.00	6.1727	0.00
11	15.85	4.80	15.8481	0.00	4.7991	0.00
12	35.89	18.41	27.8761521	8.01	14.2967951	4.11
13	3.76	1.68	3.7632	0.00	1.6835	0.00
14	7.84	5.51	7.8405	0.00	5.5136	0.00
15	21.72	2.32	14.78570145	6.93	1.580522892	0.74
16	17.51	1.94	0.891811696	16.61	0.098697903	1.84
17	27.69	3.02	2.236881091	25.45	0.244343165	2.78
18	39.45	17.75	20.40425592	19.05	9.181387648	8.57

Assumptions based on observations *Assumed the areas drained to are silty*

Landuse	% Pitched	% Flat
One Unit Residential	97	3
Multi Family/Apartments	0	100
Town Centre	0	100
Commercial	100	0
Institutional	3	97

Table D7 - Length of Streets and Lanes

	Length per road type in feet							
Catchment No.	Alleyway/Lane (ft)	Arterial (ft)	Collector (ft)	Local/Street (ft)	Total Length (ft)	(miles)	≤6% Grade (ft)	%
1			1617.98	3511.65	5129.63	0.971520471	1262	24.60%
2	501.84		2771.27	11549.38	14822.49	2.807288957	1437	9.69%
3			1059.74	6327.06	7386.80	1.399015152	3896	52.74%
4			698.86	5740.83	6439.69	1.219638432	120	1.86%
5	564.64		605.09	3682.78	4852.51	0.919036396	857	17.66%
6			1349.91	6768.51	8118.42	1.537579545	1124	13.85%
7	518.62		1958.11	7924.34	10401.07	1.969899621	1188	11.42%
8	254.63		1090.95	2656.79	4002.37	0.758024941	593	14.82%
9	2116.69	2509.02	5301.36	19536.08	29463.15	5.580142045	3471	11.78%
10			1355.85	2390.38	3746.23	0.709513258	554	14.79%
11	343.25	44.27	2974.87	9888.01	13250.40	2.509545147	3776	28.50%
12	3014.68	1313.94	4218.08	27100.27	35646.97	6.751320076	280	0.79%
13			2570.05	2457.34	5027.39	0.952157197	509	10.12%
14			2582.46	4360.58	6943.04	1.314969697	894	12.88%
15			636.01	11305.18	11941.19	2.261589015	901	7.55%
16			2461.47	8793.54	11255.01	2.131630682	1065	9.46%
17				17454.71	17454.71	3.305816288	7793	44.65%
18	669.54		2841.05	26206.70	29717.29	5.628274621	3156	10.62%

Table D8 - Soils Conditions

Catchment No.	Infilt Rate = 8 in/hour Capilona Sediments (b)	Infilt Rate = 0.05 in/hour Capilona Sediments (d)	Area in Acres Infilt Rate = ? in/hour Capilona Sediments (e)	Infilt Rate = 0.2 in/hour Vasion Drift (a)	Infilt Rate = 0.2 in/hour Re-Vasion Deposits (a)
1	6.20	31.64	0.00	2.80	0.00
2	26.53	46.03	0.00	5.66	0.00
3	0.00	50.22	0.00	0.68	0.00
4	0.00	26.13	0.00	1.25	0.00
5	0.00	15.22	0.00	4.29	0.00
6	0.00	53.47	0.00	9.97	2.04
7	0.00	69.65	0.00	5.33	1.37
8	0.00	4.48	0.00	7.11	5.03
9	0.00	133.19	0.00	2.92	1.72
10	0.00	7.25	0.00	9.42	4.08
11	0.00	42.02	0.00	2.65	0.00
12	0.00	156.43	0.00	0.00	0.00
13	0.00	11.51	0.00	0.00	0.00
14	0.00	23.02	10.67	0.00	0.00
15	0.00	61.66	0.00	0.00	0.00
16	0.00	58.57	0.00	0.00	0.00
17	15.10	90.46	0.00	4.94	0.00
18	11.35	125.21	0.00	20.70	0.00

Table D9(a) - Base Case (Future Conditions) Loading Results

By: jmr
Date: 07-Dec-09

No Treatment Base Case

Raw Data from WinSLAMM, sorted by Catchment #:

	Catchment Area	Annual Runoff Volume	Annual Particulate Solids (TSS) Yield		Particulate Solids Yield for Alternative (lbs)	Particulate Solids Concentration (mg/L)	Filterable Solids Yield (lbs)	Filterable Solids Concentration (mg/L)	Total Solids Yield (lbs)	Total Solids Concentration (mg/L)	Fecal Coliform Bacteria Yield (count)	Fecal Coliform Bacteria Concentration (#/100 ml)	Particulate Copper Yield (lbs)	Particulate Copper Concentration (ug/L)	Filterable Copper Yield (lbs)	Filterable Copper Concentration (ug/L)	Total Copper Yield (lbs)	Total Copper Concentration (ug/L)	Particulate Zinc Yield (lbs)	Particulate Zinc Concentration (ug/L)	Filterable Zinc Yield (lbs)	Filterable Zinc Concentration (ug/L)	Total Zinc Yield (lbs)	Total Zinc Concentration (ug/L)
	(ha)	(m3)	(Kg)																					
1	16.451	143,606	17,079	1,038.2 Kg/ha	37653.68	118.9368	51130.55	161.5784	88784.38	280.5689	9.06E+12	6315.363	4.781375	15.1097	0.699529	2.210594	5.480903	17.32029	42.9316	135.6688	49.03117	154.9442	91.96289	290.6134
2	31.651	303,468	33,069	1,044.8 Kg/ha	72905.32	108.9754	102625.5	153.4683	175530.8	262.4925	1.87E+13	6180.548	9.178909	13.72634	1.513522	2.263353	10.69243	15.98969	83.79563	125.3098	118.6047	177.364	202.4004	302.6739
3	20.603	171,661	24,806	1,204.0 Kg/ha	54687.57	144.5106	63065.06	166.7224	117752.5	311.2974	1.09E+13	6332.848	8.699606	22.99878	0.835373	2.208441	9.534986	25.20724	57.05639	150.8376	56.29726	148.8307	113.3537	299.6684
4	11.081	93,971	16,669	1,504.3 Kg/ha	36748.95	177.3909	34663.57	167.3994	71412.52	344.8697	5.95E+12	6340.891	7.283185	35.1724	0.455592	2.200174	7.738777	37.37257	33.95242	163.9651	30.2742	146.202	64.22664	310.1672
5	8.057	72,728	8,530	1,058.7 Kg/ha	18804.57	117.2846	26001.57	162.2451	44806.12	279.582	4.48E+12	6167.395	2.377679	14.83628	0.351826	2.195328	2.729504	17.03161	21.83943	136.274	25.03429	156.2094	46.87368	292.4832
6	26.504	459,024	23,889	901.3 Kg/ha	52666.17	52.04489	135983.1	134.4391	188649.2	186.5071	2.36E+13	5138.51	6.080644	6.0116	2.170794	2.146145	8.251445	8.157753	60.90451	60.21297	242.1208	239.3716	303.0251	299.5844
7	30.899	538,918	35,771	1,157.7 Kg/ha	78861.84	66.37825	168658.8	142.0241	247520.7	208.4321	2.85E+13	5293.149	9.423697	7.935503	2.536684	2.136089	11.96038	10.07159	90.79433	76.45605	259.7046	218.6919	350.4986	295.1477
8	6.722	123,347	7,923	1,178.7 Kg/ha	17467.89	64.2381	30659.69	112.8013	48127.66	177.0684	7.15E+12	5803.137	2.495384	9.18087	0.643914	2.36905	3.139298	11.54992	18.76313	69.03218	66.09533	243.174	84.85828	312.2056
9	55.779	1,230,807	56,846	1,019.1 Kg/ha	125324.1	46.18772	321198.5	118.4294	446522.9	164.6379	7.63E+13	6205.191	18.26896	6.735966	5.857832	2.159847	24.1268	8.895818	183.4764	67.64976	623.0416	229.7223	806.5172	297.3718
10	8.401	191,254	8,478	1,009.2 Kg/ha	18690.61	44.32963	51898.84	123.1466	70589.47	167.4961	1.25E+13	6519.258	2.852954	6.769546	0.861528	2.044251	3.71448	8.813791	30.36223	72.04411	88.15142	209.1674	118.5137	281.2115
11	18.082	394,762	20,328	1,124.2 Kg/ha	44815.62	51.49631	93721.7	107.741	138537.3	159.2603	2.53E+13	6424.345	8.268434	9.505262	1.84101	2.116397	10.10944	11.62165	47.12867	54.17839	173.2781	199.1978	220.4068	253.3763
12	63.311	1,161,893	71,276	1,125.8 Kg/ha	157138	61.34755	301930.9	117.9282	459069	179.3032	7.32E+13	6303.379	26.51783	10.35734	5.425697	2.11917	31.94351	12.4765	164.6866	64.32332	500.4846	195.4793	665.1697	259.8021
13	4.658	106,519	5,125	1,100.3 Kg/ha	11297.82	48.11175	26383.93	112.4062	37681.73	160.5393	7.61E+12	7150.855	2.319769	9.883149	0.452143	1.926313	2.771914	11.80947	12.89028	54.9178	37.90294	161.4818	50.79322	216.3996
14	13.634	238,414	15,757	1,155.7 Kg/ha	34737.98	66.09281	62547.29	119.0563	97285.48	185.1791	1.30E+13	5466.315	4.248057	8.086011	1.28528	2.44648	5.533339	10.53249	39.65777	75.48701	139.5959	265.7153	179.2535	341.2021
15	24.949	352,885	28,251	1,132.3 Kg/ha	62282.71	80.06011	101088.4	130.0002	163371	210.0961	2.00E+13	5662.889	7.470957	9.607695	1.887091	2.42681	9.358048	12.0345	73.19073	94.1237	191.2623	245.9644	264.4527	340.0878
16	23.707	218,739	24,514	1,034.0 Kg/ha	54044.23	112.0739	75085.95	155.7787	129130.2	267.9028	1.42E+13	6486.355	7.299064	15.14316	1.029563	2.136005	8.328628	17.27917	60.14856	124.7885	69.10635	143.373	129.2548	268.1614
17	44.719	388,170	46,897	1,048.7 Kg/ha	103390.1	120.8201	141354.8	165.2589	244745	286.1333	2.41E+13	6225.221	12.80748	14.97332	1.894849	2.215282	14.70233	17.18861	118.9499	139.0653	134.2059	156.9012	253.1558	295.9664
18	63.642	892,507	66,000	1,037.1 Kg/ha	145504.9	73.95169	257647.8	131.006	403153.1	204.991	5.47E+13	6135.967	19.74859	10.04156	4.373405	2.223743	24.12199	12.26529	169.0188	85.94091	409.6734	208.3064	578.6916	294.247
	472.850	7,082,673	511,208	1,081.1 Kg/ha	1127022		2045646		3172669		4.29E+14		160.1226		34.11563		194.2382		1309.547		3213.865		4523.408	

Table D9(b) - Primary Treatment Strategy Costs & Loading Results

By: jmr
Date: 07-Dec-09
Revised: 10-Apr-10

		No Treatment Base Case		Alternative Strategy - Primary Treatment							
	Catchment Area	Annual Runoff Volume	Annual Particulate Solids (TSS) Yield	Annual Runoff Volume	Annual Particulate Solids (TSS) Yield	Removal Efficiency	Treatment Design Flow	Capital Cost*	Annual O&M Cost 4.0%	Total Cost over 20 Years	$ per Kg TSS Removed
	(ha)	(m3)	(Kg)	(m3)	(Kg)		(L/s)	($)	($/yr)	($)	
1	16.451	143,606	17,079	143,606	8,540	50.0%	122	$168,100	$6,720	$302,500	$1.77
2	31.651	303,468	33,069	303,468	16,535	50.0%	414	$335,400	$13,420	$603,800	$1.83
3	20.603	171,661	24,806	171,661	12,403	50.0%	478	$363,800	$14,550	$654,800	$2.64
4	11.081	93,971	16,669	93,971	8,334	50.0%	120	$166,600	$6,660	$299,800	$1.80
5	8.057	72,728	8,530	72,728	4,265	50.0%	120	$166,600	$6,660	$299,800	$3.51
6	26.504	459,024	23,889	459,024	11,944	50.0%	164	$198,700	$7,950	$357,700	$1.50
7	30.899	538,918	35,771	538,918	17,885	50.0%	186	$213,400	$8,540	$384,200	$1.07
8	6.722	123,347	7,923	123,347	3,962	50.0%	95	$145,900	$5,840	$262,700	$3.32
9	55.779	1,230,807	56,846	1,230,807	28,423	50.0%	1,173	$604,300	$24,170	$1,087,700	$1.91
10	8.401	191,254	8,478	191,254	4,239	50.0%	147	$186,800	$7,470	$336,200	$3.97
11	18.082	394,762	20,328	394,762	10,164	50.0%	662	$437,300	$17,490	$787,100	$3.87
12	63.311	1,161,893	71,276	1,161,893	35,638	50.0%	492	$369,800	$14,790	$665,600	$0.93
13	4.658	106,519	5,125	106,519	2,562	50.0%	83	$135,200	$5,410	$243,400	$4.75
14	13.634	238,414	15,757	238,425	7,878	50.0%	209	$227,900	$9,120	$410,300	$2.60
15	24.949	352,885	28,251	352,885	14,125	50.0%	328	$294,000	$11,760	$529,200	$1.87
16	23.707	218,739	24,514	218,739	12,257	50.0%	934	$531,300	$21,250	$956,300	$3.90
17	44.719	388,170	46,897	388,170	23,448	50.0%	120	$166,600	$6,660	$299,800	$0.64
18	63.642	892,507	66,000	892,507	33,000	50.0%	156	$193,200	$7,730	$347,800	$0.53
	472.850	7,082,673	511,208	7,082,684	255,602			$4,904,900	$196,190	$8,828,700	$1.73

* Includes 20% Engineering & Administration plus 35% contingency

Raw Data for alternative, from WinSLAMM, sorted by Catchment #:

	Runoff Volume (cf)	Particulate Solids Yield for Alternative (lbs)	Particulate Solids Concentration (mg/L)	Filterable Solids Yield (lbs)	Filterable Solids Concentration (mg/L)	Total Solids Yield (lbs)	Total Solids Concentration (mg/L)	Fecal Coliform Bacteria Yield (count)	Fecal Coliform Bacteria Concentration (#/100 ml)	Particulate Copper Yield (lbs)	Particulate Copper Concentration (ug/L)	Filterable Copper Yield (lbs)	Filterable Copper Concentration (ug/L)	Total Copper Yield (lbs)	Total Copper Concentration (ug/L)	Particulate Zinc Yield (lbs)	Particulate Zinc Concentration (ug/L)	Filterable Zinc Yield (lbs)	Filterable Zinc Concentration (ug/L)	Total Zinc Yield (lbs)	Total Zinc Concentration (ug/L)
	5071220	18826.84	59.4684	51130.55	161.5784	69957.39	221.0468	9.06E+12	6315.363	2.390688	7.55485	0.699529	2.210594	3.090217	9.765444	21.4658	67.8344	49.03117	154.9442	70.49697	222.7786
	10716470	36452.66	54.4877	102625.5	153.4683	139078.2	207.956	1.87E+13	6180.548	4.589455	6.86317	1.513522	2.263353	6.102977	9.126523	41.89782	62.6549	118.6047	177.364	160.5025	240.0189
	6061920	27343.79	72.2553	63065.06	166.7224	90408.85	238.9777	1.09E+13	6332.848	4.349803	11.49939	0.835373	2.208441	5.185176	13.70783	28.5282	75.4188	56.29726	148.8307	84.82546	224.2495
	3318446	18374.48	88.69545	34663.57	167.3994	53038.05	256.0949	5.95E+12	6340.891	3.641593	17.5862	0.455592	2.200174	4.097185	19.78637	16.97621	81.98255	30.2742	146.202	47.25041	228.1846
	2568287	9402.285	58.6423	26001.57	162.2451	35403.86	220.8874	4.48E+12	6167.395	1.18884	7.41814	0.351826	2.195328	1.540665	9.613468	10.91972	68.137	25.03429	156.2094	35.95401	224.3464
	16209700	26333.09	26.02245	135983.1	134.4391	162316.2	160.4615	2.36E+13	5138.51	3.040322	3.0058	2.170794	2.146145	5.211116	5.151945	30.45226	30.10649	242.1208	239.3716	272.5731	269.4781
	19031030	39430.92	33.18913	168658.8	142.0241	208089.7	175.2132	2.85E+13	5293.149	4.711849	3.967752	2.536684	2.136089	7.248533	6.103841	45.39717	38.22803	259.7046	218.6919	305.1018	256.9199
	4355811	8733.945	32.11905	30659.69	112.8013	39393.64	144.9204	7.15E+12	5803.137	1.247692	4.590435	0.643914	2.36905	1.891606	6.959485	9.381565	34.51609	66.09533	243.174	75.4769	277.6901
	43463960	62662.05	23.09386	321198.5	118.4294	383860.6	141.5233	7.63E+13	6205.191	9.13448	3.367983	5.857832	2.159847	14.99231	5.52783	91.7382	33.82488	623.0416	229.7223	714.7798	263.5472
	6753839	9345.305	22.16482	51898.84	123.1466	61244.15	145.3114	1.25E+13	6519.258	1.426477	3.384773	0.861528	2.044251	2.288005	5.429024	15.18112	36.02206	88.15142	209.1674	103.3325	245.1895
	13940380	22407.81	25.74816	93721.7	107.741	116129.5	133.4892	2.53E+13	6424.345	4.134217	4.752631	1.84101	2.116397	5.975227	6.869028	23.56434	27.0892	173.2781	199.1978	196.8424	226.287
	41030350	78569	30.67378	301930.9	117.9282	380499.9	148.602	7.32E+13	6303.379	13.25892	5.17867	5.425697	2.11917	18.68461	7.29784	82.3433	32.16166	500.4846	195.4793	582.8279	227.641
	3761532	5648.91	24.05588	26383.93	112.4062	32032.84	136.4621	7.61E+12	7150.855	1.159885	4.941575	0.452143	1.926313	1.612028	6.867888	6.44514	27.4589	37.90294	161.4818	44.34808	188.9407
	8419607	17368.99	33.04641	62551.44	119.0586	79920.43	152.105	1.30E+13	5466.52	2.124029	4.043006	1.285313	2.446429	3.409342	6.489435	19.82889	37.74351	139.5985	265.7078	159.4274	303.4513
	12461560	31141.36	40.03006	101088.4	130.0002	132229.8	170.0303	2.00E+13	5662.889	3.735479	4.803848	1.887091	2.42681	5.62257	7.230658	36.59537	47.06185	191.2623	245.9644	227.8577	293.0263
	7724422	27022.12	56.03695	75085.95	155.7787	102108.1	211.8157	1.42E+13	6486.355	3.649532	7.57158	1.029563	2.136005	4.679095	9.707585	30.07428	62.39425	69.10635	143.373	99.18063	205.7673
	13707580	51695.05	60.41005	141354.8	165.2589	193049.9	225.669	2.41E+13	6225.221	6.40374	7.48666	1.894849	2.215282	8.298589	9.701942	59.47495	69.53265	134.2059	156.9012	193.6809	226.4339
	31517420	72752.45	36.97585	257647.8	131.006	330400.3	167.9818	5.47E+13	6135.967	9.874295	5.02078	4.373405	2.223743	14.2477	7.244523	84.5094	42.97046	409.6734	208.3064	494.1828	251.2769
	250113534	563511		2045650		2609161		4.29E+14		80.06129		34.11567		114.177		654.7737		3213.867		3868.641	

Table D9(c) - Enhanced Treatment Strategy Costs & Loading Results

By: jmr
Date: 07-Dec-09
Revised: 10-Apr-10

		No Treatment Base Case		Alternative Strategy - Enhanced End-of-Pipe Treatment							
	Catchment Area	Annual Runoff Volume	Annual Particulate Solids (TSS) Yield	Annual Runoff Volume	Annual Particulate Solids (TSS) Yield	Removal Efficiency	Treatment Design Flow	Capital Cost*	Annual O&M Cost 6.0%	Total Cost over 20 Years	$ per Kg TSS Removed
	(ha)	(m3)	(Kg)	(m3)	(Kg)		(L/s)	($)	($/yr)	($)	
1	16.451	143,606	17,079	143,606	1,708	90.0%	122	$504,300	$30,260	$1,109,500	$3.61
2	31.651	303,468	33,069	303,468	3,307	90.0%	414	$1,006,200	$60,370	$2,213,600	$3.72
3	20.603	171,661	24,806	171,661	2,481	90.0%	478	$1,091,400	$65,480	$2,401,000	$5.38
4	11.081	93,971	16,669	93,971	1,667	90.0%	120	$499,700	$29,980	$1,099,300	$3.66
5	8.057	72,728	8,530	72,728	853	90.0%	120	$499,700	$29,980	$1,099,300	$7.16
6	26.504	459,024	23,889	459,024	2,389	90.0%	164	$596,200	$35,770	$1,311,600	$3.05
7	30.899	538,918	35,771	538,918	3,577	90.0%	186	$640,100	$38,410	$1,408,300	$2.19
8	6.722	123,347	7,923	123,347	792	90.0%	95	$437,800	$26,270	$963,200	$6.75
9	55.779	1,230,807	56,846	1,230,807	5,685	90.0%	1,173	$1,812,900	$108,770	$3,988,300	$3.90
10	8.401	191,254	8,478	191,254	848	90.0%	147	$560,400	$33,620	$1,232,800	$8.08
11	18.082	394,762	20,328	394,762	2,033	90.0%	662	$1,312,000	$78,720	$2,886,400	$7.89
12	63.311	1,161,893	71,276	1,161,893	7,128	90.0%	492	$1,109,400	$66,560	$2,440,600	$1.90
13	4.658	106,519	5,125	106,519	512	90.0%	83	$405,700	$24,340	$892,500	$9.67
14	13.634	238,414	15,757	238,425	1,576	90.0%	209	$683,700	$41,020	$1,504,100	$5.30
15	24.949	352,885	28,251	352,885	2,825	90.0%	328	$882,100	$52,930	$1,940,700	$3.82
16	23.707	218,739	24,514	218,739	2,451	90.0%	934	$1,593,900	$95,630	$3,506,500	$7.95
17	44.719	388,170	46,897	388,170	4,690	90.0%	120	$499,700	$29,980	$1,099,300	$1.30
18	63.642	892,507	66,000	892,507	6,600	90.0%	156	$579,500	$34,770	$1,274,900	$1.07
	472.850	7,082,673	511,208	7,082,684	51,122			$14,714,700	$882,860	$32,371,900	$3.52

* Includes 20% Engineering & Administration plus 35% contingency

Raw Data for alternative, from WinSLAMM, sorted by Catchment #:

	Runoff Volume (cf)	Particulate Solids Yield for Alternative (lbs)	Particulate Solids Concentration (mg/L)	Filterable Solids Yield (lbs)	Filterable Solids Concentration (mg/L)	Total Solids Yield (lbs)	Total Solids Concentration (mg/L)	Fecal Coliform Bacteria Yield (count)	Fecal Coliform Bacteria Concentration (#/100 ml)	Particulate Copper Yield (lbs)	Particulate Copper Concentration (ug/L)	Filterable Copper Yield (lbs)	Filterable Copper Concentration (ug/L)	Total Copper Yield (lbs)	Total Copper Concentration (ug/L)	Particulate Zinc Yield (lbs)	Particulate Zinc Concentration (ug/L)	Filterable Zinc Yield (lbs)	Filterable Zinc Concentration (ug/L)	Total Zinc Yield (lbs)	Total Zinc Concentration (ug/L)
1	5071220	3765.368	11.89368	51130.55	161.5784	54895.92	173.4721	9.06E+12	6315.363	0.478138	1.51097	0.699529	2.210594	1.177667	3.721564	4.29316	13.56688	49.03117	154.9442	53.32433	168.5111
2	10716470	7290.532	10.89754	102625.5	153.4683	109916	234.0435	1.87E+13	6180.548	0.917891	1.372634	1.513522	2.263353	2.431413	3.635987	8.379563	12.53098	118.6047	177.364	126.9843	189.895
3	6061920	5468.757	14.45106	63065.06	166.7224	68533.82	270.3042	1.09E+13	6332.848	0.869961	2.299878	0.835373	2.208441	1.705334	4.508319	5.705639	15.08376	56.29726	148.8307	62.0029	163.9145
4	3318446	3674.895	17.73909	34663.57	167.3994	38338.47	249.0901	5.95E+12	6340.891	0.728319	3.51724	0.455592	2.200174	1.183911	5.717414	3.395242	16.39651	30.2742	146.202	33.66944	162.5985
5	2568287	1880.457	11.72846	26001.57	162.2451	27882.03	232.3685	4.48E+12	6167.395	0.237768	1.483628	0.351826	2.195328	0.589594	3.678956	2.183943	13.6274	25.03429	156.2094	27.21823	169.8368
6	16209700	5266.617	5.204489	135983.1	134.4391	141249.7	176.8209	2.36E+13	5138.51	0.608064	0.60116	2.170794	2.146145	2.778858	2.747305	6.090451	6.021297	242.1208	239.3716	248.2113	245.3929
7	19031030	7886.184	6.637825	168658.8	142.0241	176545	195.4365	2.85E+13	5293.149	0.94237	0.79355	2.536684	2.136089	3.479054	2.929639	9.079433	7.645605	259.7046	218.6919	268.784	226.3375
8	4355811	1746.789	6.42381	30659.69	112.8013	32406.48	159.9421	7.15E+12	5803.137	0.249538	0.918087	0.643914	2.36905	0.893452	3.287137	1.876313	6.903218	66.09533	243.174	67.97164	250.0772
9	43463960	12532.41	4.618772	321198.5	118.4294	333730.9	153.9062	7.63E+13	6205.191	1.826896	0.673597	5.857832	2.159847	7.684728	2.833444	18.34764	6.764976	623.0416	229.7223	641.3892	236.4873
10	6753839	1869.061	4.432963	51898.84	123.1466	53767.9	157.8231	1.25E+13	6519.258	0.285295	0.676955	0.861528	2.044251	1.146824	2.721206	3.036223	7.204411	88.15142	209.1674	91.18764	216.3718
11	13940380	4481.562	5.149631	93721.7	107.741	98203.26	146.5612	2.53E+13	6424.345	0.826843	0.950526	1.84101	2.116397	2.667853	3.066923	4.712867	5.417839	173.2781	199.1978	177.991	204.6156
12	41030350	15713.8	6.134755	301930.9	117.9282	317644.7	164.9159	7.32E+13	6303.379	2.651783	1.035734	5.425697	2.11917	8.07748	3.154904	16.46866	6.432332	500.4846	195.4793	516.9533	201.9116
13	3761532	1129.782	4.811175	26383.93	112.4062	27513.71	146.7281	7.61E+12	7150.855	0.231977	0.988315	0.452143	1.926313	0.68412	2.914628	1.289028	5.49178	37.90294	161.4818	39.19197	166.9736
14	8419607	3473.798	6.609281	62551.44	119.0586	66025.24	168.4306	1.30E+13	5466.52	0.424806	0.808601	1.285313	2.446429	1.710119	3.25503	3.965777	7.548701	139.5985	265.7078	143.5643	273.2565
15	12461560	6228.271	8.006011	101088.4	130.0002	107316.7	191.8375	2.00E+13	5662.889	0.747096	0.96077	1.887091	2.42681	2.634187	3.38758	7.319073	9.41237	191.2623	245.9644	198.5814	255.3768
16	7724422	5404.423	11.20739	75085.95	155.7787	80490.37	214.0123	1.42E+13	6486.355	0.729906	1.514316	1.029563	2.136005	1.759469	3.650321	6.014856	12.47885	69.10635	143.373	75.12121	155.8519
17	13707580	10339.01	12.08201	141354.8	165.2589	151693.8	253.4643	2.41E+13	6225.221	1.280748	1.497332	1.894849	2.215282	3.175597	3.712614	11.89499	13.90653	134.2059	156.9012	146.1009	170.8077
18	31517420	14550.49	7.395169	257647.8	131.006	272198.3	192.8685	5.47E+13	6135.967	1.974859	1.004156	4.373405	2.223743	6.348264	3.227899	16.90188	8.594091	409.6734	208.3064	426.5753	216.9005
	2.5E+08	112702.2				2158352		4.29E+14				34.11567		50.12792				3213.867		3344.822	

Table D9(d) - Biofiltration Treatment Strategy (Entire City) Costs & Loading Results

By: jmr
Date: 07-Dec-09
Revised: 10-Apr-10

		No Treatment Base Case		Alternative Strategy - "Fully Green"/Biofiltration for Entire City							
	Catchment Area	Annual Runoff Volume	Annual Particulate Solids (TSS) Yield	Annual Runoff Volume	Annual Particulate Solids (TSS) Yield	Removal Efficiency	Total Volume of Biofiltration Systems	Capital Cost*	Annual O&M Cost 7.0%	Total Cost over 20 Years	$ per Kg TSS Removed
	(ha)	(m3)	(Kg)	(m3)	(Kg)		(m3)	($)	($/yr)	($)	
1	16.451	143,606	17,079	2,137	255	98.5%	4,940	$10,004,100	$700,290	$24,009,900	$71.36
2	31.651	303,468	33,069	4,177	482	98.5%	9,500	$19,113,300	$1,337,930	$45,871,900	$70.38
3	20.603	171,661	24,806	2,495	325	98.7%	6,180	$12,487,300	$874,110	$29,969,500	$61.21
4	11.081	93,971	16,669	1,449	210	98.7%	3,320	$6,750,200	$472,510	$16,200,400	$49.21
5	8.057	72,728	8,530	1,138	136	98.4%	2,420	$4,935,900	$345,510	$11,846,100	$70.56
6	26.504	459,024	23,889	6,483	470	98.0%	7,950	$16,023,300	$1,121,630	$38,455,900	$82.10
7	30.899	538,918	35,771	7,758	716	98.0%	9,270	$18,655,100	$1,305,860	$44,772,300	$63.86
8	6.722	123,347	7,923	2,119	171	97.8%	2,020	$4,127,500	$288,930	$9,906,100	$63.89
9	55.779	1,230,807	56,846	21,402	1,198	97.9%	16,730	$33,469,600	$2,342,870	$80,327,000	$72.17
10	8.401	191,254	8,478	4,214	209	97.5%	2,520	$5,137,800	$359,650	$12,330,800	$74.56
11	18.082	394,762	20,328	8,285	441	97.8%	5,420	$10,966,000	$767,620	$26,318,400	$66.17
12	63.311	1,161,893	71,276	17,532	1,227	98.3%	18,990	$37,942,700	$2,655,990	$91,062,500	$65.00
13	4.658	106,519	5,125	2,837	121	97.6%	1,400	$2,871,100	$200,980	$6,890,700	$68.85
14	13.634	238,414	15,757	3,706	333	97.9%	4,090	$8,298,400	$580,890	$19,916,200	$64.56
15	24.949	352,885	28,251	4,959	515	98.2%	7,480	$15,085,200	$1,055,960	$36,204,400	$65.27
16	23.707	218,739	24,514	3,185	357	98.5%	7,110	$14,346,300	$1,004,240	$34,431,100	$71.27
17	44.719	388,170	46,897	887	108	99.8%	13,420	$26,906,900	$1,883,480	$64,576,500	$69.01
18	63.642	892,507	66,000	11,781	1,047	98.4%	19,090	$38,140,500	$2,669,840	$91,537,300	$70.46
	472.850	7,082,673	511,208	106,544	8,321		141,850	$285,261,200	$19,968,290	$684,627,000	$68.07

* Includes 20% Engineering & Administration plus 35% contingency

Raw Data for alternative, from WinSLAMM, sorted by Catchment #:

	Runoff Volume (cf)	Particulate Solids Yield for Alternative (lbs)	Particulate Solids Concentration (mg/L)	Filterable Solids Yield (lbs)	Filterable Solids Concentration (mg/L)	Total Solids Yield (lbs)	Total Solids Concentration (mg/L)	Fecal Coliform Bacteria Yield (count)	Fecal Coliform Bacteria Concentration (#/100 ml)	Particulate Copper Yield (lbs)	Particulate Copper Concentration (ug/L)	Filterable Copper Yield (lbs)	Filterable Copper Concentration (ug/L)	Total Copper Yield (lbs)	Total Copper Concentration (ug/L)	Particulate Zinc Yield (lbs)	Particulate Zinc Concentration (ug/L)	Filterable Zinc Yield (lbs)	Filterable Zinc Concentration (ug/L)	Total Zinc Yield (lbs)	Total Zinc Concentration (ug/L)
1	75481	561.7271	119.2092	4516.455	958.9063	5078.182	1078.169	5.67E+11	26548.4	0.053337	11.32419	0.054999	11.67703	0.108336	23.00123	0.702026	149.0499	4.003054	849.9042	4.70508	998.9542
2	147504	1062.346	115.3673	8828.094	959.1315	9890.439	1074.55	1.14E+12	27266.19	0.100425	10.9107	0.109991	11.95005	0.210416	22.86075	1.336877	145.2456	8.284388	900.0604	9.621265	1045.306
3	88119	717.4993	130.4288	5661.849	1029.685	6379.348	1160.172	6.92E+11	27748.56	0.079291	14.42023	0.067977	12.36257	0.147269	26.7828	0.862486	156.855	4.891408	889.5699	5.753894	1046.425
4	51179	462.8459	144.8644	3102.507	971.4767	3565.353	1116.406	3.75E+11	25896	0.061806	19.35316	0.036767	11.51272	0.098573	30.86587	0.523479	163.9152	2.598607	813.6923	3.122087	977.6075
5	40191	300.7901	119.8814	2276.503	907.7174	2577.293	1027.652	2.75E+11	24194	0.028472	11.35257	0.027015	10.7718	0.055487	22.12436	0.382457	152.4983	1.94669	776.2101	2.329147	928.7084
6	228935	1035.132	72.42786	12896.76	902.7857	13931.89	975.2459	2.03E+12	31255.95	0.094255	6.597929	0.178787	12.51526	0.273042	19.11319	1.298256	90.8792	17.65008	1235.523	18.94833	1326.402
7	273973	1578.918	92.31506	16754.22	980.0123	18333.14	1072.369	2.39E+12	30867.77	0.145828	8.529987	0.213659	12.49764	0.359487	21.02763	1.980806	115.8642	18.80105	1099.738	20.78185	1215.602
8	74837	376.0251	80.48577	3191.511	683.4282	3567.536	763.9499	5.91E+11	27922.83	0.039782	8.51895	0.052099	11.1564	0.091881	19.67535	0.454779	97.38603	4.677778	1001.696	5.132557	1099.083
9	755761	2640.197	55.95936	48641.99	1031.435	51282.18	1087.42	1.11E+13	51923.11	0.293768	6.229238	0.802165	17.00961	1.095933	23.23885	3.856435	81.77427	78.26622	1659.606	82.12266	1741.381
10	148813	459.8503	49.49915	7667.192	825.68	8127.042	875.2012	1.81E+12	42972.08	0.05491	5.91329	0.118181	12.72689	0.173091	18.64018	0.735795	79.23773	11.09588	1194.916	11.83168	1274.153
11	292567	972.2386	53.23154	14603.51	799.9219	15575.75	853.1772	3.68E+12	44472.19	0.136942	7.501135	0.256268	14.03731	0.39321	21.53845	1.148903	62.93232	22.15117	1213.353	23.30008	1276.285
12	619104	2705.218	69.99381	29669.59	768.0035	32374.81	838.0286	6.08E+12	34722.21	0.328679	8.507913	0.449915	11.64614	0.778594	20.15405	3.263882	84.48627	37.12815	961.0699	40.39204	1045.556
13	100178	266.9492	42.68534	4886.04	781.6303	5152.989	824.3347	1.34E+12	47427.7	0.044688	7.148767	0.077698	12.42957	0.122386	19.57833	0.349187	55.86015	6.098433	975.5794	6.44762	1031.44
14	130885	733.512	89.77128	6662.452	815.7526	7395.964	905.564	1.09E+12	29350.51	0.068957	8.44306	0.104694	12.81881	0.173651	21.26187	0.915966	112.1512	9.876175	1209.242	10.79214	1321.393
15	175118	1134.604	103.7853	7746.628	708.9221	8881.231	812.7538	1.06E+12	21332.09	0.104321	9.546803	0.105199	9.627145	0.20952	19.17395	1.442963	132.0508	8.927542	816.9919	10.3705	949.0427
16	112482	787.2401	112.1101	6444.806	918.2092	7232.046	1030.369	8.64E+11	27146.03	0.077838	11.08986	0.079188	11.28208	0.157026	22.37194	0.973455	138.6909	5.650048	804.9779	6.623504	943.6688
17	31331	238.8472	122.1162	12574.32	6431.788	12813.17	6553.959	1.52E+12	170927	0.022332	11.42281	0.148325	75.8684	0.170657	87.29121	0.299678	153.2857	10.68071	5463.205	10.98039	5616.491
18	416023	2308.533	88.88738	18756.73	722.5292	21065.26	811.4564	2.92E+12	24835.43	0.23081	8.891049	0.250059	9.63255	0.480869	18.5236	2.949639	113.6232	20.44563	787.5876	23.39527	901.2108
	3762481	18342.47				233223.6		3.95E+13				3.132986		5.099426				273.173		296.6501	

Table D9(e) - Biofiltration Treatment Strategy (50% of City) Costs & Loading Results

By: jmr
Date: 07-Dec-09
Revised: 10-Apr-10

	No Treatment Base Case		Alternative Strategy - "Half Green"/Biofiltration for 50% of City							
	Catchment Area	Annual Runoff Volume	Annual Particulate Solids (TSS) Yield	Annual Runoff Volume	Annual Particulate Solids (TSS) Yield	Removal Efficiency	Total Volume of Biofiltration Systems	Capital Cost*	Annual O&M Cost 7.0%	Total Cost over 20 Years	$ per Kg TSS Removed
	(ha)	(m3)	(Kg)	(m3)	(Kg)		(m3)	($)	($/yr)	($)	
1	16.451	143,606	17,079	72,927	8,674	49.2%	2,470	$5,036,800	$352,580	$12,088,400	$71.91
2	31.651	303,468	33,069	153,980	16,794	49.2%	4,750	$9,623,100	$673,620	$23,095,500	$70.95
3	20.603	171,661	24,806	87,158	12,576	49.3%	3,090	$6,287,100	$440,100	$15,089,100	$61.69
4	11.081	93,971	16,669	47,739	8,444	49.3%	1,660	$3,398,600	$237,900	$8,156,600	$49.58
5	8.057	72,728	8,530	36,949	4,335	49.2%	1,210	$2,485,100	$173,960	$5,964,300	$71.09
6	26.504	459,024	23,889	232,910	12,189	49.0%	3,980	$8,077,400	$565,420	$19,385,800	$82.85
7	30.899	538,918	35,771	273,543	18,261	49.0%	4,630	$9,382,400	$656,770	$22,517,800	$64.30
8	6.722	123,347	7,923	62,759	4,049	48.9%	1,010	$2,078,100	$145,470	$4,987,500	$64.37
9	55.779	1,230,807	56,846	626,970	29,062	48.9%	8,370	$16,861,100	$1,180,280	$40,466,700	$72.82
10	8.401	191,254	8,478	97,806	4,346	48.7%	1,260	$2,586,800	$181,080	$6,208,400	$75.13
11	18.082	394,762	20,328	201,724	10,393	48.9%	2,710	$5,521,100	$386,480	$13,250,700	$66.69
12	63.311	1,161,893	71,276	590,364	36,293	49.1%	9,500	$19,113,300	$1,337,930	$45,871,900	$65.56
13	4.658	106,519	5,125	54,711	2,624	48.8%	700	$1,445,600	$101,190	$3,469,400	$69.36
14	13.634	238,414	15,757	121,134	8,050	48.9%	2,050	$4,188,200	$293,170	$10,051,600	$65.21
15	24.949	352,885	28,251	179,025	14,393	49.1%	3,740	$7,595,100	$531,660	$18,228,300	$65.77
16	23.707	218,739	24,514	111,062	12,447	49.2%	3,560	$7,233,100	$506,320	$17,359,500	$71.93
17	44.719	388,170	46,897	194,716	23,525	49.8%	6,710	$13,547,000	$948,290	$32,512,800	$69.56
18	63.642	892,507	66,000	452,587	33,563	49.1%	9,550	$19,212,900	$1,344,900	$46,110,900	$71.08
	472.850	7,082,673	511,208	3,598,064	260,018		70,950	$143,672,800	$10,057,120	$344,815,200	$68.64

* Includes 20% Engineering & Administration plus 35% contingency

Raw Data for alternative, from WinSLAMM, sorted by Catchment #:

	Runoff Volume (cf)	Particulate Solids Yield for Alternative (lbs)	Particulate Solids Concentration (mg/L)	Filterable Solids Yield (lbs)	Filterable Solids Concentration (mg/L)	Total Solids Yield (lbs)	Total Solids Concentration (mg/L)	Fecal Coliform Bacteria Yield (count)	Fecal Coliform Bacteria Concentration (#/100 ml)	Particulate Copper Yield (lbs)	Particulate Copper Concentration (ug/L)	Filterable Copper Yield (lbs)	Filterable Copper Concentration (ug/L)	Total Copper Yield (lbs)	Total Copper Concentration (ug/L)	Particulate Zinc Yield (lbs)	Particulate Zinc Concentration (ug/L)	Filterable Zinc Yield (lbs)	Filterable Zinc Concentration (ug/L)	Total Zinc Yield (lbs)	Total Zinc Concentration (ug/L)
1	2575301	19122.22	118.941	51130.55	318.1763	70252.89	437.1712	9.06E+12	12436.06	2.418735	15.05136	0.699529	4.353046	3.118265	19.40441	21.83496	135.8751	49.03117	305.1122	70.86612	440.9872
2	5437548	37023.87	109.0686	102625.5	302.4597	139649.4	411.5772	1.87E+13	12180.8	4.643453	13.68527	1.513522	4.46068	6.156974	18.14595	42.61664	125.6005	118.6047	349.554	161.2214	475.1548
3	3077841	27725.51	144.2961	63065.06	328.3659	90790.56	472.7264	1.09E+13	12472.77	4.391988	22.86811	0.835373	4.349604	5.227362	27.21772	28.98706	150.9292	56.29726	293.1274	85.28435	444.0568
4	1685814	18614.96	176.8779	34663.57	329.518	53278.51	506.4749	5.95E+12	12481.75	3.673705	34.92289	0.455592	4.33094	4.129296	39.25381	17.2482	163.9644	30.2742	287.7919	47.52242	451.7565
5	1304811	9556.957	117.3258	26001.57	319.3505	35558.5	436.7284	4.48E+12	12139.42	1.20348	14.78111	0.351826	4.321111	1.555306	19.10221	11.11638	136.531	25.03429	307.4704	36.15063	444.0009
6	8224854	26873.27	52.33757	135983.1	264.955	162856.1	317.3155	2.36E+13	10127.07	3.089581	6.019866	2.170794	4.229663	5.260374	10.24953	31.12949	60.65396	242.1208	471.758	273.2503	532.4122
7	9659739	40257.75	66.75831	168658.8	279.8073	208916.6	346.5956	2.85E+13	10428.24	4.788351	7.943941	2.536684	4.208394	7.325035	12.15233	46.43394	77.03456	259.7046	430.8535	306.1382	507.8876
8	2216246	8925.767	64.51323	30659.69	221.6998	39585.51	286.2422	7.15E+12	11405.49	1.268021	9.169044	0.643914	4.656132	1.911936	13.82518	9.613431	69.51457	66.09533	477.9343	75.70862	547.4479
9	22140440	64070.34	46.35452	321198.5	232.4892	385269.2	278.8647	7.63E+13	12181.43	9.29218	6.725845	5.857832	4.240003	15.15003	10.96586	93.79873	67.89319	623.0416	450.9686	716.8395	518.8611
10	3453858	9581.359	44.43691	51898.84	240.8067	61480.21	285.2635	1.25E+13	12748.07	1.454733	6.749854	0.861528	3.997426	2.316261	10.74728	15.55956	72.19519	88.15142	409.016	103.711	481.2111
11	7123560	22913.36	51.5244	93721.7	210.8426	116635	262.3899	2.53E+13	12572.06	4.205779	9.461603	1.84101	4.141662	6.046785	13.60326	24.16109	54.35441	173.2781	389.8182	197.4392	444.1726
12	20847730	80012.55	61.47812	301930.9	232.0941	381943.5	293.5998	7.32E+13	12405.66	13.43499	10.32747	5.425697	4.170732	18.86069	14.49821	84.08318	64.6347	500.4846	384.7223	584.5666	449.3561
13	1932015	5785.039	47.96418	26383.93	218.8489	32168.94	266.8343	7.61E+12	13922.34	1.182733	9.810512	0.452143	3.75043	1.634876	13.56094	6.623173	54.93777	37.90294	314.3966	44.52612	369.3344
14	4277638	17747.38	66.45864	62551.44	234.3412	80298.87	300.8297	1.30E+13	10759.67	2.159674	8.09095	1.285313	4.815267	3.444986	12.90621	20.30219	76.05965	139.5985	522.9885	159.9005	599.0474
15	6321995	31732.33	80.40241	101088.4	256.2491	132820.7	336.6876	2.00E+13	11162.37	3.789816	9.606814	1.887091	4.783591	5.67691	14.39042	37.34696	94.6709	191.2623	484.8312	228.6089	579.5013
16	3921982	27440.44	112.0745	75085.95	306.8093	102526.5	418.9343	1.42E+13	12775	3.690894	15.08139	1.029563	4.206904	4.72046	19.28831	30.59156	125.0004	69.10635	282.376	99.69786	407.3762
17	6876097	51865.1	120.8243	141354.8	329.4457	193219.8	450.3241	2.41E+13	12410.05	6.419638	14.9618	1.894849	4.416192	8.314484	19.37799	59.68832	139.1114	134.2059	312.7845	193.8943	451.8959
18	15982360	73993.52	74.16071	257647.8	258.3454	331641.5	332.5395	5.47E+13	12100.2	9.998384	10.02546	4.373405	4.385248	14.37179	14.4107	86.09519	86.32832	409.6734	410.7827	495.7681	497.1105
	1.27E+08	573241.7				2618892		4.29E+14				34.11567		115.2218				3213.867		3881.094	

Table D9(f) - Biofiltration Treatment Strategy (Streets ≤6% only) Costs & Loading Results

By: jmr
Date: 07-Dec-09
Revised: 10-Apr-10

		No Treatment Base Case		Alternative Strategy - Biofiltration for Streets with Profile Grade <6% (+/- 19.6 km of ROW)							
	Catchment Area	Annual Runoff Volume	Annual Particulate Solids (TSS) Yield	Annual Runoff Volume	Annual Particulate Solids (TSS) Yield	Removal Efficiency	Total Volume of Biofiltration Systems	Capital Cost*	Annual O&M Cost 7.0%	Total Cost over 20 Years	$ per Kg TSS Removed
	(ha)	(m3)	(Kg)	(m3)	(Kg)		(m3)	($)	($/yr)	($)	
1	16.451	143,606	17,079	79,928	13,752	19.5%	380	$789,500	$55,270	$1,894,900	$28.48
2	31.651	303,468	33,069	181,127	26,713	19.2%	750	$1,547,700	$108,340	$3,714,500	$29.22
3	20.603	171,661	24,806	101,759	18,579	25.1%	360	$748,400	$52,390	$1,796,200	$14.42
4	11.081	93,971	16,669	62,859	11,956	28.3%	140	$293,800	$20,570	$705,200	$7.48
5	8.057	72,728	8,530	67,117	8,113	4.9%	20	$42,800	$3,000	$102,800	$12.33
6	26.504	459,024	23,889	416,216	21,498	10.0%	200	$418,200	$29,270	$1,003,600	$20.99
7	30.899	538,918	35,771	475,249	32,027	10.5%	260	$542,300	$37,960	$1,301,500	$17.38
8	6.722	123,347	7,923	95,409	6,366	19.7%	130	$273,000	$19,110	$655,200	$21.04
9	55.779	1,230,807	56,846	1,066,591	47,342	16.7%	700	$1,445,600	$101,190	$3,469,400	$18.25
10	8.401	191,254	8,478	160,404	6,758	20.3%	140	$293,800	$20,570	$705,200	$20.50
11	18.082	394,762	20,328	371,477	18,560	8.7%	80	$168,800	$11,820	$405,200	$11.46
12	63.311	1,161,893	71,276	898,494	54,950	22.9%	1,080	$2,220,600	$155,440	$5,329,400	$16.32
13	4.658	106,519	5,125	79,605	3,523	31.3%	110	$231,400	$16,200	$555,400	$17.33
14	13.634	238,414	15,757	204,521	13,824	12.3%	150	$314,600	$22,020	$755,000	$19.53
15	24.949	352,885	28,251	312,582	25,722	9.0%	150	$314,600	$22,020	$755,000	$14.93
16	23.707	218,739	24,514	158,649	20,895	14.8%	240	$501,000	$35,070	$1,202,400	$16.61
17	44.719	388,170	46,897	245,316	39,168	16.5%	710	$1,466,000	$102,620	$3,518,400	$22.76
18	63.642	892,507	66,000	615,371	51,603	21.8%	1,700	$3,479,600	$243,570	$8,351,000	$29.00
	472.850	7,082,673	511,208	5,592,674	421,349		7,300	$15,091,700	$1,056,430	$36,220,300	$20.15

* Includes 20% Engineering & Administration plus 35% contingency

Formula: #VALUE!

Raw Data for alternative, from WinSLAMM, sorted by Catchment #:

	Runoff Volume (cf)	Particulate Solids Yield for Alternative (lbs)	Particulate Solids Concentration (mg/L)	Filterable Solids Yield (lbs)	Filterable Solids Concentration (mg/L)	Total Solids Yield (lbs)	Total Solids Concentration (mg/L)	Fecal Coliform Bacteria Yield (count)	Fecal Coliform Bacteria Concentration (#/100 ml)	Particulate Copper Yield (lbs)	Particulate Copper Concentration (ug/L)	Filterable Copper Yield (lbs)	Filterable Copper Concentration (ug/L)	Total Copper Yield (lbs)	Total Copper Concentration (ug/L)	Particulate Zinc Yield (lbs)	Particulate Zinc Concentration (ug/L)	Filterable Zinc Yield (lbs)	Filterable Zinc Concentration (ug/L)	Total Zinc Yield (lbs)	Total Zinc Concentration (ug/L)
1	2822545	30317.88	172.0597	37343.53	212.0264	67661.43	384.1631	4.12E+12	5163.484	2.624044	14.89861	0.475558	2.700089	3.099606	17.59872	38.75228	220.0249	39.55935	224.6072	78.31165	444.6322
2	6396195	58891.64	147.4868	76138.88	190.7656	135030.9	338.3193	9.26E+12	5113.63	5.049568	12.65167	1.083234	2.71404	6.132803	15.36572	75.83063	189.9933	100.4063	251.5677	176.2373	441.5618
3	3593445	40960.39	182.5889	47931.62	213.7601	88892.08	396.4309	5.44E+12	5352.556	4.238591	18.90279	0.589525	2.629096	4.828127	21.53194	50.20928	223.9177	45.89924	204.6963	96.10863	428.6145
4	2219774	26357.63	190.2037	27926.73	201.6168	54284.33	391.9054	3.54E+12	5637.182	3.727422	26.9101	0.346155	2.499063	4.073582	29.4092	29.17959	210.6619	25.64647	185.1546	54.82619	395.8174
5	2370113	17885.15	120.8773	24787.39	167.6012	42672.53	288.5325	4.05E+12	6035.024	2.128489	14.39189	0.332096	2.245482	2.460583	16.63736	21.26699	143.7978	24.19936	163.6252	45.46631	307.4228
6	14698000	47395.38	51.6534	126715	138.1609	174110.2	189.8371	2.03E+13	4868.853	4.559731	4.971601	2.020227	2.20271	6.579952	7.174305	57.83498	63.05909	235.7531	257.0482	293.5883	320.1076
7	16782650	70607.25	67.39223	154876.3	147.8903	225483.2	215.3123	2.36E+13	4962.859	7.071526	6.752552	2.312773	2.208452	9.384258	8.960964	85.91875	82.04322	250.2333	238.9461	336.152	320.9893
8	3369230	14034.71	66.72587	24609.9	117.0563	38644.64	183.8121	4.99E+12	5229.156	1.504475	7.155991	0.545639	2.595315	2.050114	9.751308	16.7642	79.73843	61.9396	294.6139	78.70381	374.3524
9	37664920	104371.8	44.38815	285658.9	121.5419	390030.8	165.95	6.36E+13	5966.625	12.27477	5.222657	5.280423	2.24671	17.55519	7.469366	171.1547	72.82275	598.6114	254.6967	769.7654	327.5192
10	5664395	14898.09	42.13067	45219.49	127.9345	60117.59	170.084	1.01E+13	6280.442	1.758148	4.974133	0.753019	2.130434	2.511166	7.104562	28.15448	79.65434	83.56261	236.4144	111.7171	316.0688
11	13118110	40917.82	49.96461	88680.77	108.3362	129598.7	158.3232	2.35E+13	6340.664	7.216037	8.815418	1.759114	2.149009	8.975169	10.96445	44.69255	54.59832	169.8147	207.4529	214.5072	262.0512
12	31728850	121145.4	61.16089	244943.1	123.7161	366088.9	184.9046	5.28E+13	5879.21	16.1032	8.133418	4.499713	2.27272	20.60292	10.40614	143.7903	72.62574	461.2959	232.9918	605.0844	305.6166
13	2811118	7765.847	44.25181	20556.46	117.1885	28322.32	161.4601	5.52E+12	6944.298	1.316364	7.504337	0.357478	2.037913	1.673841	9.542245	10.79709	61.55215	33.89972	193.2558	44.69671	254.8074
14	7222326	30476.08	67.59324	55210.62	122.507	85686.91	190.1309	1.04E+13	5086.102	3.024999	6.71218	1.16606	2.587373	4.191063	9.299562	37.16235	82.45966	134.555	298.5645	171.7173	381.0241
15	11038310	56708.45	82.29363	92362.91	134.0943	149071.2	216.4245	1.68E+13	5392.52	5.906794	8.575601	1.745341	2.533921	7.652142	11.10953	69.84246	101.3987	185.2668	268.9741	255.1089	370.3722
16	5602420	46064.73	131.7086	62077.32	177.5713	108141.9	309.3382	9.52E+12	6004.273	5.038174	14.41162	0.818228	2.34053	5.856404	16.75216	55.40581	158.4875	60.16757	172.1085	115.5734	330.5959
17	8662943	86351.22	159.6703	110430.4	204.2861	196781.4	364.0273	1.31E+13	5332.303	7.846652	14.51558	1.392454	2.57591	9.239101	17.09148	109.128	201.8767	112.9555	208.9573	222.0833	410.8336
18	21730830	113765	83.85974	197662.8	145.7686	311427.6	229.6657	3.32E+13	5406.104	10.39294	7.664392	3.398851	2.506521	13.79177	10.1709	150.9854	111.3458	368.4463	271.7148	519.4318	383.0607
	197496174	928914.5		1723132		2652047		3.14E+14		101.7819		28.87589		130.6578		1196.87		2992.212		4189.08	

Table D9(g) - Street Sweeping (2x per year) Costs & Loading Results

By: jmr
Date: 07-Dec-09
Revised: 10-Apr-10

	Catchment Area	No Treatment Base Case: Annual Runoff Volume	No Treatment Base Case: Annual Particulate Solids (TSS) Yield	Alternative Strategy - Street Cleaning, Twice per Year: Annual Runoff Volume	Annual Particulate Solids (TSS) Yield	Removal Efficiency	Total Length of ROW Cleaned Annually	Capital Cost*	Annual OM&R Cost**	Total Cost over 20 Years	$ per Kg TSS Removed
							2 # of Sweepers Purchased:		1		
	(ha)	(m3)	(Kg)	(m3)	(Kg)		(Km)	($)	($/yr)	($)	
1	16.451	143,606	17,079	143,606	17,035	0.3%	6.25	$ 8,300	$ 870	$25,700	$29.20
2	31.651	303,468	33,069	303,468	32,987	0.2%	18.07	$ 23,900	$ 2,510	$74,100	$45.18
3	20.603	171,661	24,806	171,661	24,698	0.4%	9.01	$ 11,900	$ 1,250	$36,900	$17.08
4	11.081	93,971	16,669	93,971	16,561	0.6%	7.85	$ 10,400	$ 1,090	$32,200	$14.91
5	8.057	72,728	8,530	72,728	8,508	0.3%	5.92	$ 7,800	$ 820	$24,200	$55.00
6	26.504	459,024	23,889	459,024	23,850	0.2%	9.9	$ 13,100	$ 1,370	$40,500	$51.92
7	30.899	538,918	35,771	538,918	35,701	0.2%	12.68	$ 16,800	$ 1,760	$52,000	$37.14
8	6.722	123,347	7,923	123,347	7,898	0.3%	4.88	$ 6,500	$ 680	$20,100	$40.20
9	55.779	1,230,807	56,846	1,230,807	56,676	0.3%	35.92	$ 47,500	$ 4,990	$147,300	$43.32
10	8.401	191,254	8,478	191,254	8,450	0.3%	4.57	$ 6,000	$ 630	$18,600	$33.21
11	18.082	394,762	20,328	394,762	20,224	0.5%	16.16	$ 21,400	$ 2,240	$66,200	$31.83
12	63.311	1,161,893	71,276	1,161,893	70,959	0.4%	43.46	$ 57,500	$ 6,030	$178,100	$28.09
13	4.658	106,519	5,125	106,519	5,093	0.6%	6.13	$ 8,100	$ 850	$25,100	$39.22
14	13.634	238,414	15,757	238,425	15,724	0.2%	8.47	$ 11,200	$ 1,180	$34,800	$52.73
15	24.949	352,885	28,251	352,885	28,192	0.2%	14.56	$ 19,300	$ 2,020	$59,700	$50.59
16	23.707	218,739	24,514	218,739	24,441	0.3%	13.72	$ 18,200	$ 1,900	$56,200	$38.49
17	44.719	388,170	46,897	388,170	46,783	0.2%	21.28	$ 28,200	$ 2,950	$87,200	$38.25
18	63.642	892,507	66,000	892,507	65,813	0.3%	36.23	$ 47,900	$ 5,030	$148,500	$39.71
	472.850	7,082,673	511,208	7,082,684	509,593		275.06	$364,000	$38,170	$1,127,400	$34.90

Costs prorated by catchment based on length of ROW; see copmutation, below.
* Includes 5% Administration plus 35% contingency
** Includes replacement purchases of new sweepers; straight-line depreciation

Computation of Capital and OM&R Costs:

Assumed fraction that can be cleaned:	100%		68763.2	m
Passes per street, curb to curb:	2	#/st	137526.4	m total cleaning length
Operating speed (3-15 km/hr):	10	km/hr	13.75	hrs to clean all streets
Cleaning schedule: 2/year	2	/year or	27.50	hrs/yr
Annual operating time per unit, less	10%	down time:	1872	hr
# units to purchase (1 minimum):			1	
% utilization of sweepers:			1.5%	
Capital cost (at start):	$260,000	/unit *1.4	$364,000	incl 1.4 for admin & contingency
Replacement schedule:	6	years		
Replacement capital cost (over 20 years):	$520,000	total *1.4	$728,000	incl 1.4 for admin & contingency
		or	$36,400	/yr
O&M cost, per CWP:	$65	/hr	$1,788	/yr

Raw Data for alternative, from WinSLAMM, sorted by Catchment #:

Runoff Volume (cf)	Particulate Solids Yield for Alternative (lbs)	Particulate Solids Concentration (mg/L)	Filterable Solids Yield (lbs)	Filterable Solids Concentration (mg/L)	Total Solids Yield (lbs)	Total Solids Concentration (mg/L)	Fecal Coliform Bacteria Yield (count)	Fecal Coliform Bacteria Concentration (#/100 ml)	Particulate Copper Yield (lbs)	Particulate Copper Concentration (ug/L)	Filterable Copper Yield (lbs)	Filterable Copper Concentration (ug/L)	Total Copper Yield (lbs)	Total Copper Concentration (ug/L)	Particulate Zinc Yield (lbs)	Particulate Zinc Concentration (ug/L)	Filterable Zinc Yield (lbs)	Filterable Zinc Concentration (ug/L)	Total Zinc Yield (lbs)	Total Zinc Concentration (ug/L)
5071220	37556.55	118.63	51130.55	161.5784	88687.2	280.2618	9.06E+12	6315.363	4.744954	14.9946	0.699529	2.210594	5.444478	17.20518	42.89432	135.551	49.03117	154.9442	91.9256	290.4955
10716470	72723.37	108.7035	102625.5	153.4683	175348.9	262.2204	1.87E+13	6180.548	9.110682	13.62431	1.513522	2.263353	10.62421	15.88767	83.72578	125.2053	118.6047	177.364	202.3305	302.5694
6061920	54450.58	143.8843	63065.06	166.7224	117515.6	310.6709	1.09E+13	6332.848	8.610723	22.76381	0.835373	2.208441	9.446104	24.97227	56.96537	150.597	56.29726	148.8307	113.2627	299.4279
3318446	36511.91	176.2467	34663.57	167.3994	71175.51	343.7251	5.95E+12	6340.891	7.194304	34.74317	0.455592	2.200174	7.649895	36.94334	33.86142	163.5256	30.2742	146.202	64.1356	309.7275
2568287	18756.6	116.9854	26001.57	162.2451	44758.16	279.2827	4.48E+12	6167.395	2.35969	14.72403	0.351826	2.195328	2.711514	16.91935	21.82101	136.1591	25.03429	156.2094	46.85524	292.3682
16209700	52581	51.96072	135983.1	134.4391	188564	186.4229	2.36E+13	5138.51	6.048716	5.980035	2.170794	2.146145	8.219514	8.126184	60.87183	60.18066	242.1208	239.3716	302.9925	299.5522
19031030	78707.02	66.24794	168658.8	142.0241	247365.9	208.3017	2.85E+13	5293.149	9.365633	7.886608	2.536684	2.136089	11.90232	10.0227	90.73479	76.40591	259.7046	218.6919	350.4391	295.0977
4355811	17412.82	64.03558	30659.69	112.8013	48072.57	176.8657	7.15E+12	5803.137	2.474731	9.104885	0.643914	2.36905	3.118647	11.47394	18.74198	68.95438	66.09533	243.174	84.83716	312.1278
43463960	124949.5	46.04965	321198.5	118.4294	446148.4	164.4998	7.63E+13	6205.191	18.12847	6.684167	5.857832	2.159847	23.98632	8.84402	183.3324	67.59668	623.0416	229.7223	806.3735	297.3188
6753839	18629.62	44.18497	51898.84	123.1466	70528.52	167.3515	1.25E+13	6519.258	2.830083	6.715277	0.861528	2.044251	3.691609	8.759522	30.33881	71.98853	88.15142	209.1674	118.4902	281.156
13940380	44585.55	51.23194	93721.7	107.741	138307.2	158.9958	2.53E+13	6424.345	8.182164	9.406089	1.84101	2.116397	10.02317	11.52248	47.04033	54.07682	173.2781	199.1978	220.3184	253.2746
41030350	156439.6	61.0749	301930.9	117.9282	458370.4	179.0304	7.32E+13	6303.379	26.25592	10.25504	5.425697	2.11917	31.68161	12.37421	164.4185	64.21859	500.4846	195.4793	664.902	259.6975
3761532	11229.17	47.81942	26383.93	112.4062	37613.09	160.2469	7.61E+12	7150.855	2.294028	9.773482	0.452143	1.926313	2.746172	11.6998	12.86392	54.8055	37.90294	161.4818	50.76684	216.2872
8419607	34665.32	65.95149	62551.44	119.0586	97216.83	185.0397	1.30E+13	5466.52	4.220698	8.033557	1.285313	2.446429	5.506004	10.47997	39.63239	75.43517	139.5985	265.7078	179.2306	341.1425
12461560	62153.77	79.89438	101088.4	130.0002	163242.1	209.9302	2.00E+13	5662.889	7.422603	9.54551	1.887091	2.42681	9.309702	11.97233	73.14121	94.06003	191.2623	245.9644	264.4032	340.024
7724422	53883.28	111.7402	75085.95	155.7787	128969.3	267.569	1.42E+13	6486.355	7.23872	15.01797	1.029563	2.136005	8.268285	17.15398	60.0868	124.6604	69.10635	143.373	129.1931	268.0333
13707580	103139.6	120.5274	141354.8	165.2589	244494.5	285.8405	2.41E+13	6225.221	12.71351	14.86347	1.894849	2.215282	14.60837	17.07876	118.8537	138.9528	134.2059	156.9012	253.0596	295.8539
31517420	145093.2	73.74247	257647.8	131.006	402741.3	204.7816	5.47E+13	6135.967	19.59422	9.963061	4.373405	2.223743	23.96762	12.1868	168.8607	85.8605	409.6734	208.3064	578.5336	294.1666
250113534	1123468		2045650		3169119		4.29E+14		158.7898		34.11567		192.9055		1308.185		3213.867		4522.049	

Table D9(h) - Street Sweeping (1x per month) Costs & Loading Results

By: jmr
Date: 07-Dec-09
Revised: 10-Apr-10

	No Treatment Base Case		Alternative Strategy - Street Cleaning, Once per Month								
	Catchment Area	Annual Runoff Volume	Annual Particulate Solids (TSS) Yield	Annual Runoff Volume	Annual Particulate Solids (TSS) Yield	Removal Efficiency	Total Length of ROW Cleaned Annually	Capital Cost*	Annual OM&R Cost**	Total Cost over 20 Years	$ per Kg TSS Removed
							12	# of Sweepers Purchased:		1	
	(ha)	(m3)	(Kg)	(m3)	(Kg)		(Km)	($)	($/yr)	($)	
1	16.451	143,606	17,079	143,606	16,785	1.7%	37.52	$ 8,300	$ 1,070	$29,700	$5.05
2	31.651	303,468	33,069	303,468	32,518	1.7%	108.43	$ 23,900	$ 3,100	$85,900	$7.79
3	20.603	171,661	24,806	171,661	24,088	2.9%	54.04	$ 11,900	$ 1,540	$42,700	$2.97
4	11.081	93,971	16,669	93,971	15,951	4.3%	47.11	$ 10,400	$ 1,350	$37,400	$2.60
5	8.057	72,728	8,530	72,728	8,384	1.7%	35.5	$ 7,800	$ 1,010	$28,000	$9.59
6	26.504	459,024	23,889	459,024	23,631	1.1%	59.39	$ 13,100	$ 1,700	$47,100	$9.13
7	30.899	538,918	35,771	538,918	35,302	1.3%	76.09	$ 16,800	$ 2,170	$60,200	$6.42
8	6.722	123,347	7,923	123,347	7,756	2.1%	29.28	$ 6,500	$ 840	$23,300	$6.98
9	55.779	1,230,807	56,846	1,230,807	55,711	2.0%	215.53	$ 47,500	$ 6,150	$170,500	$7.51
10	8.401	191,254	8,478	191,254	8,293	2.2%	27.41	$ 6,000	$ 780	$21,600	$5.84
11	18.082	394,762	20,328	394,762	19,631	3.4%	96.93	$ 21,400	$ 2,770	$76,800	$5.51
12	63.311	1,161,893	71,276	1,161,893	69,161	3.0%	260.77	$ 57,500	$ 7,450	$206,500	$4.88
13	4.658	106,519	5,125	106,519	4,917	4.1%	36.78	$ 8,100	$ 1,050	$29,100	$7.00
14	13.634	238,414	15,757	238,425	15,536	1.4%	50.79	$ 11,200	$ 1,450	$40,200	$9.10
15	24.949	352,885	28,251	352,885	27,860	1.4%	87.35	$ 19,300	$ 2,490	$69,100	$8.84
16	23.707	218,739	24,514	218,739	24,027	2.0%	82.33	$ 18,200	$ 2,350	$65,200	$6.69
17	44.719	388,170	46,897	388,170	46,138	1.6%	127.69	$ 28,200	$ 3,650	$101,200	$6.67
18	63.642	892,507	66,000	892,507	64,753	1.9%	217.39	$ 47,900	$ 6,210	$172,100	$6.90
	472.850	7,082,673	511,208	7,082,684	500,442		1,650.33	$364,000	$47,130	$1,306,600	$6.07

Costs prorated by catchment based on length of ROW; see copmutation, below.
* Includes 5% Administration plus 35% contingency
** Includes replacement purchases of new sweepers; straight-line depreciation

Computation of Capital and OM&R Costs:

Assumed fraction that can be cleaned:	100%		68763.2	m
Passes per street, curb to curb:	2	#/st	137526.4	m total cleaning length
Operating speed (3-15 km/hr):	10	km/hr	13.75	hrs to clean all streets
Cleaning schedule: 1/month	12	/year or	165.00	hrs/yr
Annual operating time per unit, less	10%	down time:	1872	hr
# units to purchase (1 minimum):			1	
% utilization of sweepers:			8.8%	
Capital cost (at start):	$260,000	/unit *1.4	$364,000	incl 1.4 for admin & contingency
Replacement schedule:	6	years		
Replacement capital cost (over 20 years):	$520,000	total *1.4	$728,000	incl 1.4 for admin & contingency
		or	$36,400	/yr
O&M cost, per CWP:	$65	/hr	$10,725	/yr

Raw Data for alternative, from WinSLAMM, sorted by Catchment #:

	Runoff Volume (cf)	Particulate Solids Yield for Alternative (lbs)	Particulate Solids Concentration (mg/L)	Filterable Solids Yield (lbs)	Filterable Solids Concentration (mg/L)	Total Solids Yield (lbs)	Total Solids Concentration (mg/L)	Fecal Coliform Bacteria Yield (count)	Fecal Coliform Bacteria Concentration (#/100 ml)	Particulate Copper Yield (lbs)	Particulate Copper Concentration (ug/L)	Filterable Copper Yield (lbs)	Filterable Copper Concentration (ug/L)	Total Copper Yield (lbs)	Total Copper Concentration (ug/L)	Particulate Zinc Yield (lbs)	Particulate Zinc Concentration (ug/L)	Filterable Zinc Yield (lbs)	Filterable Zinc Concentration (ug/L)	Total Zinc Yield (lbs)	Total Zinc Concentration (ug/L)
	5071220	37005.23	116.8885	51130.55	161.5784	88135.84	278.5195	9.06E+12	6315.363	4.538204	14.34125	0.699529	2.210594	5.237736	16.55185	42.68261	134.882	49.03117	154.9442	91.71384	289.8264
	10716470	71690.64	107.1598	102625.5	153.4683	174316.2	260.6761	1.87E+13	6180.548	8.723415	13.04518	1.513522	2.263353	10.23694	15.30854	83.32925	124.6124	118.6047	177.364	201.9341	301.9765
	6061920	53105.26	140.3294	63065.06	166.7224	116170.3	307.1145	1.09E+13	6332.848	8.106232	21.4301	0.835373	2.208441	8.941614	23.63857	56.4488	149.2313	56.29726	148.8307	112.7461	298.062
	3318446	35166.57	169.7526	34663.57	167.3994	69830.2	337.2282	5.95E+12	6340.891	6.68981	32.30684	0.455592	2.200174	7.145402	34.50701	33.34482	161.0308	30.2742	146.202	63.61904	307.2329
	2568287	18484.31	115.2872	26001.57	162.2451	44485.86	277.5836	4.48E+12	6167.395	2.257579	14.08688	0.351826	2.195328	2.609404	16.2822	21.71645	135.5067	25.03429	156.2094	46.75071	291.7159
	16209700	52097.78	51.4832	135983.1	134.4391	188080.7	185.9451	2.36E+13	5138.51	5.867498	5.800875	2.170794	2.146145	8.038286	7.947015	60.68629	59.99722	242.1208	239.3716	302.807	299.3688
	19031030	77828.19	65.50822	168658.8	142.0241	246487.1	207.5617	2.85E+13	5293.149	9.036067	7.609087	2.536684	2.136089	11.57275	9.745175	90.39742	76.12183	259.7046	218.6919	350.1014	294.8132
	4355811	17100.22	62.88597	30659.69	112.8013	47759.93	175.7155	7.15E+12	5803.137	2.357502	8.673581	0.643914	2.36905	3.001417	11.04264	18.62193	68.51269	66.09533	243.174	84.71712	311.6862
	43463960	122823.2	45.26601	321198.5	118.4294	444021.7	163.7157	7.63E+13	6205.191	17.33106	6.390154	5.857832	2.159847	23.18891	8.550008	182.5158	67.29559	623.0416	229.7223	805.5573	297.0179
	6753839	18283.45	43.36394	51898.84	123.1466	70182.33	166.53	1.25E+13	6519.258	2.700268	6.407249	0.861528	2.044251	3.561796	8.451501	30.2059	71.67315	88.15142	209.1674	118.3573	280.8406
	13940380	43279.79	49.73153	93721.7	107.741	137001.5	157.4948	2.53E+13	6424.345	7.692493	8.843171	1.84101	2.116397	9.533486	10.95955	46.5389	53.5004	173.2781	199.1978	219.817	252.6983
	41030350	152475.3	59.52721	301930.9	117.9282	454406.3	177.4821	7.32E+13	6303.379	24.76933	9.67441	5.425697	2.11917	30.19501	11.79357	162.8961	63.62399	500.4846	195.4793	663.3797	259.1029
	3761532	10839.55	46.16021	26383.93	112.4062	37223.46	158.5869	7.61E+12	7150.855	2.147921	9.151007	0.452143	1.926313	2.600065	11.07732	12.7143	54.16806	37.90294	161.4818	50.61729	215.65
	8419607	34250.13	65.16158	62551.44	119.0586	96801.66	184.2495	1.30E+13	5466.52	4.065001	7.737209	1.285313	2.446429	5.35031	10.18363	39.47289	75.13158	139.5985	265.7078	179.0712	340.8391
	12461560	61421.95	78.95367	101088.4	130.0002	162510.4	208.9893	2.00E+13	5662.889	7.148158	9.192573	1.887091	2.42681	9.03525	11.61938	72.86018	93.69862	191.2623	245.9644	264.1223	339.6628
	7724422	52969.93	109.8461	75085.95	155.7787	128055.9	265.6741	1.42E+13	6486.355	6.896215	14.30739	1.029563	2.136005	7.925781	16.4434	59.73603	123.9327	69.10635	143.373	128.8423	267.3055
	13707580	101717.4	118.8655	141354.8	165.2589	243072.2	284.1776	2.41E+13	6225.221	12.18021	14.23998	1.894849	2.215282	14.07506	16.45526	118.3076	138.3143	134.2059	156.9012	252.5135	295.2155
	31517420	142756.6	72.5549	257647.8	131.006	400404.6	203.5935	5.47E+13	6135.967	18.71799	9.517523	4.373405	2.223743	23.09139	11.74126	167.9633	85.40418	409.6734	208.3064	577.6359	293.7102
	250113534	1103296		2045650		3148946		4.29E+14		151.225		34.11567		185.3406		1300.439		3213.867		4514.303	

Table D9(i) - Street Sweeping (1x per week) Costs & Loading Results

By: jmr
Date: 07-Dec-09
Revised: 10-Apr-10

	Catchment Area	No Treatment Base Case: Annual Runoff Volume	No Treatment Base Case: Annual Particulate Solids (TSS) Yield	Alternative Strategy - Street Cleaning, Once per Week: Annual Runoff Volume	Annual Particulate Solids (TSS) Yield	Removal Efficiency	Total Length of ROW Cleaned Annually	Capital Cost*	Annual OM&R Cost**	Total Cost over 20 Years	$ per Kg TSS Removed
							52 # of Sweepers Purchased:		1		
	(ha)	(m3)	(Kg)	(m3)	(Kg)		(Km)	($)	($/yr)	($)	
1	16.451	143,606	17,079	143,606	16,340	4.3%	162.6	$ 8,300	$ 1,880	$45,900	$3.11
2	31.651	303,468	33,069	303,468	31,684	4.2%	469.86	$ 23,900	$ 5,450	$132,900	$4.80
3	20.603	171,661	24,806	171,661	23,001	7.3%	234.16	$ 11,900	$ 2,710	$66,100	$1.83
4	11.081	93,971	16,669	93,971	14,864	10.8%	204.13	$ 10,400	$ 2,370	$57,800	$1.60
5	8.057	72,728	8,530	72,728	8,164	4.3%	153.83	$ 7,800	$ 1,780	$43,400	$5.93
6	26.504	459,024	23,889	459,024	23,240	2.7%	257.35	$ 13,100	$ 2,980	$72,700	$5.60
7	30.899	538,918	35,771	538,918	34,592	3.3%	329.71	$ 16,800	$ 3,820	$93,200	$3.95
8	6.722	123,347	7,923	123,347	7,504	5.3%	126.87	$ 6,500	$ 1,470	$35,900	$4.28
9	55.779	1,230,807	56,846	1,230,807	53,993	5.0%	933.97	$ 47,500	$ 10,820	$263,900	$4.62
10	8.401	191,254	8,478	191,254	8,013	5.5%	118.76	$ 6,000	$ 1,380	$33,600	$3.61
11	18.082	394,762	20,328	394,762	18,576	8.6%	420.04	$ 21,400	$ 4,870	$118,800	$3.39
12	63.311	1,161,893	71,276	1,161,893	65,957	7.5%	1129.99	$ 57,500	$ 13,100	$319,500	$3.00
13	4.658	106,519	5,125	106,519	4,602	10.2%	159.37	$ 8,100	$ 1,850	$45,100	$4.31
14	13.634	238,414	15,757	238,425	15,200	3.5%	220.1	$ 11,200	$ 2,550	$62,200	$5.58
15	24.949	352,885	28,251	352,885	27,269	3.5%	378.53	$ 19,300	$ 4,390	$107,100	$5.45
16	23.707	218,739	24,514	218,739	23,288	5.0%	356.78	$ 18,200	$ 4,130	$100,800	$4.11
17	44.719	388,170	46,897	388,170	44,989	4.1%	553.31	$ 28,200	$ 6,410	$156,400	$4.10
18	63.642	892,507	66,000	892,507	62,864	4.8%	942.02	$ 47,900	$ 10,920	$266,300	$4.25
	472.850	7,082,673	511,208	7,082,684	484,140		7,151.38	$364,000	$82,880	$2,021,600	$3.73

Costs prorated by catchment based on length of ROW; see copmutation, below.
* Includes 5% Administration plus 35% contingency
** Includes replacement purchases of new sweepers; straight-line depreciation

Computation of Capital and OM&R Costs:

Assumed fraction that can be cleaned:	100%		68763.2	m
Passes per street, curb to curb:	2	#/st	137526.4	m total cleaning length
Operating speed (3-15 km/hr):	10	km/hr	13.75	hrs to clean all streets
Cleaning schedule: 1/week	52	/year or	715.00	hrs/yr
Annual operating time per unit, less	10%	down time:	1872	hr
# units to purchase (1 minimum):			1	
% utilization of sweepers:			38.2%	
Capital cost (at start):	$260,000	/unit *1.4	$364,000	incl 1.4 for admin & contingency
Replacement schedule:	6	years		
Replacement capital cost (over 20 years):	$520,000	total *1.4	$728,000	incl 1.4 for admin & contingency
		or	$36,400	/yr
O&M cost, per CWP:	$65	/hr	$46,475	/yr

Raw Data for alternative, from WinSLAMM, sorted by Catchment #:

	Runoff Volume (cf)	Particulate Solids Yield for Alternative (lbs)	Particulate Solids Concentration (mg/L)	Filterable Solids Yield (lbs)	Filterable Solids Concentration (mg/L)	Total Solids Yield (lbs)	Total Solids Concentration (mg/L)	Fecal Coliform Bacteria Yield (count)	Fecal Coliform Bacteria Concentration (#/100 ml)	Particulate Copper Yield (lbs)	Particulate Copper Concentration (ug/L)	Filterable Copper Yield (lbs)	Filterable Copper Concentration (ug/L)	Total Copper Yield (lbs)	Total Copper Concentration (ug/L)	Particulate Zinc Yield (lbs)	Particulate Zinc Concentration (ug/L)	Filterable Zinc Yield (lbs)	Filterable Zinc Concentration (ug/L)	Total Zinc Yield (lbs)	Total Zinc Concentration (ug/L)
	5071220	36022.81	113.7854	51130.55	161.5784	87153.5	275.4151	9.06E+12	6315.363	4.169806	13.17707	0.699529	2.210594	4.869334	15.38766	42.30537	133.6899	49.03117	154.9442	91.33656	288.6341
	10716470	69850.56	104.4093	102625.5	153.4683	172476.1	257.9244	1.87E+13	6180.548	8.033375	12.01328	1.513522	2.263353	9.546894	14.27663	82.62265	123.5557	118.6047	177.364	201.2274	300.9198
	6061920	50708.14	133.9951	63065.06	166.7224	113773.2	300.7773	1.09E+13	6332.848	7.207311	19.05367	0.835373	2.208441	8.042684	21.2621	55.52831	146.7979	56.29726	148.8307	111.8255	295.6285
	3318446	32769.45	158.1814	34663.57	167.3994	67433.02	325.6516	5.95E+12	6340.891	5.790878	27.96566	0.455592	2.200174	6.246471	30.16584	32.4243	156.5854	30.2742	146.202	62.69852	302.7875
	2568287	17999.12	112.261	26001.57	162.2451	44000.68	274.5562	4.48E+12	6167.395	2.075634	12.95158	0.351826	2.195328	2.427458	15.1469	21.53014	134.3441	25.03429	156.2094	46.56441	290.5534
	16209700	51236.66	50.63224	135983.1	134.4391	187219.5	185.0937	2.36E+13	5138.51	5.544591	5.481635	2.170794	2.146145	7.715379	7.627774	60.35559	59.67027	242.1208	239.3716	302.4765	299.042
	19031030	76262.2	64.19012	168658.8	142.0241	244921.1	206.243	2.85E+13	5293.149	8.448841	7.114596	2.536684	2.136089	10.98552	9.250684	89.7961	75.61546	259.7046	218.6919	349.5003	294.3071
	4355811	16543.2	60.83754	30659.69	112.8013	47202.95	173.6663	7.15E+12	5803.137	2.148626	7.905097	0.643914	2.36905	2.79254	10.27415	18.40803	67.72572	66.09533	243.174	84.50321	310.8992
	43463960	119034.1	43.86958	321198.5	118.4294	440232.8	162.3187	7.63E+13	6205.191	15.91019	5.866264	5.857832	2.159847	21.76804	8.026116	181.0609	66.75914	623.0416	229.7223	804.1023	296.4814
	6753839	17666.63	41.90099	51898.84	123.1466	69565.48	165.0663	1.25E+13	6519.258	2.468958	5.858392	0.861528	2.044251	3.33049	7.902653	29.96904	71.11113	88.15142	209.1674	118.1205	280.2786
	13940380	40953.08	47.05798	93721.7	107.741	134674.8	154.82	2.53E+13	6424.345	6.819972	7.840133	1.84101	2.116397	8.660973	9.956519	45.64544	52.47328	173.2781	199.1978	218.9235	251.6711
	41030350	145411.7	56.76954	301930.9	117.9282	447342.7	174.7232	7.32E+13	6303.379	22.12043	8.639803	5.425697	2.11917	27.54614	10.75898	160.1837	62.56458	500.4846	195.4793	660.6669	258.0434
	3761532	10145.32	43.20382	26383.93	112.4062	36529.23	155.6292	7.61E+12	7150.855	1.88758	8.041852	0.452143	1.926313	2.339723	9.968163	12.44772	53.03229	37.90294	161.4818	50.35067	214.5141
	8419607	33510.36	63.75415	62551.44	119.0586	96061.97	182.8416	1.30E+13	5466.52	3.787578	7.209169	1.285313	2.446429	5.072887	9.65559	39.18885	74.59096	139.5985	265.7078	178.787	340.2982
	12461560	60117.84	77.27732	101088.4	130.0002	161206.2	207.3121	2.00E+13	5662.889	6.659126	8.563675	1.887091	2.42681	8.546222	10.99049	72.35943	93.05465	191.2623	245.9644	263.6214	339.0187
	7724422	51342.5	106.4712	75085.95	155.7787	126428.5	262.2976	1.42E+13	6486.355	6.285925	13.04123	1.029563	2.136005	7.31549	15.17724	59.11109	122.6361	69.10635	143.373	128.2174	266.0091
	13707580	99183.32	115.9041	141354.8	165.2589	240538.3	281.2151	2.41E+13	6225.221	11.22993	13.129	1.894849	2.215282	13.12477	15.34426	117.3345	137.1767	134.2059	156.9012	251.5404	294.0778
	31517420	138593	70.43882	257647.8	131.006	396241.2	201.4765	5.47E+13	6135.967	17.15669	8.723652	4.373405	2.223743	21.53007	10.94738	166.3647	84.59135	409.6734	208.3064	576.0374	292.8974
	250113534	1067350		2045650		3113001		4.29E+14		137.7454		34.11567		171.8611		1286.636		3213.867		4500.5	

Table D9(j) - Street Sweeping (2x per week) Costs & Loading Results

By: jmr
Date: 07-Dec-09
Revised: 10-Apr-10

	Catchment Area	No Treatment Base Case: Annual Runoff Volume	No Treatment Base Case: Annual Particulate Solids (TSS) Yield	Alternative Strategy - Street Cleaning, Twice per Week: Annual Runoff Volume	Annual Particulate Solids (TSS) Yield	Removal Efficiency	Total Length of ROW Cleaned Annually	Capital Cost*	Annual OM&R Cost**	Total Cost over 20 Years	$ per Kg TSS Removed
							104	# of Sweepers Purchased:		1	
	(ha)	(m3)	(Kg)	(m3)	(Kg)		(Km)	($)	($/yr)	($)	
1	16.451	143,606	17,079	143,606	16,101	5.7%	325.21	$ 8,300	$ 2,940	$67,100	$3.43
2	31.651	303,468	33,069	303,468	31,236	5.5%	939.72	$ 23,900	$ 8,500	$193,900	$5.29
3	20.603	171,661	24,806	171,661	22,418	9.6%	468.31	$ 11,900	$ 4,240	$96,700	$2.02
4	11.081	93,971	16,669	93,971	14,281	14.3%	408.26	$ 10,400	$ 3,690	$84,200	$1.76
5	8.057	72,728	8,530	72,728	8,046	5.7%	307.65	$ 7,800	$ 2,780	$63,400	$6.55
6	26.504	459,024	23,889	459,024	23,031	3.6%	514.7	$ 13,100	$ 4,650	$106,100	$6.18
7	30.899	538,918	35,771	538,918	34,211	4.4%	659.42	$ 16,800	$ 5,960	$136,000	$4.36
8	6.722	123,347	7,923	123,347	7,368	7.0%	253.74	$ 6,500	$ 2,290	$52,300	$4.71
9	55.779	1,230,807	56,846	1,230,807	53,071	6.6%	1867.94	$ 47,500	$ 16,890	$385,300	$5.10
10	8.401	191,254	8,478	191,254	7,863	7.3%	237.52	$ 6,000	$ 2,150	$49,000	$3.98
11	18.082	394,762	20,328	394,762	18,010	11.4%	840.07	$ 21,400	$ 7,600	$173,400	$3.74
12	63.311	1,161,893	71,276	1,161,893	64,239	9.9%	2259.98	$ 57,500	$ 20,440	$466,300	$3.31
13	4.658	106,519	5,125	106,519	4,433	13.5%	318.74	$ 8,100	$ 2,880	$65,700	$4.75
14	13.634	238,414	15,757	238,425	15,020	4.7%	440.19	$ 11,200	$ 3,980	$90,800	$6.16
15	24.949	352,885	28,251	352,885	26,952	4.6%	757.06	$ 19,300	$ 6,850	$156,300	$6.02
16	23.707	218,739	24,514	218,739	22,893	6.6%	713.56	$ 18,200	$ 6,450	$147,200	$4.54
17	44.719	388,170	46,897	388,170	44,372	5.4%	1106.62	$ 28,200	$ 10,010	$228,400	$4.52
18	63.642	892,507	66,000	892,507	61,852	6.3%	1884.04	$ 47,900	$ 17,040	$388,700	$4.69
	472.850	7,082,673	511,208	7,082,684	475,397		14,302.73	$364,000	$129,340	$2,950,800	$4.12

Costs prorated by catchment based on length of ROW; see copmutation, below.
* Includes 5% Administration plus 35% contingency
** Includes replacement purchases of new sweepers; straight-line depreciation

Computation of Capital and OM&R Costs:

Assumed fraction that can be cleaned:	100%		68763.2	m
Passes per street, curb to curb:	2	#/st	137526.4	m total cleaning length
Operating speed (3-15 km/hr):	10	km/hr	13.75	hrs to clean all streets
Cleaning schedule: 2/week	104	/year or	1430.00	hrs/yr
Annual operating time per unit, less	10%	down time:	1872	hr
# units to purchase (1 minimum):			1	
% utilization of sweepers:			76.4%	
Capital cost (at start):	$260,000	/unit *1.4	$364,000	incl 1.4 for admin & contingency
Replacement schedule:	6	years		
Replacement capital cost (over 20 years):	$520,000	total *1.4	$728,000	incl 1.4 for admin & contingency
		or	$36,400	/yr
O&M cost, per CWP:	$65	/hr	$92,950	/yr

Raw Data for alternative, from WinSLAMM, sorted by Catchment #:

Runoff Volume (cf)	Particulate Solids Yield for Alternative (lbs)	Particulate Solids Concentration (mg/L)	Filterable Solids Yield (lbs)	Filterable Solids Concentration (mg/L)	Total Solids Yield (lbs)	Total Solids Concentration (mg/L)	Fecal Coliform Bacteria Yield (count)	Fecal Coliform Bacteria Concentration (#/100 ml)	Particulate Copper Yield (lbs)	Particulate Copper Concentration (ug/L)	Filterable Copper Yield (lbs)	Filterable Copper Concentration (ug/L)	Total Copper Yield (lbs)	Total Copper Concentration (ug/L)	Particulate Zinc Yield (lbs)	Particulate Zinc Concentration (ug/L)	Filterable Zinc Yield (lbs)	Filterable Zinc Concentration (ug/L)	Total Zinc Yield (lbs)	Total Zinc Concentration (ug/L)
5071220	35495.97	112.1212	51130.55	161.5784	86626.64	273.7502	9.06E+12	6315.363	3.972234	12.55272	0.699529	2.210594	4.671764	14.76332	42.10303	133.0505	49.03117	154.9442	91.13424	287.9948
10716470	68863.68	102.9342	102625.5	153.4683	171489.3	256.4487	1.87E+13	6180.548	7.6633	11.45986	1.513522	2.263353	9.176823	13.72322	82.24369	122.989	118.6047	177.364	200.8484	300.353
6061920	49422.5	130.5978	63065.06	166.7224	112487.6	297.3787	1.09E+13	6332.848	6.725209	17.77915	0.835373	2.208441	7.560585	19.9876	55.03463	145.4927	56.29726	148.8307	111.3319	294.3235
3318446	31483.86	151.9758	34663.57	167.3994	66147.45	319.4432	5.95E+12	6340.891	5.308787	25.63752	0.455592	2.200174	5.764376	27.83767	31.93063	154.2013	30.2742	146.202	62.2049	300.4037
2568287	17738.91	110.6381	26001.57	162.2451	43740.45	272.9324	4.48E+12	6167.395	1.978058	12.34272	0.351826	2.195328	2.329883	14.53804	21.43021	133.7206	25.03429	156.2094	46.46448	289.9299
16209700	50774.87	50.1759	135983.1	134.4391	186757.9	184.6373	2.36E+13	5138.51	5.371415	5.310425	2.170794	2.146145	7.542204	7.456566	60.17827	59.49497	242.1208	239.3716	302.2991	298.8666
19031030	75422.36	63.48323	168658.8	142.0241	244081.3	205.5358	2.85E+13	5293.149	8.133906	6.849396	2.536684	2.136089	10.67059	8.98549	89.47356	75.34386	259.7046	218.6919	349.1778	294.0355
4355811	16244.47	59.73898	30659.69	112.8013	46904.23	172.5672	7.15E+12	5803.137	2.036603	7.49295	0.643914	2.36905	2.680517	9.861999	18.29332	67.30368	66.09533	243.174	84.38859	310.4775
43463960	117002.1	43.12068	321198.5	118.4294	438200.9	161.5695	7.63E+13	6205.191	15.14818	5.585301	5.857832	2.159847	21.00602	7.745152	180.2806	66.47144	623.0416	229.7223	803.3217	296.1935
6753839	17335.83	41.11641	51898.84	123.1466	69234.76	164.2816	1.25E+13	6519.258	2.344909	5.564047	0.861528	2.044251	3.206435	7.608292	29.842	70.80968	88.15142	209.1674	117.9935	279.9773
13940380	39705.28	45.62416	93721.7	107.741	133426.9	153.3855	2.53E+13	6424.345	6.352046	7.302214	1.84101	2.116397	8.193048	9.4186	45.16628	51.92245	173.2781	199.1978	218.4444	251.1203
41030350	141623.4	55.29055	301930.9	117.9282	443554.7	173.2436	7.32E+13	6303.379	20.69984	8.084946	5.425697	2.11917	26.12554	10.20412	158.7289	61.99637	500.4846	195.4793	659.2122	257.4752
3761532	9773.002	41.61831	26383.93	112.4062	36156.9	154.043	7.61E+12	7150.855	1.74796	7.447015	0.452143	1.926313	2.200104	9.373328	12.30476	52.42321	37.90294	161.4818	50.20774	213.9052
8419607	33113.6	62.99931	62551.44	119.0586	95665.11	182.0862	1.30E+13	5466.52	3.638794	6.925977	1.285313	2.446429	4.924107	9.372406	39.03649	74.30094	139.5985	265.7078	178.6348	340.0084
12461560	59418.49	76.37836	101088.4	130.0002	160506.8	206.4127	2.00E+13	5662.889	6.396863	8.226402	1.887091	2.42681	8.283957	10.65322	72.09082	92.70921	191.2623	245.9644	263.3528	338.6733
7724422	50469.69	104.6612	75085.95	155.7787	125555.8	260.4872	1.42E+13	6486.355	5.95863	12.3622	1.029563	2.136005	6.988195	14.49821	58.77593	121.9408	69.10635	143.373	127.8822	265.3137
13707580	97824.38	114.3161	141354.8	165.2589	239179.2	279.6263	2.41E+13	6225.221	10.72028	12.53316	1.894849	2.215282	12.61513	14.74844	116.8126	136.5665	134.2059	156.9012	251.0185	293.4677
31517420	136360.2	69.30399	257647.8	131.006	394007.9	200.3409	5.47E+13	6135.967	16.31935	8.297892	4.373405	2.223743	20.69275	10.52163	165.5072	84.15533	409.6734	208.3064	575.1801	292.4615
250113534	1048073		2045650		3093724		4.29E+14		130.5164		34.11567		164.632		1279.233		3213.867		4493.097	

Table D9(k) - Street Sweeping (daily) Costs & Loading Results

By: jmr
Date: 07-Dec-09
Revised: 10-Apr-10

	Catchment Area	No Treatment Base Case: Annual Runoff Volume	No Treatment Base Case: Annual Particulate Solids (TSS) Yield	Alternative Strategy - Street Cleaning, Once per Day: Annual Runoff Volume	Annual Particulate Solids (TSS) Yield	Removal Efficiency	Total Length of ROW Cleaned Annually	Capital Cost*	Annual OM&R Cost**	Total Cost over 20 Years	$ per Kg TSS Removed
	(ha)	(m3)	(Kg)	(m3)	(Kg)		364 (Km)	# of Sweepers Purchased: 3 ($)	($/yr)	($)	
1	16.451	143,606	17,079	143,606	15,822	7.4%	1138.23	$ 24,800	$ 9,880	$222,400	$8.85
2	31.651	303,468	33,069	303,468	30,713	7.1%	3289.03	$ 71,700	$ 28,550	$642,700	$13.64
3	20.603	171,661	24,806	171,661	21,737	12.4%	1639.09	$ 35,800	$ 14,230	$320,400	$5.22
4	11.081	93,971	16,669	93,971	13,600	18.4%	1428.92	$ 31,200	$ 12,400	$279,200	$4.55
5	8.057	72,728	8,530	72,728	7,908	7.3%	1076.78	$ 23,500	$ 9,350	$210,500	$16.92
6	26.504	459,024	23,889	459,024	22,786	4.6%	1801.44	$ 39,300	$ 15,640	$352,100	$15.96
7	30.899	538,918	35,771	538,918	33,766	5.6%	2307.98	$ 50,300	$ 20,030	$450,900	$11.24
8	6.722	123,347	7,923	123,347	7,210	9.0%	888.09	$ 19,400	$ 7,710	$173,600	$12.17
9	55.779	1,230,807	56,846	1,230,807	51,995	8.5%	6537.8	$ 142,600	$ 56,750	$1,277,600	$13.17
10	8.401	191,254	8,478	191,254	7,688	9.3%	831.3	$ 18,100	$ 7,220	$162,500	$10.28
11	18.082	394,762	20,328	394,762	17,349	14.7%	2940.25	$ 64,100	$ 25,520	$574,500	$9.64
12	63.311	1,161,893	71,276	1,161,893	62,234	12.7%	7909.94	$ 172,500	$ 68,660	$1,545,700	$8.55
13	4.658	106,519	5,125	106,519	4,236	17.3%	1115.59	$ 24,300	$ 9,680	$217,900	$12.26
14	13.634	238,414	15,757	238,425	14,810	6.0%	1540.67	$ 33,600	$ 13,370	$301,000	$15.89
15	24.949	352,885	28,251	352,885	26,581	5.9%	2649.7	$ 57,800	$ 23,000	$517,800	$15.50
16	23.707	218,739	24,514	218,739	22,431	8.5%	2497.48	$ 54,500	$ 21,680	$488,100	$11.72
17	44.719	388,170	46,897	388,170	43,653	6.9%	3873.18	$ 84,500	$ 33,620	$756,900	$11.67
18	63.642	892,507	66,000	892,507	60,670	8.1%	6594.15	$ 143,800	$ 57,240	$1,288,600	$12.09
	472.850	7,082,673	511,208	7,082,684	465,189		50,059.62	$1,091,800	$434,530	$9,782,400	$10.63

Costs prorated by catchment based on length of ROW; see copmutation, below.
* Includes 5% Administration plus 35% contingency
** Includes replacement purchases of new sweepers; straight-line depreciation

Computation of Capital and OM&R Costs:

Assumed fraction that can be cleaned:	100%		68763.2	m
Passes per street, curb to curb:	2	#/st	137526.4	m total cleaning length
Operating speed (3-15 km/hr):	10	km/hr	13.75	hrs to clean all streets
Cleaning schedule: 1/day	364	/year or	5005.00	hrs/yr
Annual operating time per unit, less	10%	down time:	1872	hr
# units to purchase (1 minimum):			3	
% utilization of sweepers:			267.4%	
Capital cost (at start):	$260,000	/unit *1.4	$1,092,000	incl 1.4 for admin & contingency
Replacement schedule:	6	years		
Replacement capital cost (over 20 years):	$1,560,000	total *1.4	$2,184,000	incl 1.4 for admin & contingency
		or	$109,200	/yr
O&M cost, per CWP:	$65	/hr	$325,325	/yr

Raw Data for alternative, from WinSLAMM, sorted by Catchment #:

Runoff Volume (cf)	Particulate Solids Yield for Alternative (lbs)	Particulate Solids Concentration (mg/L)	Filterable Solids Yield (lbs)	Filterable Solids Concentration (mg/L)	Total Solids Yield (lbs)	Total Solids Concentration (mg/L)	Fecal Coliform Bacteria Yield (count)	Fecal Coliform Bacteria Concentration (#/100 ml)	Particulate Copper Yield (lbs)	Particulate Copper Concentration (ug/L)	Filterable Copper Yield (lbs)	Filterable Copper Concentration (ug/L)	Total Copper Yield (lbs)	Total Copper Concentration (ug/L)	Particulate Zinc Yield (lbs)	Particulate Zinc Concentration (ug/L)	Filterable Zinc Yield (lbs)	Filterable Zinc Concentration (ug/L)	Total Zinc Yield (lbs)	Total Zinc Concentration (ug/L)
5071220	34881.08	110.179	51130.55	161.5784	86011.7	271.8069	9.06E+12	6315.363	3.741657	11.82407	0.699529	2.210594	4.441186	14.03466	41.86696	132.3045	49.03117	154.9442	90.89817	287.2487
10716470	67711.92	101.2126	102625.5	153.4683	170337.6	254.7265	1.87E+13	6180.548	7.231406	10.814	1.513522	2.263353	8.744932	13.07736	81.80149	122.3277	118.6047	177.364	200.4061	299.6916
6061920	47922.14	126.6331	63065.06	166.7224	110987.2	293.4123	1.09E+13	6332.848	6.162578	16.29175	0.835373	2.208441	6.997953	18.50019	54.45853	143.9697	56.29726	148.8307	110.7558	292.8004
3318446	29983.49	144.7334	34663.57	167.3994	64647.09	312.1976	5.95E+12	6340.891	4.746153	22.92041	0.455592	2.200174	5.201746	25.12059	31.3545	151.4191	30.2742	146.202	61.62875	297.6213
2568287	17435.24	108.744	26001.57	162.2451	43436.78	271.0375	4.48E+12	6167.395	1.86418	11.63214	0.351826	2.195328	2.216005	13.82747	21.31361	132.9931	25.03429	156.2094	46.34789	289.2024
16209700	50235.88	49.64326	135983.1	134.4391	186218.7	184.1042	2.36E+13	5138.51	5.169306	5.11061	2.170794	2.146145	7.340099	7.256755	59.97136	59.29041	242.1208	239.3716	302.092	298.6619
19031030	74442.23	62.65826	168658.8	142.0241	243101.1	204.7104	2.85E+13	5293.149	7.766364	6.539896	2.536684	2.136089	10.30305	8.675988	89.09724	75.02697	259.7046	218.6919	348.8015	293.7186
4355811	15895.84	58.4569	30659.69	112.8013	46555.6	171.2846	7.15E+12	5803.137	1.905866	7.01195	0.643914	2.36905	2.549782	9.381007	18.15945	66.81116	66.09533	243.174	84.25465	309.9847
43463960	114630.7	42.24671	321198.5	118.4294	435829	160.6949	7.63E+13	6205.191	14.25887	5.257401	5.857832	2.159847	20.1167	7.417251	179.3699	66.13567	623.0416	229.7223	802.4113	295.8579
6753839	16949.78	40.2008	51898.84	123.1466	68848.66	163.3654	1.25E+13	6519.258	2.200135	5.220524	0.861528	2.044251	3.061663	7.264774	29.69377	70.45795	88.15142	209.1674	117.8452	279.6255
13940380	38249	43.95079	93721.7	107.741	131970.6	151.7113	2.53E+13	6424.345	5.805943	6.674422	1.84101	2.116397	7.646945	8.790809	44.60707	51.27959	173.2781	199.1978	217.8852	250.4774
41030350	137202.3	53.56453	301930.9	117.9282	439133.5	171.5168	7.32E+13	6303.379	19.04191	7.437392	5.425697	2.11917	24.46762	9.556566	157.0314	61.33334	500.4846	195.4793	657.5143	256.8121
3761532	9338.479	39.76789	26383.93	112.4062	35722.38	152.1917	7.61E+12	7150.855	1.585015	6.752803	0.452143	1.926313	2.03716	8.679122	12.1379	51.71233	37.90294	161.4818	50.04087	213.1943
8419607	32650.56	62.11837	62551.44	119.0586	95202.13	181.205	1.30E+13	5466.52	3.465159	6.595485	1.285313	2.446429	4.750472	9.041914	38.85866	73.96247	139.5985	265.7078	178.4569	339.6699
12461560	58602.27	75.32917	101088.4	130.0002	159690.6	205.363	2.00E+13	5662.889	6.090782	7.832781	1.887091	2.42681	7.977874	10.25959	71.77749	92.30627	191.2623	245.9644	263.0396	338.2704
7724422	49451.07	102.5489	75085.95	155.7787	124537.2	258.3737	1.42E+13	6486.355	5.57665	11.56972	1.029563	2.136005	6.606214	13.70573	58.38481	121.1293	69.10635	143.373	127.491	264.502
13707580	96238.24	112.4626	141354.8	165.2589	237593	277.7718	2.41E+13	6225.221	10.12551	11.83781	1.894849	2.215282	12.02034	14.05308	116.2035	135.8544	134.2059	156.9012	250.4095	292.7557
31517420	133754.3	67.97958	257647.8	131.006	391402.2	199.016	5.47E+13	6135.967	15.34214	7.801009	4.373405	2.223743	19.71553	10.02474	164.5065	83.64655	409.6734	208.3064	574.1793	291.9526
250113534	1025575		2045650		3071225		4.29E+14		122.0796		34.11567		156.1953		1270.594		3213.867		4484.458	

City of White Rock

Table D10 - Summary of Costs for Urban Runoff Treatment Strategies

By: jmr
Date: 07-Dec-09
Revised: 10-Apr-10

NOTE: Class D Cost Estimates
Capital Costs for End-of-Pipe and Biofiltration Systems include 5% administration, 15% engineering and 35% contingency
Capital Costs for Street Sweepers include 5% administration and 35% contingency
O&M Costs for End-of-Pipe and Biofiltration Systems are based on a percentage of Capital Costs
O&M Costs for Street Sweepers are based on an hourly cost applied to annual usage

END-of-PIPE TREATMENT SYSTEMS

			Primary EOP Treatment Only					Enhanced EOP Treatment				
Catchment #	Catchment Area (ha)	Annual TSS Generated (Kg)	% TSS Removal (%)	Capital Cost ($)	Annual O&M Cost @ 4% ($/yr)	Cost over 20 years ($)	Cost per Kg TSS Removed ($/Kg)	% TSS Removal (%)	Capital Cost ($)	Annual O&M Cost @ 6% ($/yr)	Cost over 20 years ($)	Cost per Kg TSS Removed ($/Kg)
1	16.451	17,079	50%	$168,100	$6,720	$302,500	$1.77	90%	$504,300	$30,260	$1,109,500	$3.61
2	31.651	33,069	50%	$335,400	$13,420	$603,800	$1.83	90%	$1,006,200	$60,370	$2,213,600	$3.72
3	20.603	24,806	50%	$363,800	$14,550	$654,800	$2.64	90%	$1,091,400	$65,480	$2,401,000	$5.38
4	11.081	16,669	50%	$166,600	$6,660	$299,800	$1.80	90%	$499,700	$29,980	$1,099,300	$3.66
5	8.057	8,530	50%	$166,600	$6,660	$299,800	$3.51	90%	$499,700	$29,980	$1,099,300	$7.16
6	26.504	23,889	50%	$198,700	$7,950	$357,700	$1.50	90%	$596,200	$35,770	$1,311,600	$3.05
7	30.899	35,771	50%	$213,400	$8,540	$384,200	$1.07	90%	$640,100	$38,410	$1,408,300	$2.19
8	6.722	7,923	50%	$145,900	$5,840	$262,700	$3.32	90%	$437,800	$26,270	$963,200	$6.75
9	55.779	56,846	50%	$604,300	$24,170	$1,087,700	$1.91	90%	$1,812,900	$108,770	$3,988,300	$3.90
10	8.401	8,478	50%	$186,800	$7,470	$336,200	$3.97	90%	$560,400	$33,620	$1,232,800	$8.08
11	18.082	20,328	50%	$437,300	$17,490	$787,100	$3.87	90%	$1,312,000	$78,720	$2,886,400	$7.89
12	63.311	71,276	50%	$369,800	$14,790	$665,600	$0.93	90%	$1,109,400	$66,560	$2,440,600	$1.90
13	4.658	5,125	50%	$135,200	$5,410	$243,400	$4.75	90%	$405,700	$24,340	$892,500	$9.67
14	13.634	15,757	50%	$227,900	$9,120	$410,300	$2.60	90%	$683,700	$41,020	$1,504,100	$5.30
15	24.949	28,251	50%	$294,000	$11,760	$529,200	$1.87	90%	$882,100	$52,930	$1,940,700	$3.82
16	23.707	24,514	50%	$531,300	$21,250	$956,300	$3.90	90%	$1,593,900	$95,630	$3,506,500	$7.95
17	44.719	46,897	50%	$166,600	$6,660	$299,800	$0.64	90%	$499,700	$29,980	$1,099,300	$1.30
18	63.642	66,000	50%	$193,200	$7,730	$347,800	$0.53	90%	$579,500	$34,770	$1,274,900	$1.07
	472.85	511,208		$4,904,900	$196,190	$8,828,700			$14,714,700	$882,860	$32,371,900	

BIOFILTRATION SYSTEMS

			Complete Biofiltration System					Biofiltration for 50% of City					Biofiltration for Public ROW <6% Grade				
Catchment #	Catchment Area (ha)	Annual TSS Generated (Kg)	% TSS Removal (%)	Capital Cost ($/yr)	Annual O&M Cost @ 7% ($)	Cost over 20 years ($)	Cost per Kg TSS Removed ($/Kg)	% TSS Removal (%)	Capital Cost ($)	Annual O&M Cost @ 7% ($)	Cost over 20 years ($)	Cost per Kg TSS Removed ($/Kg)	% TSS Removal (%)	Capital Cost ($)	Annual O&M Cost @ 7% ($)	Cost over 20 years ($)	Cost per Kg TSS Removed ($/Kg)
1	16.451	17,079	99%	$10,004,100	$700,290	$24,009,900	$71.36	49%	$5,036,800	$352,580	$12,088,400	$71.91	20%	$789,500	$55,270	$1,894,900	$28.48
2	31.651	33,069	99%	$19,113,300	$1,337,930	$45,871,900	$70.38	49%	$9,623,100	$673,620	$23,095,500	$70.95	19%	$1,547,700	$108,340	$3,714,500	$29.22
3	20.603	24,806	99%	$12,487,300	$874,110	$29,969,500	$61.21	49%	$6,287,100	$440,100	$15,089,100	$61.69	25%	$748,400	$52,390	$1,796,200	$14.42
4	11.081	16,669	99%	$6,750,200	$472,510	$16,200,400	$49.21	49%	$3,398,600	$237,900	$8,156,600	$49.58	28%	$293,800	$20,570	$705,200	$7.48
5	8.057	8,530	98%	$4,935,900	$345,510	$11,846,100	$70.56	49%	$2,485,100	$173,960	$5,964,300	$71.09	5%	$42,800	$3,000	$102,800	$12.33
6	26.504	23,889	98%	$16,023,300	$1,121,630	$38,455,900	$82.10	49%	$8,077,400	$565,420	$19,385,800	$82.85	10%	$418,200	$29,270	$1,003,600	$20.99
7	30.899	35,771	98%	$18,655,100	$1,305,860	$44,772,300	$63.86	49%	$9,382,400	$656,770	$22,517,800	$64.30	11%	$542,300	$37,960	$1,301,500	$17.38
8	6.722	7,923	98%	$4,127,500	$288,930	$9,906,100	$63.89	49%	$2,078,100	$145,470	$4,987,500	$64.37	20%	$273,000	$19,110	$655,200	$21.04
9	55.779	56,846	98%	$33,469,600	$2,342,870	$80,327,000	$72.17	49%	$16,861,100	$1,180,280	$40,466,700	$72.82	17%	$1,445,600	$101,190	$3,469,400	$18.25
10	8.401	8,478	98%	$5,137,800	$359,650	$12,330,800	$74.56	49%	$2,586,800	$181,080	$6,208,400	$75.13	20%	$293,800	$20,570	$705,200	$20.50
11	18.082	20,328	98%	$10,966,000	$767,620	$26,318,400	$66.17	49%	$5,521,100	$386,480	$13,250,700	$66.69	9%	$168,800	$11,820	$405,200	$11.46
12	63.311	71,276	98%	$37,942,700	$2,655,990	$91,062,500	$65.00	49%	$19,113,300	$1,337,930	$45,871,900	$65.56	23%	$2,220,600	$155,440	$5,329,400	$16.32
13	4.658	5,125	98%	$2,871,100	$200,980	$6,890,700	$68.85	49%	$1,445,600	$101,190	$3,469,400	$69.36	31%	$231,400	$16,200	$555,400	$17.33
14	13.634	15,757	98%	$8,298,400	$580,890	$19,916,200	$64.56	49%	$4,188,200	$293,170	$10,051,600	$65.21	12%	$314,600	$22,020	$755,000	$19.53
15	24.949	28,251	98%	$15,085,200	$1,055,960	$36,204,400	$65.27	49%	$7,595,100	$531,660	$18,228,300	$65.77	9%	$314,600	$22,020	$755,000	$14.93
16	23.707	24,514	99%	$14,346,300	$1,004,240	$34,431,100	$71.27	49%	$7,233,100	$506,320	$17,359,500	$71.93	15%	$501,000	$35,070	$1,202,400	$16.61
17	44.719	46,897	100%	$26,906,900	$1,883,480	$64,576,500	$69.01	50%	$13,547,000	$948,290	$32,512,800	$69.56	17%	$1,466,000	$102,620	$3,518,400	$22.76
18	63.642	66,000	98%	$38,140,500	$2,669,840	$91,537,300	$70.46	49%	$19,212,900	$1,344,900	$46,110,900	$71.08	22%	$3,479,600	$243,570	$8,351,000	$29.00
	472.85	511,208		$285,261,200	$19,968,290	$684,627,000			$143,672,800	$10,057,120	$344,815,200			$15,091,700	$1,056,430	$36,220,300	

STREET CLEANING

			Street Cleaning, Twice/Year					Street Cleaning, Once/Month				
Catchment #	Catchment Area (ha)	Annual TSS Generated (Kg)	% TSS Removal (%)	Capital Cost ($)	Annual O&M Cost ($)	Cost over 20 years ($)	Cost per Kg TSS Removed ($/Kg)	% TSS Removal (%)	Capital Cost ($)	Annual O&M Cost ($)	Cost over 20 years ($)	Cost per Kg TSS Removed ($/Kg)
1	16.451	17,079	0%	$8,300	$870	$25,700	$29.20	2%	$8,300	$1,070	$29,700	$5.05
2	31.651	33,069	0%	$23,900	$2,510	$74,100	$45.18	2%	$23,900	$3,100	$85,900	$7.79
3	20.603	24,806	0%	$11,900	$1,250	$36,900	$17.08	3%	$11,900	$1,540	$42,700	$2.97
4	11.081	16,669	1%	$10,400	$1,090	$32,200	$14.91	4%	$10,400	$1,350	$37,400	$2.60
5	8.057	8,530	0%	$7,800	$820	$24,200	$55.00	2%	$7,800	$1,010	$28,000	$9.59
6	26.504	23,889	0%	$13,100	$1,370	$40,500	$51.92	1%	$13,100	$1,700	$47,100	$9.13
7	30.899	35,771	0%	$16,800	$1,760	$52,000	$37.14	1%	$16,800	$2,170	$60,200	$6.42
8	6.722	7,923	0%	$6,500	$680	$20,100	$40.20	2%	$6,500	$840	$23,300	$6.98
9	55.779	56,846	0%	$47,500	$4,990	$147,300	$43.32	2%	$47,500	$6,150	$170,500	$7.51
10	8.401	8,478	0%	$6,000	$630	$18,600	$33.21	2%	$6,000	$780	$21,600	$5.84
11	18.082	20,328	1%	$21,400	$2,240	$66,200	$31.83	3%	$21,400	$2,770	$76,800	$5.51
12	63.311	71,276	0%	$57,500	$6,030	$178,100	$28.09	3%	$57,500	$7,450	$206,500	$4.88
13	4.658	5,125	1%	$8,100	$850	$25,100	$39.22	4%	$8,100	$1,050	$29,100	$7.00
14	13.634	15,757	0%	$11,200	$1,180	$34,800	$52.73	1%	$11,200	$1,450	$40,200	$9.10
15	24.949	28,251	0%	$19,300	$2,020	$59,700	$50.59	1%	$19,300	$2,490	$69,100	$8.84
16	23.707	24,514	0%	$18,200	$1,900	$56,200	$38.49	2%	$18,200	$2,350	$65,200	$6.69
17	44.719	46,897	0%	$28,200	$2,950	$87,200	$38.25	2%	$28,200	$3,650	$101,200	$6.67
18	63.642	66,000	0%	$47,900	$5,030	$148,500	$39.71	2%	$47,900	$6,210	$172,100	$6.90
	472.85	511,208		$364,000	$38,170	$1,127,400			$364,000	$47,130	$1,306,600	
				# Sweepers Required:	1				# Sweepers Required:	1		
				Average Utilization Rate:	1% (not incl normal down time)				Average Utilization Rate:	9% (not incl normal down time)		

	Street Cleaning, Once/Week					Street Cleaning, Twice/Week				
Catchment #	% TSS Removal (%)	Capital Cost ($)	Annual O&M Cost ($)	Cost over 20 years ($)	Cost per Kg TSS Removed ($/Kg)	% TSS Removal (%)	Capital Cost ($)	Annual O&M Cost ($)	Cost over 20 years ($)	Cost per Kg TSS Removed ($/Kg)
1	4%	$8,300	$1,880	$45,900	$3.11	6%	$8,300	$2,940	$67,100	$3.43
2	4%	$23,900	$5,450	$132,900	$4.80	6%	$23,900	$8,500	$193,900	$5.29
3	7%	$11,900	$2,710	$66,100	$1.83	10%	$11,900	$4,240	$96,700	$2.02
4	11%	$10,400	$2,370	$57,800	$1.60	14%	$10,400	$3,690	$84,200	$1.76
5	4%	$7,800	$1,780	$43,400	$5.93	6%	$7,800	$2,780	$63,400	$6.55
6	3%	$13,100	$2,980	$72,700	$5.60	4%	$13,100	$4,650	$106,100	$6.18
7	3%	$16,800	$3,820	$93,200	$3.95	4%	$16,800	$5,960	$136,000	$4.36
8	5%	$6,500	$1,470	$35,900	$4.28	7%	$6,500	$2,290	$52,300	$4.71
9	5%	$47,500	$10,820	$263,900	$4.62	7%	$47,500	$16,890	$385,300	$5.10
10	6%	$6,000	$1,380	$33,600	$3.61	7%	$6,000	$2,150	$49,000	$3.98
11	9%	$21,400	$4,870	$118,800	$3.39	11%	$21,400	$7,600	$173,400	$3.74
12	8%	$57,500	$13,100	$319,500	$3.00	10%	$57,500	$20,440	$466,300	$3.31
13	10%	$8,100	$1,850	$45,100	$4.31	14%	$8,100	$2,880	$65,700	$4.75
14	4%	$11,200	$2,550	$62,200	$5.58	5%	$11,200	$3,980	$90,800	$6.16
15	4%	$19,300	$4,390	$107,100	$5.45	5%	$19,300	$6,850	$156,300	$6.02
16	5%	$18,200	$4,130	$100,800	$4.11	7%	$18,200	$6,450	$147,200	$4.54
17	4%	$28,200	$6,410	$156,400	$4.10	5%	$28,200	$10,010	$228,400	$4.52
18	5%	$47,900	$10,920	$266,300	$4.25	6%	$47,900	$17,040	$388,700	$4.69
		$364,000	$82,880	$2,021,600			$364,000	$129,340	$2,950,800	
		# Sweepers Required:	1				# Sweepers Required:	1		
		Average Utilization Rate:	38% (not incl normal down time)				Average Utilization Rate:	76% (not incl normal down time)		

	Street Cleaning, Every Day				
Catchment #	% TSS Removal (%)	Capital Cost ($)	Annual O&M Cost ($)	Cost over 20 years ($)	Cost per Kg TSS Removed ($/Kg)
1	7%	$24,800	$9,880	$222,400	$8.85
2	7%	$71,700	$28,550	$642,700	$13.64
3	12%	$35,800	$14,230	$320,400	$5.22
4	18%	$31,200	$12,400	$279,200	$4.55
5	7%	$23,500	$9,350	$210,500	$16.92
6	5%	$39,300	$15,640	$352,100	$15.96
7	6%	$50,300	$20,030	$450,900	$11.24
8	9%	$19,400	$7,710	$173,600	$12.17
9	9%	$142,600	$56,750	$1,277,600	$13.17
10	9%	$18,100	$7,220	$162,500	$10.28
11	15%	$64,100	$25,520	$574,500	$9.64
12	13%	$172,500	$68,660	$1,545,700	$8.55
13	17%	$24,300	$9,680	$217,900	$12.26
14	6%	$33,600	$13,370	$301,000	$15.89
15	6%	$57,800	$23,000	$517,800	$15.50
16	8%	$54,500	$21,680	$488,100	$11.72
17	7%	$84,500	$33,620	$756,900	$11.67
18	8%	$143,800	$57,240	$1,288,600	$12.09
		$1,091,800	$434,530	$9,782,400	
		# Sweepers Required:	3		
		Average Utilization Rate:	89% (not incl normal down time)		