Appendix B—Low Impact Development Techniques

Appendix B – Low Impact Development

Introduction

Low Impact Development (LID) is an innovative approach that uses state-of-the-art science and technology to manage urban stormwater by working with the hydrological cycle and its associated natural processes. The goal of LID is to design new development or redevelopment in a way that minimizes the impacts of the new impervious surfaces, its surface water runoff, and its non-point sources of pollution sources, in a way that that is consistent with the natural hydrological cycle for the site and the watershed. Using LID, stormwater is managed in a series of small, cost-effective landscape features, similar to existing natural systems, located on each lot rather than being conveyed and managed in larger pond facilities, located at the bottom of the basin.

Applicability to Mason County

Much of the Mason County Area is largely undeveloped. Due to the site-specific nature of LID designs, it is difficult to propose LID site planning on such a large planning level, without conceptual drawings of the proposed development(s). Therefore, the intent of this appendix is to introduce general LID concepts, strategies, and case studies in the form of a brief literature review that may be applied within Mason County. LID designs for surface water management generally do not replace needed surface water management detention and water quality treatment facilities; however, they can be used to reduce the size of these facilities. They are also often used to achieve infiltration, water quality enhancement, aquifer recharge, low flow augmentation, and other natural functions that most conventional surface water management facilities are not normally designed to achieve.

LID Goals

The primary goal of LID is to mimic the predevelopment site hydrology by using site specific design techniques to store, treat, infiltrate, evaporate, and detain runoff. Using these techniques helps to reduce off-site runoff, enhance groundwater recharge, and provide opportunities for improving water quality (Prince George's County, Maryland, 1999). Reported water quality benefits of LID practices are summarized in Table B.1. In general, LID strategies are most effective at removing total suspended solids and metals, followed by biological oxygen demand and bacteria, and finally by the removal of total phosphorous and nitrogen.

Table B.1
Reported Pollutant Removal Efficiency of LID Practices

LID Practice	*TSS*	*Total P*	*Total N*	*Zinc*	*Lead*	*BOD*	*Bacteria*
Bio-retention	-	81	43	99	99	-	-
Dry Well	80-100	40-40	40-60	80-100	80-100	60-80	60-80
Infiltration Trench	80-100	40-60	40-60	80-100	80-100	60-80	60-80
Filter/Buffer Strip	20-100	0-60	0-60	20-100	20-100	0-80	-
Vegetated Swale	30-65	10-25	0-15	20-50	20-50	-	-
Infiltration Swale	90	65	50	80-90	80-90	-	-
Wet Swale	80	20	40	40-70	40-70	-	-

Reference #4 and #7

By attempting to maintain the pre-development hydrological balance, LID designs often contribute to other environmental benefits. For example, many LID practices incorporate landscape plantings which create habitat features. Landscaping can also be used to attenuate heating-island effects common in many urban areas.

Comparison of Conventional and LID Stormwater Management Approaches

The fundamental concept of LID design is to treat rainfall on-site through site and building specific designs. One LID design objective is to capture as much rainfall on site as possible, and then return it to its natural hydrologic pathways (i.e. infiltration and evapotranspiration) or reuse it at the source. On the other hand, conventional stormwater management typically routes water to a pond or infiltration area, often located off site.

Table B.2 summarizes how conventional stormwater management and LID can be used to alter or preserve the natural hydrologic regime.

Table B.2
Comparison of Conventional and LID Stormwater Management Impacts on the Hydrologic Cycle

Hydrologic Parameter	*Conventional*	*LID*
Vegetation/Natural Cover	typically not incorporated into drainage designs.	used to maintain pre-development hydrology
Time of Concentration	shortened, reduced as a by-product of drainage efficiency	increased where possible to approximate predevelopment conditions
Runoff Volume	increases in runoff volume	controlled to predevelopment conditions
Peak Discharge	controlled to predeveloped design criteria	controlled to predeveloped conditions for all storms
Runoff Frequency	increased, especially for small, more frequent storms	controlled to predeveloped conditions for all storms
Rainfall Abstractions (Interception, Infiltration, Depression Storage)	large reduction in all elements	maintained to predevelopment conditions
Groundwater Recharge	reduction in recharge	maintained to predevelopment conditions

Reference#1.

LID Designs and Practices

LID practices to maintain hydrologic functions can include the following:
- *Impervious Surface Control Devices*—alternative pavers, green roof, etc.
- *Infiltration Facilities*—dry well, infiltration trench, etc.
- *Semi-natural Conveyance System*—bioretention, grass swale, bioswale, etc.
- *Storage* – cistern, rain barrel
- *Landscaping* – effective grading, installation of plants for water quality and quantity control.

Each of these LID practices is briefly described below.

Impervious Surface Control Devices
Runoff from new impervious surfaces is the primary cause of flooding and stream degradation. Reducing the amount of new impervious surface area in development is one of the most effective methods to achieve a reduction in the total volume of runoff. For example, most residential streets can be as narrow as 22 to 26 feet wide without sacrificing emergency access, on-street parking, or vehicular and pedestrian safety. A shift to narrower streets can result in a 5 to 20 percent overall reduction in impervious area. Reducing road area also reduces paving costs.

Examples of narrow residential street widths from different regions of the country are listed in Table B.3.

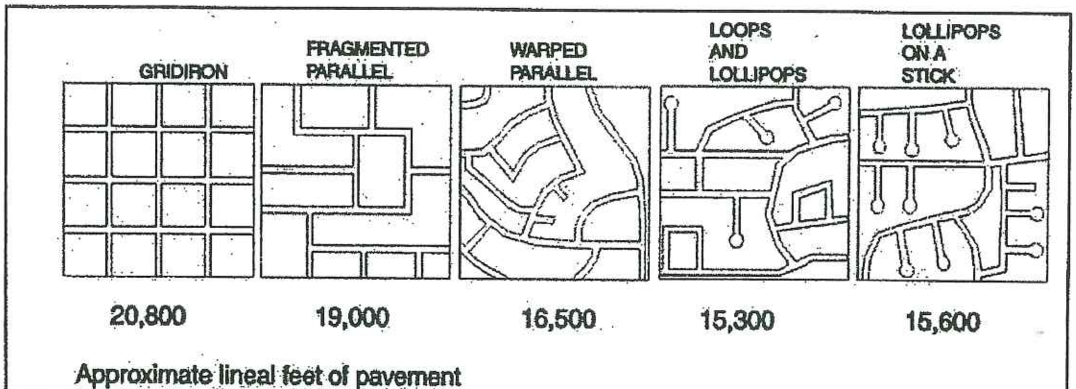
Table B.3
Examples of Narrow Residential Street Widths

State	*Jurisdiction*	*Standard*
Arizona	City of Phoenix	28 feet(parking on both sides)
California	City of Novato	24 feet (both sides, 2 to 4 du) 28 feet (both sides, 5 to 15 du)
Colorado	City of Boulder	20 feet (150 ADT) 20 feet (no parking, 350 – 1000 ADT) 22 feet (one side, 350 ADT) 26 feet (both sides, 350 ADT) 26 feet (one side, 500 – 1000 ADT)
Delaware	Delaware DOT	21 feet (one side)
Florida	City of Orlando	28 feet (both sides, res. lots <55 feet wide) 22 feet (both sides, res. lots >55 feet wide)
Maine	City of Portland	24 feet (one side)
Maryland	Howard County	24 feet (1000 ADT)
Michigan	City of Birmingham	26 feet (both sides) 20 feet (one side)
Montana	City of Missoula	26 feet (both sides, 3 – 80 du) 32 feet (both sides, 81 – 200 du) 12 feet (alley)
New Mexico	Albuquerque	28 feet (one side)
New Jersey		20 feet (no parking, 0 – 3500 ADT) 28 feet (one side, 0 – 3500 ADT)
Oregon	City of Portland	26 feet (both sides) 20 feet (one side)
Pennsylvania	Bucks County	12 feet (alley) 16 – 18 feet (no parking, 200 ADT) 20-22 feet (no parking, 200 – 1000 ADT) 26 feet (one side, 200 ADT) 28 feet (one side, 200 – 1000 ADT)
Tennessee	City of Johnson City	22 feet (<240 ADT) 24 feet – 28 feet (240 – 1500 ADT) 28 feet (>1500 ADT)

Table B.3 (cont.) Examples of Narrow Residential Street Widths		
State	***Jurisdiction***	***Standard***
Vermont	City of Burlington	30 feet (both sides)
Washington	City of Kirkland	12 feet (alley) 20 feet (one side) 24 feet (both sides, low density only) 28 feet (both sides)
W. Virginia	Morgantown	22 feet (one side)
Wisconsin	City of Madison	27 feet (both sides, <3 du/ac) 28 feet (both sides, 3 – 10 du/ac)
ADT = average daily traffic du = dwelling unit		

Reference #2 and #3

Other typical LID approaches include alternative roadway layout (Figure B.1) and reduced parking standards (Table B.4). The potential results of impervious surface reduction, or on the overall effective impervious area, are listed in Table B.5. Note how small reductions in the total impervious area can have a relatively large reduction of the amount of on-site impacts and resulting effective impervious area within the watersheds.



Reference #11

Figure B.1 – Length of pavement of various roadway layout options.

Table B.4 Conventional Minimum Parking Ratios			
Land Use	***Parking Requirement***		***Actual Average Parking Demand***
	Parking Ratio	***Typical Range***	
Single-family homes	2 spaces per dwelling unit	1.5 – 2.5	1.11 spaces per dwelling unit
Shopping center	5 spaces per 1000 ft² GFA	4.0 – 6.5	3.97 per 1000 ft² GFA
Convenience store	3.3 spaces per 1000 ft² GFA	2.0 – 10.0	—
Industrial	1 space per 1000 ft² GFA	0.5 – 2.0	1.48 per 1000 ft² GFA
Medical/dental office	5.7 spaces per 1000 ft² GFA	4.5 – 10.0	4.11 per 1000 ft² GFA
GFA = Gross floor area of a building without storage or utility spaces.			

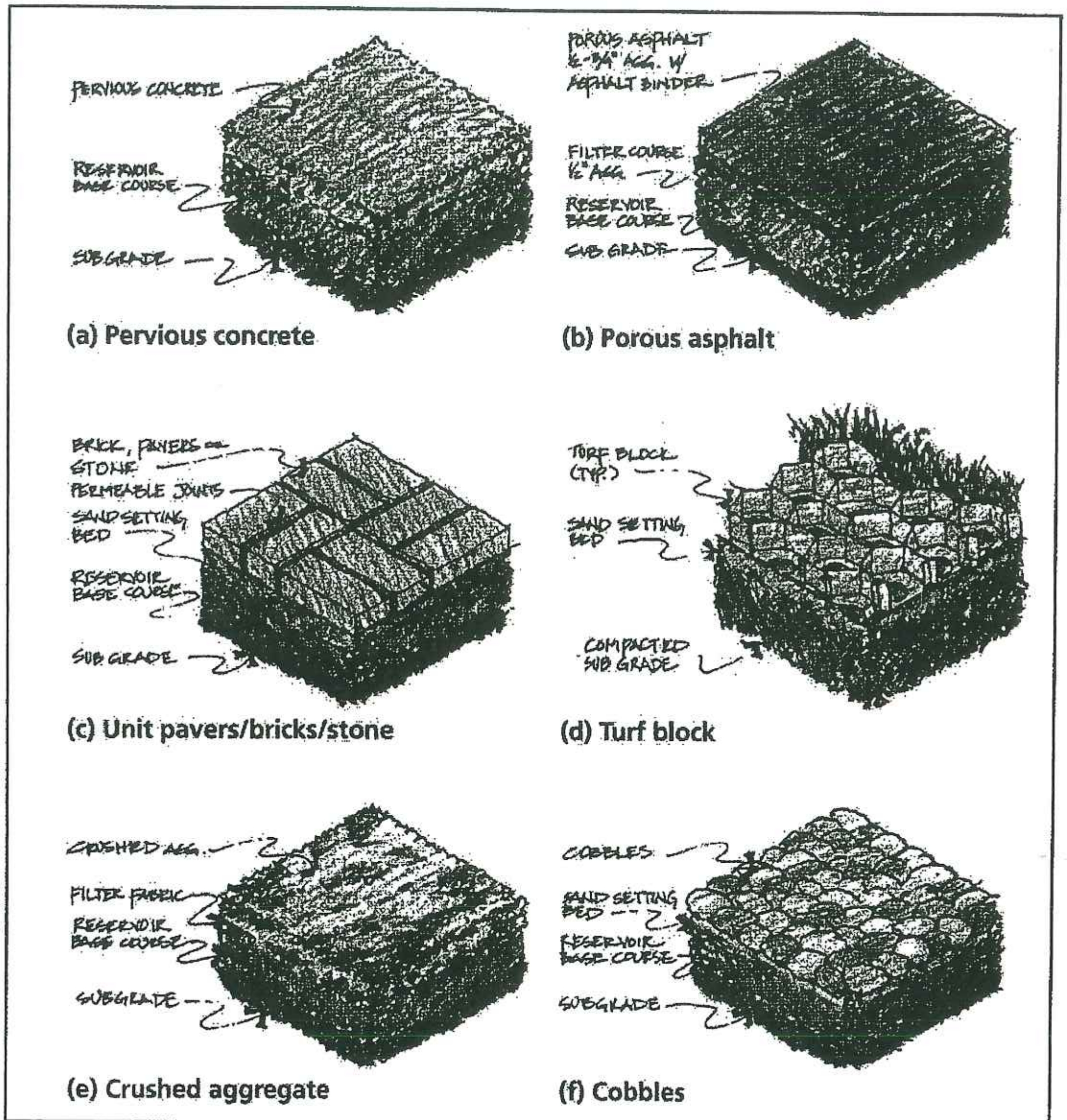
Reference # 11, #14, and #15

Table B.5 Basin and Site Coverage Assessment Reduction Analysis Results						
Potential Strategy			***Impervious Surface Reduction Percentages (%)***			
			Site-Specific		Basinwide	
			Total	Effective	Total	Effective
1.		Reduce residential sidewalks by 50 percent by installing the walks on one side of the street only.	1.33	1.00	1.59	0.83
2.		Reduce residential sidewalks from 5 feet width to 4 feet width.	0.53	0.40	0.64	0.33
3.	a.	Reduce local access street widths from 32 feet to 27 feet.	2.50	2.00	2.98	3.12
	b.	Reduce local access street widths from 32 feet to 25 feet.	3.50	2.80	4.17	4.37
	c.	Reduce local access street widths from 32 feet to 20 feet.	6.00	4.80	7.15	7.49
4.	a.	Reduce commercial parking by 5 percent.	2.67	2.67	1.04	1.37
	b.	Reduce commercial parking by 10 percent.	5.33	5.33	2.09	2.74
	c.	Reduce commercial parking by 20 percent.	10.67	10.67	4.18	5.47
5.	a.	Reduce multifamily parking by 5 percent.	0.74	0.74	0.16	0.21
	b.	Reduce multifamily parking by 10 percent.	1.48	1.48	0.32	0.42
	c.	Reduce multifamily parking by 20 percent.	2.95	2.95	0.64	0.84
6.	a.	Reduce commercial, industrial, and multifamily roof areas by 10 percent.	4.25	4.25	1.38	.094
	b.	Reduce commercial, industrial, and multifamily roof areas by 20 percent.	8.50	8.50	2.76	1.89

Reference #15

Alternative Pavers

Alternative pavers are permeable or semi-permeable surfaces that can be used for driveways, parking lots, and walkways. Figure B.2 shows typical alternative pavers. The effectiveness of alternative pavers will vary depending on the soil layer underneath. Underlying soils need to have a permeability between 0.5 and 3.0 inches per hour. The City of Seattle gives credit for porous pavement (Table B.6) in computing runoff rates from a developed site.



Reference #17

Figure B.2 – Alternative Pavers

Table B.6 Porous Pavement Impervious Surface Reduction Credit				
	SCS Hydrologic Soil Group			
	A	*B*	*C*	*D*
Curve Number (without credit)	98	98	98	98
Curve Number (with credit)	78	85	89	91

Reference #16

Due to the permeability of porous pavers, there is some risk of contaminating groundwater, although most paving alternatives have some pollutant removal effects through the infiltration process. Therefore, they should be located at least two to five feet above the seasonally high groundwater table and at least 100 feet away from drinking water wells[1]. Other design considerations for alternative pavers are listed as Table B.7.

Table B.7 Design Criteria for Alternative Pavers	
Design Criterion	***Guidelines***
Site Evaluation	Take soil boring to a depth of at least 4 feet below bottom of pavers to check for soil permeability, porosity, depth of seasonally high water table, and depth to bedrock.
	Not recommended on slopes greater than 5%. Best with slopes as flat as possible.
	Minimum infiltration rate 3 feet below bottom of pavers: 0.5 inches per hour.
	Minimum depth to bedrock and seasonally high water table: 4 feet.
	Minimum setback from water supply wells: 100 feet.
	Minimum setback from building foundations: 10 feet downgradient, 30 meters (100 feet) upgradient.
	Not recommended in areas where wind erosion supplies significant amounts of windblown sediment.
	Drainage area should be less than 15 acres.
Traffic Conditions	Use for low-volume automobile parking areas and lightly used access roads.
	Avoid moderate to high traffic areas and significant truck traffic.
	Avoid snow removal operation. Post with signs to restrict the use of sand, salt, and other deicing chemicals typically associated with snow cleaning activities.

[1]Please refer to the new draft State Underground Injection Control Rule, 2005.

Table B.7 (cont.) Design Criteria for Alternative Pavers	
Design Criterion	***Guidelines***
Design Storm Storage Volume	Highly variable; depends upon regulatory requirements. Typically design for storm water runoff volume produced in the tributary watershed by the 6-month, 24-hour duration storm event.
Drainage Time for Design Storm	Minimum: 12 hours.
	Maximum: 72 hours.
	Recommended: 24 hours.
Construction	Excavate and grade with light equipment with tracks or oversized tires to prevent soil compaction.
	As needed, divert storm water runoff away from planned pavement area before and during construction.
	A typical porous pavement cross-section consists of the following layers: 1) porous asphalt course, 2-4 inches thick; 2) filter aggregate course; 3) reservoir course of 1.5-3-inches of washed rock; and 4) filter fabric
Porous Pavement Placement	Paving temperature: 240° - 260° F.
	Minimum air temperature: 50° F.
	Compact with one or two passes of a 10-ton roller.
	Prevent any vehicular traffic on pavement for at least two days.
Pretreatment	Pretreatment recommended to treat runoff from off-site areas. For example, place a 25-foot wide vegetative filter strip around the perimeter of the porous pavement where drainage flows onto the pavement surface.

Reference #18

Green Roofs

Green roof applications can be appropriate for some commercial and multi-family residential lots where the buildings occupy a large portion of the site. A layer of absorbent soil on the top of building retains rainfall and allows it to evaporate or transpire from the rooftop vegetation. The runoff from a green roof passes through the absorbent soil layer to an underdrain layer (there is no surface runoff), and therefore, peak runoff rates are attenuated. Green roofs provide multiple benefits such as attenuation of heat island effects which help to save on the energy cost of the building and sound reduction.

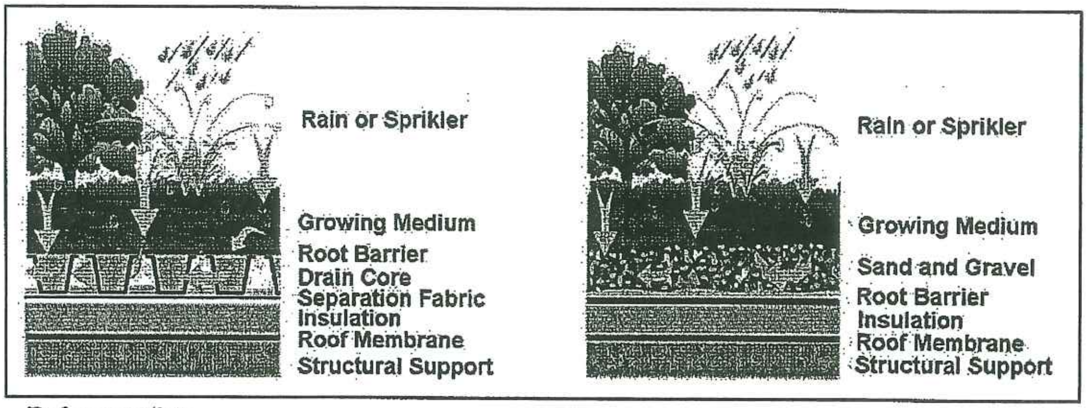
Green roofs are classed into two categories:

- extensive green roofs; shallow soil layer of 3 to 7-inch
  20-34 lb/square feet weight

- intensive green roofs; thick soil layer of 8-inch to 8-foot

80-150 lb/square feet weight

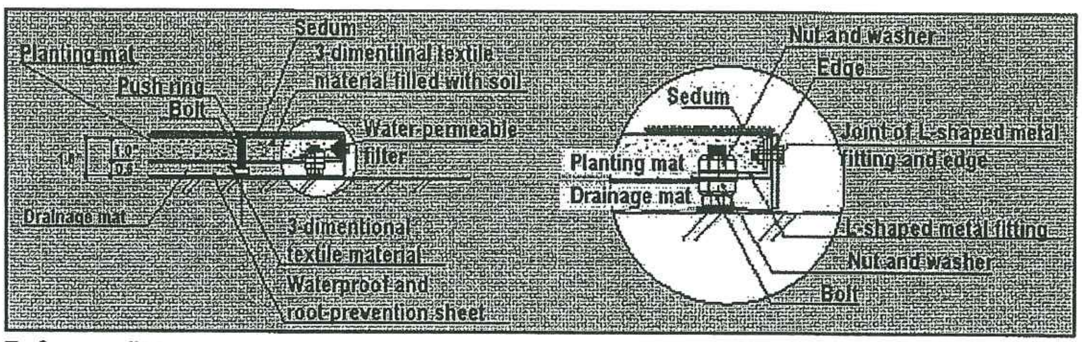
Recently, new technologies have made green roofs lighter to reduce the additional cost of supporting structure of the building. Figure B.3 shows typical green roof profiles.



Reference #19

Figure B.3 – Green Roof Profile

As the least weight green roof, sedum roof has been tested at many locations. Sedum is dry-tolerant plant that can grow with a thin soil layer (one to two-inch). It reduces the weight of green roof five to eight lb/square feet, eliminating the need for additional structural support. Figure B.4 shows sedum roof profiles and details.



Reference #20

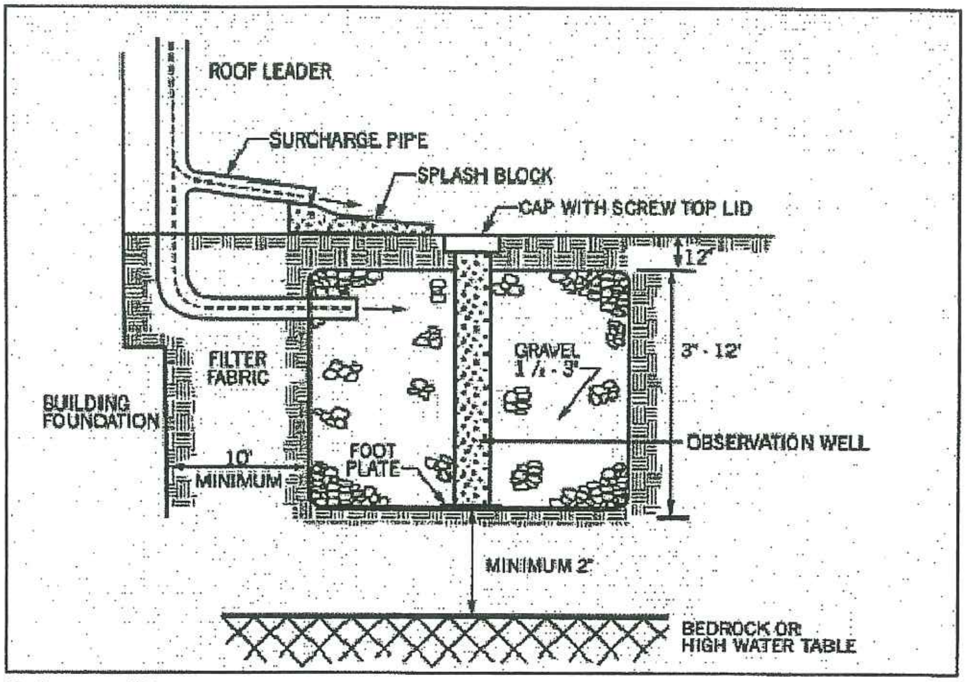
Figure B.4 – Sedum Roof Profile and Detail

Studies show that about one-foot of soil depth is needed to achieve the maximum reduction in runoff rate from prolonged winter storms. However, significant reduction in runoff rates from short intense storms that occur during dry weather periods can be achieved with as little as four inches of soil depth.

The City of Portland gives new green roofs the same credit as forest cover, allowing a curve number of 48 for roof gardens (intensive green roof) and a curve number of 61 for Eco-Roof (extensive green roof). In Germany, 3-inch green roofs have been found to be cost effective, and appreciable runoff will not begin until rainfall amounts exceed 0.6 inch.

Infiltration Facilities – Dry Well

Dry wells are small, excavated trenches backfilled with aggregate. They function as infiltration systems and are often used to control runoff from building rooftops. Dry well designs can be modified to act as catch basins, where they both collect and infiltrate direct surface runoff. Figure B.5 shows a typical detail of a dry well.

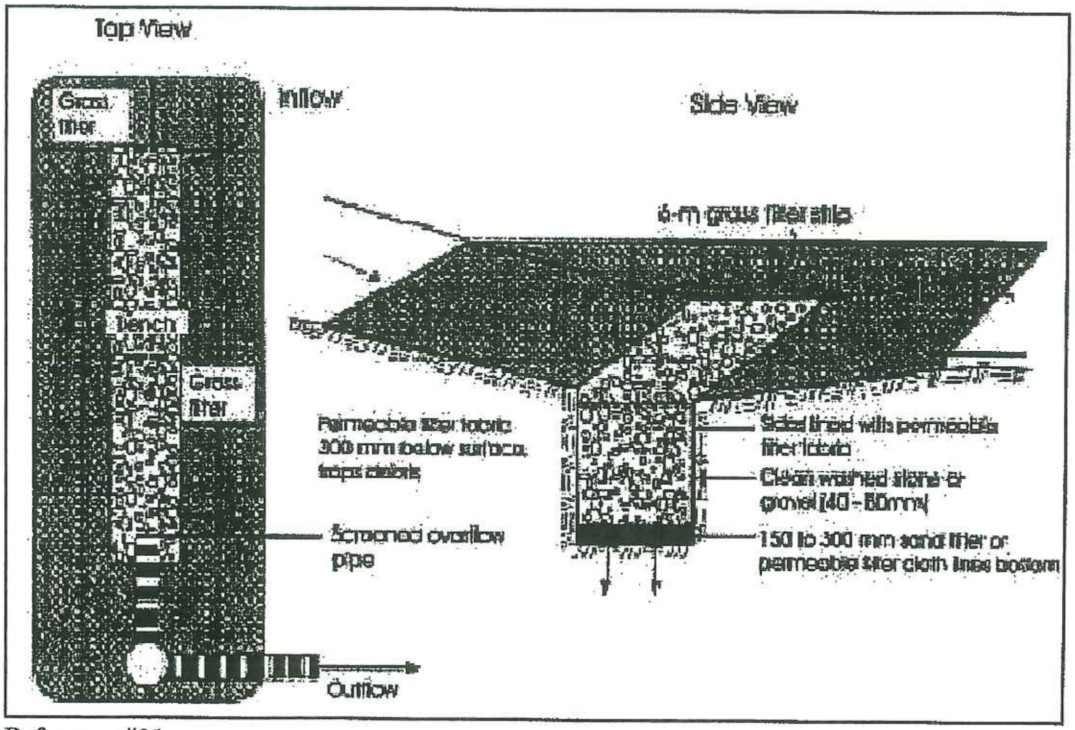


Reference #7

Figure B.5 – Typical Dry Well Section

Infiltration Facilities – Infiltration Trench

An infiltration trench is a shallow excavated trench that has been backfilled with coarse stone aggregate. It can be an underground reservoir or subsurface basin (Figures B.6 and B.7). Stormwater runoff is diverted into the trench and is stored until it can be infiltrated into the soil, usually over a period of several days. Infiltration trenches are a good design option in sandy soils where the depth to the maximum wet-season water table or hardpan is greater than three to six-feet. (Note: The new draft of the Washington State Underground Injection Control Rule has specific design recommendations for dry wells based on soil types and risk of aquifer contamination.)



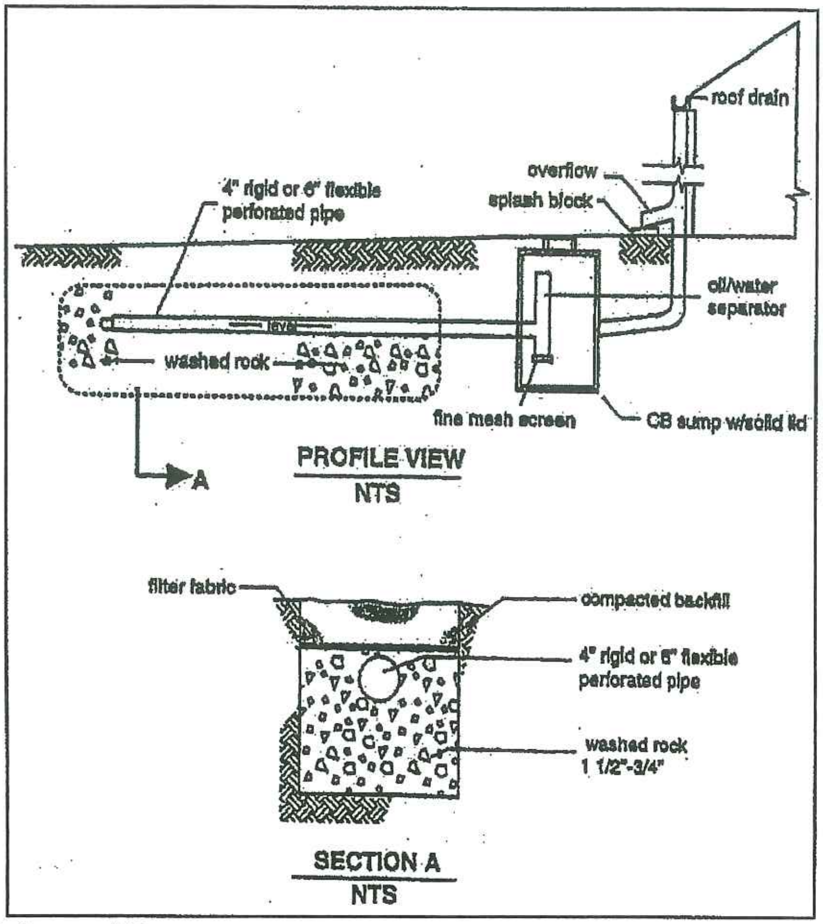
Reference #21

Figure B.6 – Subsurface Infiltration Trench

Bioretention

Bioretention is a water quality and water quantity control practice. It uses the chemical, biological, and physical properties of plants, microbes, and soils for removal of pollutants from stormwater runoff. Bioretention typically is used to treat small (0.25-1.0 acre), highly impervious surfaces such as parking lots and commercial areas. It is designed to contain an average annual storm event of about 0.5 – 0.7 inches of rainfall (Reference #21).

Bioretention consists of grass buffer strips (pretreatment area), ponded area, planting soil, sand bed, organic layer (mulch), and vegetation. A conceptual illustration for a bioretention area is presented in Figure B.8. The bioretention area design provides infiltration and water storage for uptake by vegetation.



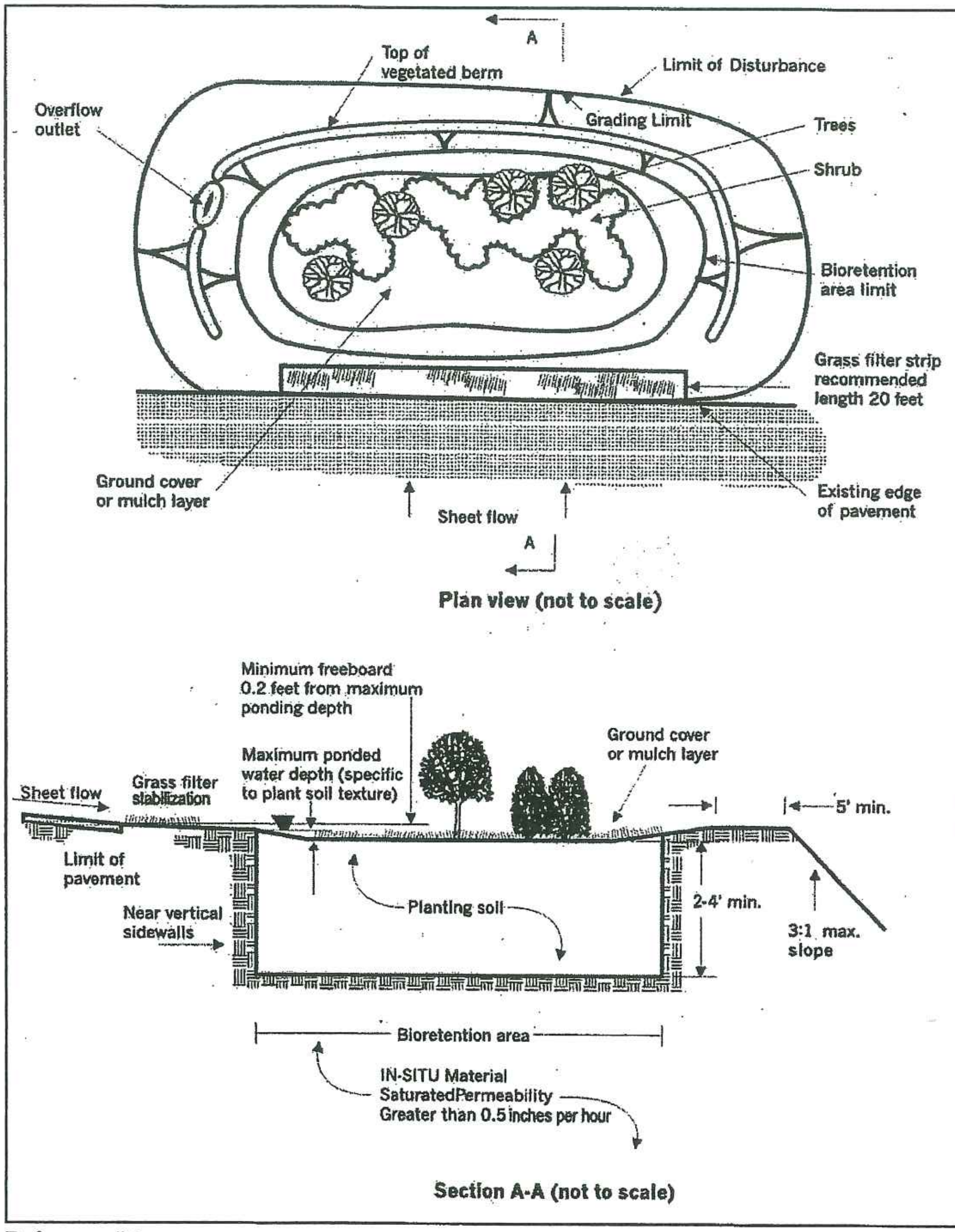
Reference #16

Figure B.7 – Underground Infiltration Trench

The surface of the planting soil is depressed to allow for ponding of runoff. Collected runoff is infiltrated through a surface organic layer of mulch and/or a ground cover to the planting soil. The runoff is stored in the planting soil where it is discharged over a period of days to the native soil underlying the bioretention area.

Bioretention areas should be designed as an off-line treatment system. In off-line systems, the "first flush", which is the most contaminated sheet flow, is retained, and larger flows are bypassed into the normal storm drain system. Such a design prevents the first flush from being washed out by higher discharges associated with on-line systems.

Bioretention has many potential side benefits other than water quality treatment. Plantings can improve the aesthetic value of the site as well as providing ecological value, such as improved habitat for small animals, shade, privacy screens, and wind breaks.



Reference #7

Figure B.8 – Plan View and Section of Bioretention Area

Cost reduction is another benefit of bioretention facilities. In Prince George's County, Maryland, a case study demonstrated that bioretention can be an economical alternative for providing treatment for the first half-inch of runoff from commercial and residential sites. For example, the total estimated cost of a water quality treatment facility for an office building was reduced from $174,000 with oil-grit separators to $111,600 with a bioretention area. For other office building sites, evaluated, bioretention practices reduced the amount of storm drainpipe from 800 to 230 feet.

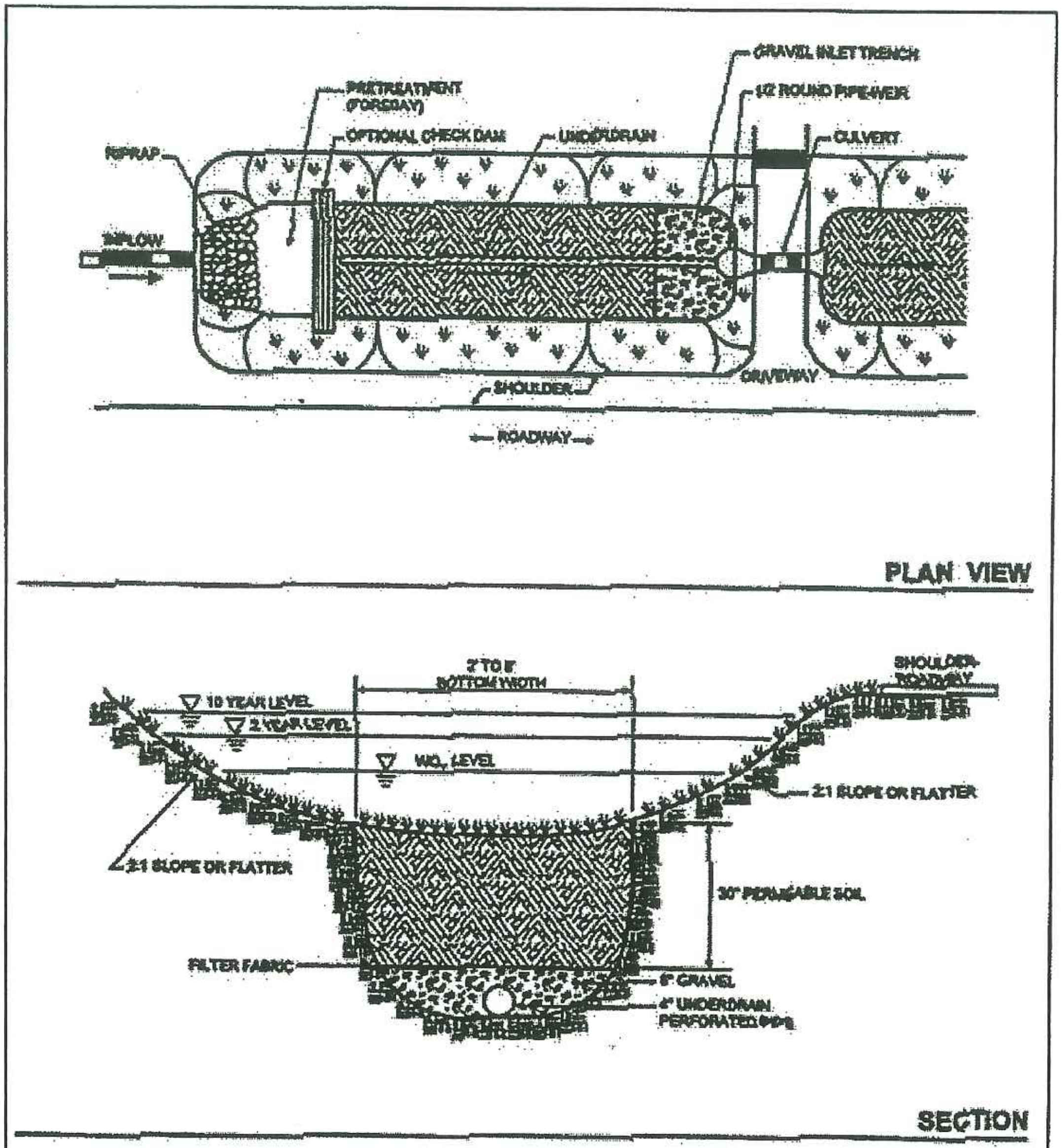
Grass Swale

Grass swales provide a series of vegetated open channels that are designed specifically to treat and attenuate stormwater runoff. They are best applied on a relatively small scale (generally less than five acres of impervious surface). There are many design variations including dry swales, wet swales, and biofiltration swales. These systems work well along roadways, driveways, and parking lots.

Dry swales are similar in design to bioretention areas. They typically have a sand/soil mix layer that meets minimum permeability required at the bottom of the channel. An underdrain system is also installed under the soil bed. Typically, the underdrain system is created by a gravel layer which encases a perforated pipe. Stormwater treated by the soil bed flows into the underdrain, which conveys treated stormwater back to the storm conveyance system (Figure B.9).

Wet swales intersect the groundwater and behave like a linear wetland cell. This design variation incorporates a shallow permanent pool and wetland vegetation to provide stormwater treatment. One disadvantage to the wet swale is that shallow standing water in the swale can cause public nuisance by providing mosquito breeding habitat.

A biofiltration swale is similar to a dry swale. It is more specifically designed for the treatment of stormwater. The primary pollutant removal mechanisms are filtration by grass blades which enhance sedimentation, trapping, and adhesion of pollutants to the grass and thatch. Biofiltration swales generally do not effectively remove dissolved pollutants. Maintaining dense vegetation is the key to its effectiveness. Therefore, a swale should receive a minimum of six-hours of sunlight daily during the summer months for healthy grass growth. A swale must dry between storms to maintain vegetation in good condition. For permanent saturated soil conditions, a wet biofiltration swale should be installed. Because typical grass dies when soil saturation exceeds two weeks, vegetation specifically adapted to saturated soil conditions should be used.



Reference #1

Figure B.9 – Plan View and Section of Dry Swale

Grass filter strips are vegetated areas intended to treat sheet flow from adjacent impervious areas. Filter strips function by reducing runoff velocities and filtering sediment and other pollutants. With proper maintenance, filter strips can provide relatively high pollutant removal. Grass filter strips require a relatively large amount of space, typically equal to the impervious area they treat. The land requirements for this practice can be a critical drawback in urban environments, where land prices are high. (Reference #1)

Storage
Rain barrels and cisterns are low-cost, effective, and easily maintainable storage units applicable to both residential and commercial/industrial site. Rain barrels operate by retaining a predetermined volume of rooftop runoff. In general, cisterns have a larger capacity and are installed either on rooftop or underground. Washington State Department of Ecology's stormwater design manual suggests that cisterns should provide at least 1,000 gallons of storage to have any significant hydrologic effect.

Costs and Benefits

Conventional and LID stormwater management costs are difficult to compare, because "marginal costs" are rarely defined for either approach. Some case studies and pilot programs show at least a 25 to 30 percent reduction in costs associated with site development, stormwater fees, and maintenance for residential developments that use LID strategies. These savings are achieved by reductions in clearing, grading, pipes, ponds, inlets, curbs, and paving. However, many LID projects have not been fully assessed in the long run due to its early stage in implementation. Some of this basic information is also lacking for conventional stormwater management as well. For instance, the costs to retrofit and repair an entire pipe system after 50 or 60 years are rarely estimated for conventional management. (Reference #8)

In addition, costs are site specific. Each project will be unique based on the site's soil conditions, topography, existing vegetation, land availability, etc. Some commonly seen cost benefits of LID projects include the following:

1. Multi-functionality—In many projects, LID was originally designed as a landscaped feature before its functionality as a stormwater control was introduced. In these situations, the landscaping and construction costs for stormwater have not been included and financially appear to be free. Additionally, the cost of maintaining the landscaped areas is typically included in the project cost and not in the cost of the stormwater system.
2. Lower lifecycle costs—It is important to take into account not just the initial capital costs but also those over the structure's lifetime, which can include operation, repair, maintenance, and decommissioning. Many LID techniques are self-perpetuating, easily repairable, or can be left as natural areas at the end of their functional lifetime, while conventional facilities may require high costs to take out of commission, repair, maintain, and/or replace.
3. Reduced off-site costs—Since LID addresses stormwater trunkline conveyance at its source, it is unlikely to incur major off-site costs in the form of conveyance network or outfalls. Most conventional techniques will require an off-site conveyance network to collect the stormwater from the on-site system, resulting

in additional project costs for the enhancement of downstream systems as urban areas expand.

4. Functional use of open space land—LID practices, such as bioretention, can usually be designed as part of the development's open space. Unlike large detention ponds, if these multifunctional LID practices are distributed throughout set-aside open space or previously designated landscaped land, they can contribute to a more park-like and community-friendly setting without incurring any additional costs for land allocation to the drainage system.

LID techniques will become less expensive over time, as a growing number of competing LID practitioners drive down prices and the technology becomes standard. Roofscapes Inc. expects that overall cost of green roof systems to decline by about 25 percent over the next couple of years (Reference #12).

Currently, costs of each LID technique are estimated as follows:

- Green roof; $5.6 to $14 /square feet[2]
- Absorbent landscaping/Bioretention; $2.3 to $6.5 /square feet[3]
- Dry swale (80 percent bioretention area): $1.8/square feet to $5.2/square feet (Reference #1)
- Porous pavement: $2 to $3 /square feet (conventional asphalt costs $0.5 to $1/square feet)
- Infiltration facilities : $2.8/square feet to $16/square feet
- Manually constructed cisterns (reinforced concrete, size of 3,000 gallons): $1,000

Summary: Applicability of LID to Mason County

Due to its natural setting, there will be many opportunities to use LID designs for the management of surface water runoff as the land within Mason County continue to develope. Table B.8 summarizes the applicability of the five major practices of LID design briefly discussed in the above literature review.

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[2] Extensive roofs are in the lower range, and intensive roofs are in the higher range. A pilot project in the City of White Rock, BC, which has a four-inch deep soil layer, costs about $8.4/square feet than a conventional impervious roof. (Reference #5)

[3] Sites with six-inch deep absorbent soil layer are in the lower range, and sites with 1.5-foot deep absorbent soil layer in the higher range.

Table B.8
Potential Applicability of LID Practices within Mason County

LID Practice	*Examples*	*Applicability to Mason County*
Impervious Surface Control	Porous Pavement	- Could be incorporated into any building design.
	Green Roofs	- Could be incorporated into any building design.
Infiltration Facilities	Dry Well	- Recommended for rooftop runoff, provides some attenuation of storms and some infiltration.
	Infiltration Trench	- Recommended for conveyance, provides infiltration and some detention
Semi-Natural Conveyance System	Bioretention	- Include with landscaping where possible.
	Grass Swale/Bioswale	- Good for small site attenuation and treatment.
	Filter Strips	- Good for parking lots.
Storage	Cistern	- Of limited use (unless of a large scale).
	Rain Barrel	- Could be used for some dry season watering
Landscaping	Effective Grading Use of Plants	- Of limited stormwater benefit unless of a large scale. - Recommend incorporating LID into landscape and green space areas to save costs and provide natural aesthetic look to the site.

In general, LID strategies can be beneficial and are recommended for future development within Mason County. The greatest attraction of the LID in surface water management design is the ability to better mimic some of the naturally occurring drainage systems. As development occurs, LID strategies could be used to simulate these natural systems.

The challenge for the Mason County land owners is to determine which LID strategies should be used and where should they be located. LID designs typically require land, and typically are more costly than conventional drainage designs. Unless they can be incorporated into required landscape and open-space areas, the use of the conventional regional detention and treatment systems may still be the best way for a land owners or developers to optimize the amount of land available for new construction. Clearly a reasonable tradeoff will need to be made between costs, availability of land, and the cost and ability to mitigate environmental impacts as development within Mason County continues.

References

1. Better Site Design Fact Sheet homepage, http://www.stormwatercenter.net

2. Center for Watershed Protection. 1998. *Better Site Design: A Handbook for Changing Development Rules in Your Community*. Ellicott City, MD

3. Cohen, A. *Narrow Streets Database*. Congress for the New Urbanism. Available online at: www.sonic.net/abcaia/narrow.htm

4. CRC, 1996; Davis et al. 1997; MWCG, 1987; Urbonas and Stahre, 1993; Yousef et al., 1985; Yu et al., 1992; Yu et al., 1993.

5. *Effectiveness of Stormwater Source Control*, Greater Vancouver Sewerage & Drainage District, 2002

6. Introduction to LID, Low Impact Development Center Inc., http://www.lid-stormwater.net/intro/background.htm#1

7. *Low-Impact Development Design Strategies, An Integrated Design Approach*, Prince George's County, Maryland, 1999

8. Low-Impact Development, Mary Catherine Hager, Stormwater January/February 2003

9. *Municipal Guide to Low Impact Development*, Low Impact Development Center Inc., http://www.lowimpactdevelopment.org/lid%20articles/Municipal_LID.pdf

10. *Natural Approach to Stormwater Management*, Puget Sound Action Team, March 2003

11. *Parking Generation, 2nd edition*. Institute of Transportation Engineers, Washington, DC. 1987.

12. Roofscape Inc., homepage, http://www.roofmeadow.com/

13. SEA Street homepage, Seattle Public Utility, http://www.seattle.gov/util/SEAStreets/default.htm

14. Smith, Thomas. *Flexible Parking Requirements*. Planning Advisory Service Report No. 377. American Planning Association, Chicago, IL. 40 pp. 1984

15. Wells, Cedar. *Impervious Surface Reduction Technical Study.* Draft Report. City of Olympia Public Works Department. Washington Department of Ecology, Olympia, WA. 1994.

16. City of Seattle. *Flow Control Technical Guidance Manual*, November, 2000.

17. *Green Streets. Innovative Solutions for Stormwater and Stream Crossings*, Metro June 2002.

18. Stormwater Technology Fact Sheet, Porous Pavement, EPA, September, 1999.

19. Amergreen Roof Garden System, http://www.americanwick.com/pdf/amergreen.pdf.

20. Thin-Layer Roof Top Greening System Using Sedum Carpet, http://www.takenaka.co.jp/takenaka-e/techno/lolo-sedum/.

21. Schueler, T.R., *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban Best Management Practice*, Metropolitan Washington Council of Governments. 1987.

22. *The Bioretention Manual.* Programs and Planning Division, Department of Environmental Resources, Price George's County, Maryland, November 2001.

Low Impact Development (LID) Screening Matrix

LID Technique*	Description	Applicability	Comments
1. Site assessment	The site assessment process evaluates the hydrology, topography, soils, vegetation, and water features of the site to identify how stormwater moves through the site prior to development. Wetlands, riparian management areas and floodplains are considered in the assessment process.	All subbasins	Mason Co. GIS includes information such as topography, soils, and water features (including wetlands and floodplains) that can be shared with property owners. Provide contact information in a brochure distributed to the public.
2. Site planning and design	Site planning and design addresses road, driveway, and parking layouts, road crossings, street trees, site layout, and building design. LID practices applicable to a given site influence the planning and design of these elements for the site.	All subbasins	Provide information and examples in a brochure distributed to the public.
3. Site phasing and fingerprinting	Site construction phase planning is performed to minimize impacts on LID elements. Site fingerprinting refers to placing development away from environmentally sensitive areas (wetlands, steep slopes, etc.), future open spaces, tree save areas, future restoration areas, and temporary and permanent vegetative buffer zones. It also confines ground disturbance to areas where structures, roads and rights-of-way will exist after construction is complete.	All subbasins	Mason Co. GIS includes information such as topography, soils, and water features (including wetlands and floodplains) that can be shared with property owners. Provide information and examples in a brochure distributed to the public.
4. Preserving native soils and vegetation	This technique addresses preservation of native soils and vegetation as a primary LID objective to limit impacts on aquatic systems. This is done through reduction of total impervious surface coverage; providing areas for infiltration of project runoff; and maintaining or closely mimicking the natural hydrologic function of the site.	Basins EF090, EF100, EF010, EF020, and other sites with wetlands, and/or streams	Mason Co. GIS includes information such as topography, soils, and water features (including wetlands and floodplains) that can be shared with property owners. Provide information and examples in a brochure distributed to the public.

*Basic Source: Puget Sound Action Team ● Washington State University Pierce County Extension, *Low Impact Development Guidance Manual for Puget Sound*, January 2005 (Revised May 2005)

Low Impact Development (LID) Screening Matrix

LID Technique	Description	Applicability	Comments
5. Clearing and grading	For project clearing and grading, the primary LID technique is to minimize site disturbance through reducing the extent of grading and retaining vegetative cover. This technique seeks to minimize hydrologic modifications and control sediment yield from the site.	All subbasins	Mason County proposed zoning currently limits the structure size and the maximum allowable lot coverage of many of the proposed zones.
6. Bioretention cells	Bioretention cells (also known as "rain gardens") provide for on-site retention of stormwater through the use of vegetated depressions engineered to collect, store and infiltrate runoff.	All subbasins	Provide information and examples in a brochure distributed to the public. Good for small (0.25 – 1 ac), highly impervious sites such as parking lots and commercial areas.
7. Sloped biodetention	The sloped biodetention technique uses grassy vegetative barriers such as hedgerows on contours to detain stormwater and reduce pollutant loads.	BP, R-3	
8. Bioretention swales	Bioretention swales function to collect, store and infiltrate runoff on a linear basis such as in landscaped swales in roadway medians.	All basins	May be used instead of curb and gutter infrastructure.
9. Tree box filters	Tree box filters are a mini bioretnention areas installed beneath trees. With this technique, runoff is directed to the tree box where it is cleaned by vegetation and soil before being discharged to a catch basin. The runoff also helps to irrigate the tree.	BP, R-3, POS, VC, VR	
10. Maintenance	On-going maintenance and long term protection of native vegetation and soils associated with LID stormwater facilities are necessary to their successful performance. Clearly written maintenance procedures and LID area protection plans are important to this element.	POS	County to provide maintenance of their right of way. Provide information and examples in a brochure distributed to the public.

Low Impact Development (LID) Screening Matrix

LID Technique	Description	Applicability	Comments
11. Amending construction site soils	With this technique, disturbed site soils are amended to enhance their hydrologic attributes and environmental benefits in landscaped areas. Soil amendment specifications include organic matter content, pH, depth of amendment and subsoil preparation.	All basins	Provide information and examples in a brochure distributed to the public.
12. Permeable pavement	Permeable pavement surfaces accommodate pedestrian, bicycle and vehicular traffic while allowing the infiltration, treatment and storage of stormwater. The general categories of this technique relate to the pavement wearing material and include: • Permeable asphalt concrete • Permeable concrete • Permeable gravel • Permeable pavers Permeable pavement sections consist of: (1) a permeable wearing course or surface area designed to provide the strength needed for traffic loads; (2) an aggregate base below the surface section for support, vertical and lateral dispersion of water, and temporary storage of runoff; (3) and separation layer using non-woven geotextile fabric below the aggregate base to prevent upward migration of fine soil particles; and (4) where required, a water quality treatment layer to filter pollutants and protect the ground water.	All basins	(+) Provides groundwater recharge, no space requirements, and high removal efficiency (US GBC) (-) Requires permeable soils, not suitable for high traffic or high speed areas, high potential for failure, requires maintenance (US GBC)

Low Impact Development (LID) Screening Matrix

LID Technique	Description	Applicability	Comments
13. Vegetated roof	Vegetated roofs are also known as green roofs and eco-roofs. They are categorized as either intensive (deeper soil layer, intensive plantings, higher maintenance) and extensive (shallower soil layer, lower cost, lower maintenance). Benefits identified for vegetated roofs include energy efficiency and air quality, temperature and noise reduction in urban areas, improved aesthetics, extended roof life, and reduction in stormwater flows. The typical vegetated roof section includes from top to bottom: vegetation layer; growth medium (soil) layer; separation layer; drainage, aeration, water storage and root barrier layer; water proof membrane; and roof structure section.	All basins	Provide information and examples in a brochure distributed to the public.
14. Minimal excavation foundations	This LID technique seeks to limit soil disturbance during construction by the use of minimal excavation systems. The objective is to limit compaction of site soils from heavy equipment operations which would result in degradation of the infiltration and storage capacities of the site soils.	All basins	Provide information and examples in a brochure distributed to the public.
15. Homeowner education	Homeowner education is an important component of a successful LID maintenance program and LID area protection plan. Clearly written operations and maintenance procedures and protection management plans should be a part of any homeowner education program.	All basins	Provide information and examples in a brochure distributed to the public.
16. Downspout dispersion	Downspout dispersion provides for the dispersion and infiltration of roof runoff onsite. Several dispersion methods are available including splash blocks, gravel trenches and sheet flow.	Low density Residential zoning areas	Basins with well draining soil and low % impervious

Low Impact Development (LID) Screening Matrix

LID Technique	Description	Applicability	Comments
17. Roof stormwater harvesting systems	Roof stormwater harvesting (also know as "rainwater harvesting") is the collection and storage of roof runoff for domestic or irrigation purposes. Harvesting systems include a collection (roof) area, a filter, a storage device (tank or vault) and an outflow device.	Subbasins requiring rate control EF010, EF015, SF010, SF020, and SF030	Helps reduce the size of regional facilities subbasins requiring rate control.
18. Filter strips	Filter strips are grassy slopes located adjacent to an impervious area subject to vehicular traffic. Pollutants are removed by the action of grass blades which enhance sedimentation and trapping and adhesion of pollutants to the grass. Filter strips are graded to provide for sheet flow over the entire filter area.	Roads in residential areas (<10 units per acre?)	This low maintenance water quality feature is economical and even provides some habitat (US Green Building Council). Filter strips work best with low velocity flows.
19. Media filtration	Media filtration includes sand filter units or patented units using leaf compost material or other media such as perlite, zeolite and others. Pollutants are removed through filtration in sand filters and filtration, adsorption, ion exchange and microbial degradation in the patented units.	Near outfalls without enough open space to provide another WQ facility	
20. Constructed Wetland	Constructed Wetlands are engineered systems that are designed to mimic natural wetland treatment properties. Advanced designs incorporate a wide variety of wetland trees, shrubs, and plants while basic systems only include a limited number of vegetation types (US GBC).	Upstream of outfalls and/or at shared use public open space	Good for large developments, or regional facilities, peak volume control, high removal efficiency, and aesthetic value. Requires significant space, some maintenance, and is not economical for small developments.

Appendix C—Hydrologic Analysis

MGSFlood Analysis

Summary of MGS Flood Analysis - Future Flows based on County Zoning
MGS Flood, Version 3.
Modeled by: Laura Ruppert, 11/27-29/2006, updated 12-11-06
Checked by:

		Surface Water Runoff*		Detention			Water Quality			Typical Results Per 1 Acre Developed		
				Pond Dimensions		Volume	Volume	Design Discharge				
Subbasin Name	Proposed Subbasin Area (ac)	2-yr (cfs)	25-yr (cfs)	Bottom Area (sf)	Top Area (sf)	At Riser (cfs)	Basic Wet Pond (cf)	On-line (cfs)	Off-line (cfs)	Detention (CF)	Top Area (SF)	Wet Pond (CF)
Sherwood Creek North	52.15	4.5 / 2.7	10.5 / 7.4	100,800	117,936	309,997	193,100	4.37	2.46	5,944	2,261	3,800
Sherwood Creek South	21.13	1.3 / 0.7	3.3 / 2.2	80,000	94,976	256,505	92,437	2.35	1.35	12,139	4,495	4,400
Unnamed Channel	18.2	3.3 / 3.6	9.1 / 7.8	NA	NA	NA	76,221	1.71	0.96	NA	NA	4,200
Kayak Park Outfall	25.59	4.33	9.16	NA	NA	NA	89,734	2.22	1.26	NA	NA	3,600
Evans St. Outfall	127.59	29.96	56.03	NA	NA	NA	608,835	15.2	8.7	NA	NA	4,800
Wade St. Outfall	53.67	16.36	28.35	NA	NA	NA	320,424	9.34	5.45	NA	NA	6,000
Power Easement Outfall	86.72	21.54	39.90	NA	NA	NA	433,449	11.15	6.4	NA	NA	5,000

* Predeveloped / Postdevelopment for basin requiring rate control

Notes:
Assumes SR3 runoff will be kept separate from the proposed outfalls

MGS Flood, Version 3.
10 acre test plot results
Modeled by: Laura Ruppert, 11/22/2006
Checked by:

Proposed Condition			Detention					Water Quality			Typical Results Per 1 Acre Developed				
Zoning*	Land Use Developed		Pond Dimensions			Volume		Volume	Design Discharge						
	Acres Impervious	Acres Till Grass	Bottom (ftxft)	Bottom (sf)	Max Storage Depth (ft)	At Riser (cfs)	At Max (cfs)	Basic Wet Pond (cf)	On-line (cfs)	Off-line (cfs)	Detention (CF)	Footprint (SF)	Wet Pond (CF)	On-line (cfs)	Off-line (cfs)
R-1	4	6	290x145	42,050	3.20	148,294	176,636	43,789	0.97	0.54	14,900	4,300	4,400	0.10	0.05
HC	8	2	370x185	65,480	3.10	228,532	260,456	60,200	1.75	1.02	22,900	6,600	6,100	0.18	0.10

* Zoning descriptions are provided in the report text.

MGS FLOOD
PROJECT REPORT

Program Version: 3.09 **Run Date: 12/06/2006 9:45 AM**

Input File Name: **PortPark_noSR3.fld**
Project Name: Port Park no SR-3 - New Outfall
Analysis Title: Proposed runoff to proposed port park outfall - no SR-3
Comments: Basin EF080 drains to the proposed port park outfall. Looked up long. and lat. online. Requires WQ treatment.

********** Precipitation Input**********

Extended Precipitation Timeseries Selected
Climatic Region Number: 7
Full Period of Record Available used for Routing
Precipitation Station : 950056 Puget West 56 in MAP 10/01/1939-10/01/2097
Evaporation Station : 951056 Puget West 56 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

********** Watershed Definition **********

Number of Subbasins: 1

********** Subbasin Number: 1 **********

***Tributary to Node: 1
***Bypass to Node : None

	Area(Acres)		
		Developed	
	Predeveloped	To Node	Bypass Node
Till Forest	1.270	1.270	0.000
Till Pasture	2.480	2.480	0.000
Till Grass	5.630	5.630	0.000
Outwash Forest	0.800	0.800	0.000
Outwash Pasture	0.670	0.670	0.000
Outwash Grass	5.280	5.280	0.000
Wetland	0.000	0.000	0.000
Impervious	9.460	9.460	0.000
Subbasin Total	25.590	25.590	0.000

*** Subbasin Connection Summary ***

Subbasin 1 -------------> Node 1

*** By-Pass Area Connection Summary ***
No By-Passed Areas in Watershed

Predeveloped Compliance Node: 1
Postdeveloped Compliance Node: 1

*** Postdeveloped Structure Summary ***

***********Water Quality Facility Data *************

Node No: 1

Basic Wet Pond Volume (91% Exceedance): 89734. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 134601. cu-ft
2-Year Discharge Rate : 4.325 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
On-line Design Discharge Rate (91% Exceedance): 2.22 cfs
Off-line Design Discharge Rate (91% Exceedance): 1.26 cfs

Computed Flow Splitter Data
Orifice Diameter: 5.00 inches
Baffle Wall Height (WQ Design Depth): 3.46 feet
Baffle Wall (Weir) Length: 5.05 feet (60.5 inches)
Ratio: WQ Depth/Orifice Diameter: 8.3 (>=2 PASS)

***********Compliance Point Results *************

Predeveloped Compliance Node: 1
Postdeveloped Compliance Node: 1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

Predevelopment Runoff		Postdevelopment Runoff	
Tr (Years)	**Discharge (cfs)**	**Tr (Years)**	**Discharge (cfs)**
2-Year	4.325	2-Year	4.325
5-Year	5.898	5-Year	5.898
10-Year	6.892	10-Year	6.892
25-Year	9.164	25-Year	9.164
50-Year	10.423	50-Year	10.423
100-Year	11.490	100-Year	11.490
200-Year	12.818	200-Year	12.818

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance According to Dept. of Ecology Criteria ******

Excursion at Predeveloped ½Q2 (Must be Less Than 0%):	0.0%	PASS
Maximum Excursion from ½Q2 to Q2 (Must be Less Than 0%):	0.0%	PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	0.0%	PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%):	0.0%	PASS

*** POND MEETS ALL DURATION DESIGN CRITERIA: PASS**

MGS FLOOD
PROJECT REPORT

Program Version: 3.09 **Run Date: 12/06/2006 10:17 AM**

Input File Name: **Evans_noSR3.fld**
Project Name: Evens St. - New Outfall - no SR3 improvements
Analysis Title: Proposed runoff to proposed Evans St. Outfall
Comments: Basins EF040 and 050 drain to the proposed outfall. Looked up long. and lat. online. Requires WQ treatment.

********** Precipitation Input**********

Extended Precipitation Timeseries Selected
Climatic Region Number: 7
Full Period of Record Available used for Routing
Precipitation Station : 950056 Puget West 56 in MAP 10/01/1939-10/01/2097
Evaporation Station : 951056 Puget West 56 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

********** Watershed Definition **********

Number of Subbasins: 1

********** Subbasin Number: 1 **********

***Tributary to Node: 1
***Bypass to Node : None

	Area(Acres)		
		Developed	
	Predeveloped	To Node	Bypass Node
Till Forest	10.260	10.260	0.000
Till Pasture	15.880	15.880	0.000
Till Grass	32.020	32.020	0.000
Outwash Forest	0.000	0.000	0.000
Outwash Pasture	0.000	0.000	0.000
Outwash Grass	0.910	0.910	0.000
Wetland	0.140	0.140	0.000
Impervious	68.380	68.380	0.000
Subbasin Total	127.590	127.590	0.000

*** Subbasin Connection Summary ***

Subbasin 1 -------------> Node 1

*** By-Pass Area Connection Summary ***
No By-Passed Areas in Watershed

Predeveloped Compliance Node: 1
Postdeveloped Compliance Node: 1

*** Postdeveloped Structure Summary ***

***********Water Quality Facility Data *************

Node No: 1

Basic Wet Pond Volume (91% Exceedance): 608335. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 912503. cu-ft
2-Year Discharge Rate : 29.961 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
On-line Design Discharge Rate (91% Exceedance): 15.20 cfs
Off-line Design Discharge Rate (91% Exceedance): 8.70 cfs

Computed Flow Splitter Data
Orifice Diameter: 12.00 inches
Baffle Wall Height (WQ Design Depth): 4.96 feet
Baffle Wall (Weir) Length: 17.43 feet (209.2 inches)
Ratio: WQ Depth/Orifice Diameter: 5.0 (>=2 PASS)

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

Predevelopment Runoff		Postdevelopment Runoff	
Tr (Years)	**Discharge (cfs)**	**Tr (Years)**	**Discharge (cfs)**
2-Year	29.961	2-Year	29.961
5-Year	36.424	5-Year	36.424
10-Year	44.999	10-Year	44.999
25-Year	56.031	25-Year	56.031
50-Year	65.805	50-Year	65.805
100-Year	70.548	100-Year	70.548
200-Year	83.002	200-Year	83.002

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance According to Dept. of Ecology Criteria ******

Excursion at Predeveloped ½Q2 (Must be Less Than 0%):	0.0%	PASS
Maximum Excursion from ½Q2 to Q2 (Must be Less Than 0%):	0.0%	PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	0.0%	PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%):	0.0%	PASS

*** POND MEETS ALL DURATION DESIGN CRITERIA: PASS**

MGS FLOOD
PROJECT REPORT

Program Version: 3.09 **Run Date: 12/06/2006 10:08 AM**

Input File Name: **Wade_noSR3.fld**
Project Name: Wade St. - New Outfall - No SR-3 improvements
Analysis Title: Proposed runoff to proposed Wade St. Outfall
Comments: Basins EF030 and 035 drain to the proposed outfall. Looked up long. and lat. online. Requires WQ treatment.

********** Precipitation Input**********

Extended Precipitation Timeseries Selected
Climatic Region Number: 7
Full Period of Record Available used for Routing
Precipitation Station : 950056 Puget West 56 in MAP 10/01/1939-10/01/2097
Evaporation Station : 951056 Puget West 56 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

********** Watershed Definition **********

Number of Subbasins: 1

********** Subbasin Number: 1 **********

***Tributary to Node: 1
***Bypass to Node : None

	Area(Acres)		
		Developed	
	Predeveloped	To Node	Bypass Node
Till Forest	1.260	1.260	0.000
Till Pasture	1.260	1.260	0.000
Till Grass	8.241	8.241	0.000
Outwash Forest	0.030	0.030	0.000
Outwash Pasture	0.030	0.030	0.000
Outwash Grass	0.020	0.020	0.000
Wetland	0.000	0.000	0.000
Impervious	42.829	42.829	0.000
Subbasin Total	53.670	53.670	0.000

*** Subbasin Connection Summary ***

Subbasin 1 -----------> Node 1

*** By-Pass Area Connection Summary ***

No By-Passed Areas in Watershed

Predeveloped Compliance Node: 1
Postdeveloped Compliance Node: 1

************Water Quality Facility Data *************

Node No: 1

Basic Wet Pond Volume (91% Exceedance): 320424. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 480636. cu-ft
2-Year Discharge Rate : 16.363 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
On-line Design Discharge Rate (91% Exceedance): 9.34 cfs
Off-line Design Discharge Rate (91% Exceedance): 5.45 cfs

Computed Flow Splitter Data
Orifice Diameter: 9.00 inches
Baffle Wall Height (WQ Design Depth): 6.15 feet
Baffle Wall (Weir) Length: 6.72 feet (80.7 inches)
Ratio: WQ Depth/Orifice Diameter: 8.2 (>=2 PASS)

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

Predevelopment Runoff		Postdevelopment Runoff	
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	16.363	2-Year	16.363
5-Year	20.214	5-Year	20.214
10-Year	24.076	10-Year	24.076
25-Year	28.347	25-Year	28.347
50-Year	33.615	50-Year	33.615
100-Year	37.573	100-Year	37.573
200-Year	42.971	200-Year	42.971

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance According to Dept. of Ecology Criteria ******

Excursion at Predeveloped ½Q2 (Must be Less Than 0%):	0.0%	PASS
Maximum Excursion from ½Q2 to Q2 (Must be Less Than 0%):	0.0%	PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	0.0%	PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%):	0.0%	PASS

*** POND MEETS ALL DURATION DESIGN CRITERIA: PASS**

MGS FLOOD
PROJECT REPORT

Program Version: 3.09 **Run Date: 12/06/2006 10:01 AM**

Input File Name: **Tacoma_noSR3.fld**
Project Name: Tacoma Power Easement - New Outfall - no SR-3
Analysis Title: Proposed runoff to proposed Tacoma Power Easement outfall
Comments: Basins EF010, 020, and 025 drain to the proposed power easement outfall. Looked up long. and lat. online. Requires WQ treatment.

*********** Precipitation Input**********

Extended Precipitation Timeseries Selected
Climatic Region Number: 7
Full Period of Record Available used for Routing
Precipitation Station : 950056 Puget West 56 in MAP 10/01/1939-10/01/2097
Evaporation Station : 951056 Puget West 56 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

*********** Watershed Definition **********

Number of Subbasins: 1

********** Subbasin Number: 1 **********

***Tributary to Node: 1
***Bypass to Node : None

	Area(Acres)		
		Developed	
	Predeveloped	**To Node**	**Bypass Node**
Till Forest	5.210	5.210	0.000
Till Pasture	5.070	5.070	0.000
Till Grass	25.850	25.850	0.000
Outwash Forest	0.150	0.150	0.000
Outwash Pasture	0.150	0.150	0.000
Outwash Grass	0.120	0.120	0.000
Wetland	0.000	0.000	0.000
Impervious	50.170	50.170	0.000
Subbasin Total	86.720	86.720	0.000

*** Subbasin Connection Summary ***

Subbasin 1 --------------> Node 1

*** By-Pass Area Connection Summary ***
No By-Passed Areas in Watershed

Predeveloped Compliance Node: 1
Postdeveloped Compliance Node: 1

************Water Quality Facility Data *************

Node No: 1

Basic Wet Pond Volume (91% Exceedance): 433449. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 650173. cu-ft
2-Year Discharge Rate : 21.543 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
On-line Design Discharge Rate (91% Exceedance): 11.15 cfs
Off-line Design Discharge Rate (91% Exceedance): 6.40 cfs

Computed Flow Splitter Data
Orifice Diameter: 9.00 inches
Baffle Wall Height (WQ Design Depth): 8.47 feet
Baffle Wall (Weir) Length: 5.96 feet (71.5 inches)
Ratio: WQ Depth/Orifice Diameter: 11.3 (>=2 PASS)

*** Point of Compliance Flow Frequency Data ***

Recurrence Interval Computed Using Gringorten Plotting Position

Predevelopment Runoff		Postdevelopment Runoff	
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	21.543	2-Year	21.543
5-Year	26.223	5-Year	26.223
10-Year	32.581	10-Year	32.581
25-Year	39.895	25-Year	39.895
50-Year	47.357	50-Year	47.357
100-Year	51.251	100-Year	51.251
200-Year	59.746	200-Year	59.746

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

**** Flow Duration Performance According to Dept. of Ecology Criteria ****

Excursion at Predeveloped ½Q2 (Must be Less Than 0%):	0.0%	PASS
Maximum Excursion from ½Q2 to Q2 (Must be Less Than 0%):	0.0%	PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	0.0%	PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%):	0.0%	PASS

*** POND MEETS ALL DURATION DESIGN CRITERIA: PASS**

MGS FLOOD
PROJECT REPORT

Program Version: 3.09 **Run Date: 11/29/2006 8:25 AM**

Input File Name: **Sherwood_N.fld**
Project Name: Sherwood Creek North Basin
Analysis Title: Sherwood Creek Basins SP010 and SF010
Comments: Sherwood Creek subbasins SP010 and SF010. Looked up long. and lat. online. Requires RC and WQ

********** Precipitation Input**********

Extended Precipitation Timeseries Selected
Climatic Region Number: 7
Full Period of Record Available used for Routing
Precipitation Station : 950056 Puget West 56 in MAP 10/01/1939-10/01/2097
Evaporation Station : 951056 Puget West 56 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

********** Watershed Definition **********

Number of Subbasins: 1

********** Subbasin Number: 1 **********

***Tributary to Node: 1
***Bypass to Node : None

	Area(Acres)		
		Developed	
	Predeveloped	**To Node**	**Bypass Node**
Till Forest	20.140	3.820	0.000
Till Pasture	3.460	3.930	0.000
Till Grass	6.020	16.850	0.000
Outwash Forest	8.020	0.000	0.000
Outwash Pasture	0.000	0.000	0.000
Outwash Grass	3.370	7.120	0.000
Wetland	5.430	3.250	0.000
Impervious	5.710	17.180	0.000
Subbasin Total	52.150	52.150	0.000

*** Subbasin Connection Summary ***

Subbasin 1 --------------> Node 1

*** By-Pass Area Connection Summary ***
No By-Passed Areas In Watershed

*** Postdeveloped Node Connection Summary ***

Upstream Node No.	Link Type	Downstream Node
Node 1	Pond	Node 2

Predeveloped Compliance Node: 1
Postdeveloped Compliance Node: 2

*** Postdeveloped Structure Summary ***

Link No. 1, Pond: North Pond

Upstream Node : 1, Downstream Node: 2

Prismatic Pond Option Used

Pond Floor Elevation	: 100.00ft	
Riser Crest Elevation	: 102.90ft	
Max Pond Elevation	: 104.00ft	
Max Storage Depth	: 2.90 ft	
Pond Bottom Length	: 480.0 ft	
Pond Bottom Width	: 210.0 ft	
Pond Side Slopes	: L1= 3.00 L2= 3.00 W1= 3.00 W2= 3.00 ft/ft	
Pond Bottom Area	: 100800.	sq-ft
Area at Riser Crest El	: 113,109.	sq-ft
	: 2.597 acres	
Volume at Riser Crest	: 309,997.	cu-ft
	: 7.117	ac-ft
Area at Max Elevation	: 117936.	sq-ft
	: 2.707 acres	
Vol at Max Elevation	: 437,024.	cu-ft
	: 10.033	ac-ft
Hydraulic Conductivity	: 0.00	in/hr
Depth to Water Table	: 100.00	ft

Riser Geometry

Riser Structure Type	: Circular
Riser Diameter	: 36.00 in
Common Length	: 0.900 ft
Riser Crest Elevation	: 102.90 ft

Hydraulic Structure Geometry

Number of Devices: 2

---Device Number 1 ---

Device Type	: Circular Orifice
Invert Elevation	: 100.00 ft
Diameter	: 8.90 in
Orientation	: Horizontal
Elbow	: No

--- Device Number 2 ---

Device Type	: Vertical Rectangular Orifice
Invert Elevation	: 101.10 ft
Length	: 11.10 in
Height	: 23.50 in
Orientation	: Vertical
Elbow	: No

Postdeveloped Water Surface Elevation Data (ft)

Recurrence Interval Computed Using Gringorten Plotting Position

Tr (yrs)	Link: 1
1.05-Year	100.663
1.11-Year	100.774
1.25-Year	100.921
2.00-Year	101.314
3.33-Year	101.563
5-Year	101.741
10-Year	102.096
25-Year	102.381
50-Year	102.719
100-Year	102.794

Postdeveloped Infiltrated Water Statistics
Volume Statistics Computed for Entire Simulation

Statistic	Link: 1
Total Inflow Volume (ac-ft)	20850.
Total Volume Infiltrated (ac-ft)	0.
Percent Infiltrated	0.00 %

***********Water Quality Facility Data *************

Node No: 1

Basic Wet Pond Volume (91% Exceedance): 193100. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 289650. cu-ft
2-Year Discharge Rate : 8.795 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
On-line Design Discharge Rate (91% Exceedance): 4.37 cfs
Off-line Design Discharge Rate (91% Exceedance): 2.46 cfs

Computed Flow Splitter Data
Orifice Diameter: 6.25 inches
Baffle Wall Height (WQ Design Depth): 5.37 feet
Baffle Wall (Weir) Length: 5.56 feet (66.7 inches)
Ratio: WQ Depth/Orifice Diameter: 10.3 (>=2 PASS)

Node No: 2

Basic Wet Pond Volume (91% Exceedance): 156776. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 235164. cu-ft
2-Year Discharge Rate : 2.712 cfs

***********Compliance Point Results *************

Predeveloped Compliance Node: 1
Postdeveloped Compliance Node: 2

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

Predevelopment Runoff Tr (Years)	Discharge (cfs)	Postdevelopment Runoff Tr (Years)	Discharge (cfs)
2-Year	4.480	2-Year	2.712
5-Year	6.621	5-Year	4.150
10-Year	8.182	10-Year	5.492
25-Year	10.489	25-Year	7.396
50-Year	12.676	50-Year	8.467
100-Year	13.841	100-Year	8.971
200-Year	14.259	200-Year	9.821

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance According to Dept. of Ecology Criteria ******

Excursion at Predeveloped ½Q2 (Must be Less Than 0%):	-6.7%	PASS
Maximum Excursion from ½Q2 to Q2 (Must be Less Than 0%):	-2.8%	PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	-14.0%	PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%):	0.0%	PASS

*** POND MEETS ALL DURATION DESIGN CRITERIA: PASS**

MGS FLOOD
PROJECT REPORT

Program Version: 3.09 **Run Date: 11/29/2006 8:56 AM**

Input File Name: **Sherwood_S.fld**
Project Name: Sherwood Creek South Basin
Analysis Title: Sherwood Creek Basins SP020,030 & SF020,030
Comments: Sherwood Creek subbasins SP020,030 & SF020,030. Looked up long. and lat. online. Requires RC and WQ

********** Precipitation Input**********

Extended Precipitation Timeseries Selected
Climatic Region Number: 7
Full Period of Record Available used for Routing
Precipitation Station : 950056 Puget West 56 in MAP 10/01/1939-10/01/2097
Evaporation Station : 951056 Puget West 56 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

********** Watershed Definition **********

Number of Subbasins: 1

********** Subbasin Number: 1 **********

***Tributary to Node: 1
***Bypass to Node : None

	Area(Acres)		
		Developed	
	Predeveloped	To Node	Bypass Node
Till Forest	11.890	1.180	0.000
Till Pasture	0.940	1.220	0.000
Till Grass	1.580	5.310	0.000
Outwash Forest	3.080	0.000	0.000
Outwash Pasture	0.000	0.000	0.000
Outwash Grass	0.970	2.470	0.000
Wetland	2.150	0.800	0.000
Impervious	0.520	10.150	0.000
Subbasin Total	21.130	21.130	0.000

*** Subbasin Connection Summary ***

Subbasin 1 --------------> Node 1

*** By-Pass Area Connection Summary ***

No By-Passed Areas in Watershed

*** Postdeveloped Node Connection Summary ***

Upstream Node No.	Link Type	Downstream Node
Node 1	Pond	Node 2

Predeveloped Compliance Node: 1
Postdeveloped Compliance Node: 2

*** Postdeveloped Structure Summary ***

Link No. 1, Pond: South Pond

Upstream Node : 1, Downstream Node: 2

Prismatic Pond Option Used

Pond Floor Elevation	:	100.00ft	
Riser Crest Elevation	:	103.00ft	
Max Pond Elevation	:	104.00ft	
Max Storage Depth	:	3.00 ft	
Pond Bottom Length	:	400.0 ft	
Pond Bottom Width	:	200.0 ft	
Pond Side Slopes	:	L1= 3.00 L2= 3.00 W1= 3.00 W2= 3.00 ft/ft	
Pond Bottom Area	:	80000.	sq-ft
Area at Riser Crest El	:	91,124.	sq-ft
	:	2.092 acres	
Volume at Riser Crest	:	256,505.	cu-ft
	:	5.889	ac-ft
Area at Max Elevation	:	94976.	sq-ft
	:	2.180 acres	
Vol at Max Elevation	:	349,524.	cu-ft
	:	8.024 ac-ft	
Hydraulic Conductivity	:	0.00	in/hr
Depth to Water Table	:	100.00	ft

Riser Geometry

Riser Structure Type	: Circular
Riser Diameter	: 30.00 in
Common Length	: 0.410 ft
Riser Crest Elevation	: 103.00 ft

Hydraulic Structure Geometry

Number of Devices: 2

---Device Number 1 ---

Device Type	: Circular Orifice
Invert Elevation	: 100.00 ft
Diameter	: 4.50 in
Orientation	: Horizontal
Elbow	: No

--- Device Number 2 ---

Device Type	: Vertical Rectangular Orifice
Invert Elevation	: 101.50 ft
Length	: 4.50 in
Height	: 18.02 in
Orientation	: Vertical
Elbow	: No

*** Post-Developed Link Statistics ***

Postdeveloped Water Surface Elevation Data (ft)
Recurrence Interval Computed Using Gringorten Plotting Position

Tr (yrs)	Link: 1
1.05-Year	100.861
1.11-Year	100.950
1.25-Year	101.044
2.00-Year	101.533
3.33-Year	101.775
5-Year	101.996
10-Year	102.336
25-Year	102.520
50-Year	102.845
100-Year	102.905

Postdeveloped Infiltrated Water Statistics

- Volume Statistics Computed for Entire Simulation

Statistic	Link: 1
Total Inflow Volume (ac-ft)	9600.
Total Volume Infiltrated (ac-ft)	0.
Percent Infiltrated	0.00 %

**************Water Quality Facility Data ****************

Node No: 1

Basic Wet Pond Volume (91% Exceedance): 92437. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 138655. cu-ft
2-Year Discharge Rate : 4.469 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
On-line Design Discharge Rate (91% Exceedance): 2.35 cfs
Off-line Design Discharge Rate (91% Exceedance): 1.35 cfs

Computed Flow Splitter Data
Orifice Diameter: 5.00 inches
Baffle Wall Height (WQ Design Depth): 3.93 feet
Baffle Wall (Weir) Length: 3.84 feet (46.1 Inches)
Ratio: WQ Depth/Orifice Diameter: 9.4 (>=2 PASS)

Node No: 2

2-Year Discharge Rate : 0.677 cfs

**************Compliance Point Results ****************

Predeveloped Compliance Node: 1
Postdeveloped Compliance Node: 2

***** Point of Compliance Flow Frequency Data *****

Recurrence Interval Computed Using Gringorten Plotting Position

Predevelopment Runoff		Postdevelopment Runoff	
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	1.304	2-Year	0.677
5-Year	2.073	5-Year	1.114
10-Year	2.560	10-Year	1.587
25-Year	3.332	25-Year	2.212
50-Year	3.844	50-Year	2.464
100-Year	4.520	100-Year	2.585
200-Year	4.587	200-Year	2.599

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance According to Dept. of Ecology Criteria ******

Excursion at Predeveloped ½Q2 (Must be Less Than 0%):		-4.0%	PASS
Maximum Excursion from ½Q2 to Q2 (Must be Less Than 0%):		-1.0%	PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%):		3.6%	PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%):	7.2%	PASS	

*** POND MEETS ALL DURATION DESIGN CRITERIA: PASS**

MGS FLOOD
PROJECT REPORT

Program Version: 3.09 **Run Date: 11/29/2006 8:55 AM**

Input File Name: **UnnamedTrib.fld**
Project Name: Unnamed Channel Basins 010 and 015
Analysis Title: Unnamed Channel Basin 010 and 015
Comments: Rate Control for Unnamed Channel Basins 010, and 015. PreDev and Dev land use. Looked up long. and lat. online. Requires RC and WQ

********** Precipitation Input**********

Extended Precipitation Timeseries Selected
Climatic Region Number: 7
Full Period of Record Available used for Routing
Precipitation Station : 950056 Puget West 56 in MAP 10/01/1939-10/01/2097
Evaporation Station : 951056 Puget West 56 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

********** Watershed Definition **********

Number of Subbasins: 1

********** Subbasin Number: 1 **********

***Tributary to Node: 1
***Bypass to Node : 3

	Area(Acres)		
		Developed	
	Predeveloped	**To Node**	**Bypass Node**
Till Forest	23.880	0.930	3.080
Till Pasture	9.110	0.930	8.390
Till Grass	7.610	8.560	11.110
Outwash Forest	1.500	0.000	0.000
Outwash Pasture	0.000	0.000	0.000
Outwash Grass	0.480	0.640	0.000
Wetland	0.000	0.000	0.000
Impervious	2.710	7.140	4.510
Subbasin Total	45.290	18.200	27.090

*** Subbasin Connection Summary ***

Subbasin 1 ------------> Node 1

*** By-Pass Area Connection Summary ***

Subbasin 1: By-Pass 27.090 Acres to Node 3

*** Postdeveloped Node Connection Summary ***

Upstream Node No.	Link Type	Downstream Node
Node 1	Copy	Node 2

Predeveloped Compliance Node: 1
Postdeveloped Compliance Node: 2

*** Postdeveloped Structure Summary ***

Link No. 1, Copy
Upstream Node : 1, Downstream Node: 2
Copy Upstream to Downstream Node

************Water Quality Facility Data *************

Node No: 1

Basic Wet Pond Volume (91% Exceedance): 76221. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 114331. cu-ft
2-Year Discharge Rate : 3.614 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
On-line Design Discharge Rate (91% Exceedance): 1.71 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.96 cfs

Computed Flow Splitter Data
Orifice Diameter: 4.50 inches
Baffle Wall Height (WQ Design Depth): 3.06 feet
Baffle Wall (Weir) Length: 4.93 feet (59.1 inches)
Ratio: WQ Depth/Orifice Diameter: 8.2 (>=2 PASS)

Node No: 2

Basic Wet Pond Volume (91% Exceedance): 76221. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 114331. cu-ft
2-Year Discharge Rate : 3.614 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
On-line Design Discharge Rate (91% Exceedance): 1.71 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.96 cfs

Computed Flow Splitter Data
Orifice Diameter: 4.50 inches
Baffle Wall Height (WQ Design Depth): 3.06 feet
Baffle Wall (Weir) Length: 4.93 feet (59.1 inches)
Ratio: WQ Depth/Orifice Diameter: 8.2 (>=2 PASS)

Node No: 3

Basic Wet Pond Volume (91% Exceedance): 93300. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 139950. cu-ft
2-Year Discharge Rate : 3.456 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
On-line Design Discharge Rate (91% Exceedance): 1.49 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.84 cfs

Computed Flow Splitter Data
Orifice Diameter: 4.00 inches
Baffle Wall Height (WQ Design Depth): 3.73 feet
Baffle Wall (Weir) Length: 4.25 feet (51.0 inches)
Ratio: WQ Depth/Orifice Diameter: 11.2 (>=2 PASS)

*** Point of Compliance Flow Frequency Data ***

Recurrence Interval Computed Using Gringorten Plotting Position

Predevelopment Runoff		Postdevelopment Runoff	
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	3.316	2-Year	3.614
5-Year	5.310	5-Year	4.820
10-Year	7.166	10-Year	6.029
25-Year	9.064	25-Year	7.817
50-Year	10.762	50-Year	8.914
100-Year	11.474	100-Year	9.285
200-Year	12.192	200-Year	11.020

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

**** Flow Duration Performance According to Dept. of Ecology Criteria ****

Excursion at Predeveloped ½Q2 (Must be Less Than 0%):		-46.0%	PASS
Maximum Excursion from ½Q2 to Q2 (Must be Less Than 0%):		-42.2%	PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%):		-37.1%	PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%):	0.0%	PASS	

*** POND MEETS ALL DURATION DESIGN CRITERIA: PASS**

MGS Flood Analysis - Summary of existing runoff
Allyn 30784
6/29/07 mrc

Basin ID	Peak Runoff from MGS Flood (cfs)		
	2-yr	25-yr	50-yr
10	2.05	3.21	3.54
10, 15	4.74	7.75	8.45
20, 25	11.85	18.04	19.57
30	2.69	4.06	4.38
40, 42 & 45	18.26	27.20	29.41
50	0.56	0.86	0.89
60	1.39	2.19	2.29
70	1.17	1.78	1.82
80	1.39	2.54	2.58

MGS FLOOD
PROJECT REPORT

Program Version: 3.12 **Run Date: 06/27/2007 10:41 AM**

```
Input File Name:       Basin10.fld
Project Name:          Allyn SWMP
Analysis Title:        Existing Conditions
Comments:

                 ********** Precipitation Input**********

Precipitation Station Data Selected
Climatic Region Number: 16
Full Period of Record Available used for Routing
Precipitation Station : 455549        Montesano        10/01/1954-10/01/1999
Evaporation Station   : 456803        Puyallup
At Site 25-Year, 24-Hour Precipitation  (inches): 4.80
Gage 25-Year, 24-Hour Precipitation  (inches)    : 5.46
Precipitation Scale Factor : 0.878
Evaporation Scale Factor   : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name   : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************
```

Subbasin 10

	Area (Acres)		
		Developed	
	Predeveloped	To Node	Bypass Node
Till Forest	16.950	16.950	0.000
Till Pasture	1.330	1.330	0.000
Till Grass	2.400	2.400	0.000
Outwash Forest	0.000	0.000	0.000
Outwash Pasture	0.000	0.000	0.000
Outwash Grass	0.000	0.000	0.000
Wetland	0.000	0.000	0.000
Impervious	1.110	1.110	0.000
Subbasin Total	21.790	21.790	0.000

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

Predevelopment Runoff Tr (Years)	Discharge (cfs)	Postdevelopment Runoff Tr (Years)	Discharge (cfs)
2-Year	2.047	2-Year	2.047
5-Year	2.656	5-Year	2.656
10-Year	3.040	10-Year	3.040
25-Year	3.209	25-Year	3.209
50-Year	3.539	50-Year	3.539
100-Year	**	100-Year	**
200-Year	**	200-Year	**

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

Subbasin 10&15

	Area (Acres)		
		Developed	
	Predeveloped	To Node	Bypass Node
Till Forest	23.880	23.880	0.000
Till Pasture	9.110	9.110	0.000
Till Grass	7.610	7.610	0.000
Outwash Forest	0.340	0.340	0.000
Outwash Pasture	1.160	1.160	0.000
Outwash Grass	0.480	0.480	0.000
Wetland	0.000	0.000	0.000
Impervious	2.710	2.710	0.000
Subbasin Total	45.290	45.290	0.000

*** Point of Compliance Flow Frequency Data ***
Recurrence Interval Computed Using Gringorten Plotting Position

Predevelopment Runoff		Postdevelopment Runoff	
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	4.739	2-Year	4.739
5-Year	6.280	5-Year	6.280
10-Year	7.041	10-Year	7.041
25-Year	7.748	25-Year	7.748
50-Year	8.449	50-Year	8.449
100-Year	**	100-Year	**
200-Year	**	200-Year	**

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

Subbasin 20 & 25

	Area (Acres)		
		Developed	
	Predeveloped	To Node	Bypass Node
Till Forest	39.320	39.320	0.000
Till Pasture	30.380	30.380	0.000
Till Grass	10.910	10.910	0.000
Outwash Forest	0.100	0.100	0.000
Outwash Pasture	0.080	0.080	0.000
Outwash Grass	0.140	0.140	0.000
Wetland	0.000	0.000	0.000
Impervious	12.040	12.040	0.000
Subbasin Total	92.970	92.970	0.000

*** Point of Compliance Flow Frequency Data ***
Recurrence Interval Computed Using Gringorten Plotting Position

Predevelopment Runoff		Postdevelopment Runoff	
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	11.852	2-Year	11.852
5-Year	15.127	5-Year	15.127
10-Year	16.595	10-Year	16.595
25-Year	18.039	25-Year	18.039
50-Year	19.573	50-Year	19.573
100-Year	**	100-Year	**
200-Year	**	200-Year	**

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

Subbasin 30

	Area (Acres)		
		Developed	
	Predeveloped	To Node	Bypass Node
Till Forest	11.040	11.040	0.000
Till Pasture	2.790	2.790	0.000
Till Grass	3.870	3.870	0.000
Outwash Forest	0.000	0.000	0.000
Outwash Pasture	0.000	0.000	0.000
Outwash Grass	0.000	0.000	0.000
Wetland	0.000	0.000	0.000
Impervious	2.760	2.760	0.000
Subbasin Total	20.460	20.460	0.000

*** Point of Compliance Flow Frequency Data ***
Recurrence Interval Computed Using Gringorten Plotting Position

Predevelopment Runoff		Postdevelopment Runoff	
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	2.688	2-Year	2.688
5-Year	3.400	5-Year	3.400
10-Year	3.763	10-Year	3.763
25-Year	4.061	25-Year	4.061
50-Year	4.380	50-Year	4.380
100-Year	**	100-Year	**
200-Year	**	200-Year	**

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

Subbasin 40, 42 & 45

	Area (Acres)		
		Developed	
	Predeveloped	To Node	Bypass Node
Till Forest	27.410	27.410	0.000
Till Pasture	35.420	35.420	0.000
Till Grass	25.420	25.420	0.000
Outwash Forest	1.270	1.270	0.000
Outwash Pasture	0.420	0.420	0.000
Outwash Grass	0.190	0.190	0.000
Wetland	0.380	0.380	0.000
Impervious	22.370	22.370	0.000
Subbasin Total	112.880	112.880	0.000

*** Point of Compliance Flow Frequency Data ***
Recurrence Interval Computed Using Gringorten Plotting Position

Predevelopment Runoff		Postdevelopment Runoff	
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	18.262	2-Year	18.262
5-Year	22.601	5-Year	22.601
10-Year	24.523	10-Year	24.523
25-Year	27.197	25-Year	27.197
50-Year	29.409	50-Year	29.409
100-Year	**	100-Year	**
200-Year	**	200-Year	**

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

Subbasin 50

	Area (Acres)		
		Developed	
	Predeveloped	To Node	Bypass Node
Till Forest	1.460	1.460	0.000
Till Pasture	0.240	0.240	0.000
Till Grass	0.540	0.540	0.000
Outwash Forest	0.040	0.040	0.000
Outwash Pasture	0.290	0.290	0.000
Outwash Grass	0.670	0.670	0.000
Wetland	0.000	0.000	0.000
Impervious	0.740	0.740	0.000
Subbasin Total	3.980	3.980	0.000

*** Point of Compliance Flow Frequency Data ***
Recurrence Interval Computed Using Gringorten Plotting Position

Predevelopment Runoff		Postdevelopment Runoff	
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	0.555	2-Year	0.555
5-Year	0.714	5-Year	0.714
10-Year	0.772	10-Year	0.772
25-Year	0.860	25-Year	0.860
50-Year	0.890	50-Year	0.890
100-Year	**	100-Year	**
200-Year	**	200-Year	**

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

Subbasin 60

	Area (Acres)		
		Developed	
	Predeveloped	To Node	Bypass Node
Till Forest	3.950	3.950	0.000
Till Pasture	1.010	1.010	0.000
Till Grass	1.700	1.700	0.000
Outwash Forest	0.210	0.210	0.000
Outwash Pasture	0.670	0.670	0.000
Outwash Grass	1.460	1.460	0.000
Wetland	0.000	0.000	0.000
Impervious	1.600	1.600	0.000
Subbasin Total	10.600	10.600	0.000

*** Point of Compliance Flow Frequency Data ***
Recurrence Interval Computed Using Gringorten Plotting Position

Predevelopment Runoff		Postdevelopment Runoff	
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	1.389	2-Year	1.389
5-Year	1.809	5-Year	1.809
10-Year	1.966	10-Year	1.966
25-Year	2.192	25-Year	2.192
50-Year	2.290	50-Year	2.290
100-Year	**	100-Year	**
200-Year	**	200-Year	**

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

Subbasin 70

	Area (Acres)		
		Developed	
	Predeveloped	To Node	Bypass Node
Till Forest	2.200	2.200	0.000
Till Pasture	0.060	0.060	0.000
Till Grass	0.290	0.290	0.000
Outwash Forest	2.260	2.260	0.000
Outwash Pasture	1.260	1.260	0.000
Outwash Grass	2.140	2.140	0.000
Wetland	0.000	0.000	0.000
Impervious	2.000	2.000	0.000
Subbasin Total	10.210	10.210	0.000

*** Point of Compliance Flow Frequency Data ***
Recurrence Interval Computed Using Gringorten Plotting Position

Predevelopment Runoff		Postdevelopment Runoff	
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	1.166	2-Year	1.166
5-Year	1.517	5-Year	1.517
10-Year	1.718	10-Year	1.718
25-Year	1.775	25-Year	1.775
50-Year	1.820	50-Year	1.820
100-Year	**	100-Year	**
200-Year	**	200-Year	**

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

Subbasin 80

	Area (Acres)		
		Developed	
	Predeveloped	To Node	Bypass Node
Till Forest	5.560	5.560	0.000
Till Pasture	1.300	1.300	0.000
Till Grass	1.920	1.920	0.000
Outwash Forest	1.750	1.750	0.000
Outwash Pasture	1.420	1.420	0.000
Outwash Grass	2.390	2.390	0.000
Wetland	0.000	0.000	0.000
Impervious	1.030	1.030	0.000
Subbasin Total	15.370	15.370	0.000

*** Point of Compliance Flow Frequency Data ***
Recurrence Interval Computed Using Gringorten Plotting Position

Predevelopment Runoff		Postdevelopment Runoff	
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	1.385	2-Year	1.385
5-Year	2.009	5-Year	2.009
10-Year	2.273	10-Year	2.273
25-Year	2.543	25-Year	2.543
50-Year	2.577	50-Year	2.577
100-Year	**	100-Year	**
200-Year	**	200-Year	**

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

Land Use Data

Existing Landuse - Allyn UGA Monday, 11/20/06

RESULTANT PERLND/TABLE FORMAT

	EE010	EE015	EE020	EE025	EE030	EE040	EE042	EE045	EE050	EE060	EE070	EE080	EE090	EE100	Lakeland \	SE010	SE020	SE030	Totals
Imp	1.11	1.6	8.34	3.7	2.76	7.82	5.16	9.39	0.74	1.6	2	1.03	0.47	9.7	0	5.71	0.52	0	61.65
Till-F	16.95	6.93	38.51	0.81	11.04	8.51	18.47	0.43	1.46	3.95	2.2	5.56	0.19	7.36	0	20.14	8.11	3.78	154.4
Till-P	1.33	7.78	22.73	7.65	2.79	12.51	22.91	0	0.24	1.01	0.06	1.3	0.16	3.65	0	3.46	0.94	0	88.52
Till-G	2.4	5.21	9.78	1.13	3.87	13.82	7.1	4.5	0.54	1.7	0.29	1.92	0.27	7.03	0	6.02	1.58	0	67.16
Out-F	0	0.34	0	0.1	0	0	0.07	1.2	0.04	0.21	2.26	1.75	0.23	6.2	0	6.12	2.51	0	21.03
Out-P	0	1.16	0	0.08	0	0	0.34	0.08	0.29	0.67	1.26	1.42	0.59	4.89	0	1.9	0.57	0	13.25
Out-G	0	0.48	0	0.14	0	0	0	0.19	0.67	1.46	2.14	2.39	1.23	6	0	3.37	0.97	0	19.04
Sat	0	0	0	0	0	0	0.22	0.16	0	0	0	0	0.69	4.36	0	5.43	1.08	1.07	13.01
Water	0	0	0	0	0	0	0	0	0	0	0	0	0	1.75	0	0	0	0	1.75
Totals	21.79	23.50	79.36	13.61	20.46	42.66	54.27	15.95	3.98	10.60	10.21	15.37	3.83	50.94	0.00	52.15	16.28	4.85	439.81

Future Landuse - Allyn UGA Wednesday, 11/22/06

RESULTANT PERLND/TABLE FORMAT

	EF010	EF015	EF020	EF025	EF030	EF035	EF040	EF042	EF045	EF050	EF060	EF070	EF080	EF090	EF100	Lakeland	SF010	SF020	SF030	Total
Imp	4.51	7.14	33.96	12.82	40.02	3.57	39.75	0	0	29.07	0	0	10.24	1.73	32.29	0	17.18	10.15	0	242.43
Till-F	3.08	0.93	1.49	0.64	1.26	0	10.26	0	0	0	0	0	1.27	0	0	0	3.82	1.18	0	23.93
Till-P	3.08	0.93	1.35	0.64	1.26	0	15.88	0	0	0	0	0	2.48	0	0	0	3.97	1.18	0	30.77
Till-G	11.11	8.56	12.31	1.31	7.08	0.4	30.86	0	0	0.72	0	0	4.85	0.31	9.02	0	16.85	5.31	0	108.69
Out-F	0	0	0	0.15	0.03	0	0	0	0	0	0	0	0.8	0	0	0	0	0	0	0.98
Out-P	0	0	0	0.15	0.03	0	0	0	0	0	0	0	0.67	0	0	0	0	0	0	0.85
Out-G	0	0.64	0	0.12	0.02	0	0.12	0	0	0.79	0	0	5.28	1.42	7.12	0	7.12	2.47	0	25.1
Sat	0	0	0	0	0	0	0.06	0	0	0.08	0	0	0	0.37	2.54	0	3.25	0.8	0	7.1
Water	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	21.78	18.20	49.11	15.83	49.70	3.97	96.93	0.00	0.00	30.66	0.00	0.00	25.59	3.83	50.97	0.00	52.19	21.09	0.00	439.85

439.85

PERLND Data for basins requiring rate control.
Predeveloped areas modeled as forest. Data modifications are shown in red.

Sherwood Creek Basin

	North of Creek			
	Existing	Future	Fut-Ex	PreDev
	SE010	SF010	*Difference*	SP010
Imp	5.71	17.18	*11.47*	5.71
Till-F	20.14	3.82	*-16.32*	20.14
Till-P	3.46	3.93	*0.47*	3.46
Till-G	6.02	16.85	*10.83*	6.02
Out-F	6.12	0	*-6.12*	8.02
Out-P	1.9	0	*-1.9*	0
Out-G	3.37	4.94	*1.57*	3.37
Sat	5.43	5.43	*0*	5.43
Water	0	0	*0*	0
Totals	52.15	52.15		52.15

Swapped 0.04 ac Till-P from N to S to make existing and future areas the same.
Swapped 2.18 from Out-G to Sat b/c saturated won't become unsaturated.
Difference with (-) sign shows what needs to be shown as forest in the Pre-Dev.
Moved 1.9 ac from Out-P to Out-F for PreDev.

Sherwood Creek Basin

	South of Creek					
	Existing			Future	Fut-Ex	PreDev
	SE020	SE030	SE Total	SF020	*Difference*	SP010
Imp	0.52	0	0.52	10.15	*9.63*	0.52
Till-F	8.11	3.78	11.89	1.18	*-10.71*	11.89
Till-P	0.94	0	0.94	1.22	*0.28*	0.94
Till-G	1.58	0	1.58	5.31	*3.73*	1.58
Out-F	2.51	0	2.51	0	*-2.51*	3.08
Out-P	0.57	0	0.57	0	*-0.57*	0
Out-G	0.97	0	0.97	1.12	*0.15*	0.97
Sat	1.08	1.07	2.15	2.15	*0*	2.15
Water	0	0	0	0	*0*	0
Totals	16.28	4.85	21.13	21.13		21.13

Swapped 0.04 ac from N to S to make existing and future areas the same.
SF030 is 0.00 ac
Swapped 1.35 from Out-G to Sat b/c saturated won't become unsaturated.
Difference with (-) sign shows what needs to be shown as forest in the Pre-Dev.
Moved 0.57 ac from Out-P to Out-F for PreDev.

Modeled Areas

PERLND Data for basins requiring rate control.
Predeveloped areas modeled as forest. Data modifications are shown in red.

Unnamed Channel Basin

	Existing			Future						Fut-Ex	Pre-Dev.
	EE010	EE015	**Subtotal**	EF010	EF015	Other	Trib - 015	Bypass	**Subtotal**	*Difference*	EP015
Imp	1.11	1.6	2.71	4.51	7.14	0	7.14	4.51	11.65	*8.94*	2.71
Till-F	16.95	6.93	23.88	3.08	0.93	0	0.93	3.08	4.01	*-19.87*	23.88
Till-P	1.33	7.78	9.11	3.08	0.93	5.31	0.93	8.39	9.32	*0.21*	9.11
Till-G	2.4	5.21	7.61	11.11	8.56	0	8.56	11.11	19.67	*12.06*	7.61
Out-F	0	0.34	0.34	0	0	0	0	0	0	*-0.34*	1.50
Out-P	0	1.16	1.16	0	0	0	0	0	0	*-1.16*	0.00
Out-G	0	0.48	0.48	0	0.64	0	0.64	0	0.64	*0.16*	0.48
Sat	0	0	0	0	0	0	0	0	0	*0*	0.00
Water	0	0	0	0	0	0	0	0	0	*0*	0.00
Totals	21.79	23.50	45.29	21.78	18.20	5.31	18.2	27.09	45.29		45.29
Future - Existing					5.31						

Other is the 5.3 acres of existing pasturethat becomes part of EF025
Difference with (-) sign shows what needs to be shown as forest in the Pre-Dev.
Moved 1.16 ac from Out-P to Out-F for PreDev.

Modeled Areas

Proposed New Direct Discharge Outfalls - *Without SR-3 improvements

PERLND data is modified (*in red*) to remove the assumption that SR-3 ROW will be developed to 90% impervious. SR-3 ROW is removed because it is a State highway (not County) and will require enhanced water quality treatment. County roads/ROW in Allyn have low enough traffic volumes that basic water quality treatment is adequate.

Land use was modified in the following manner:

1) Determine the area of SR-3 ROW in each basin with proposed regional WQ treatment
2) Impervious: remove 0.9*SR-3 area and replace with 0.53*SR-3 area (0.53 for 60' ROW)
3) Grass: remove 0.1*SR-3 area and replace with 0.47*SR-3 area (0.47 for 60' ROW)

Replacement percentages are based on 2, 12' lanes with 4' shoulders (32'wide impervious)
The percent impervious is the impervious width divided by ROW width

ROW W(ft)	% Imp.	% grass
60	53%	47%
100	32%	68%
135	24%	76%

Kayak Park Outfall

	EF080	Kayak*	SR-3 Area	1.528065 ac
Imp	10.24	*9.460*	Remove	1.375 ac. Imp
Till-F	1.27	1.27		0.153 ac. Till-G
Till-P	2.48	2.48		
Till-G	4.85	*5.630*	Replace	0.595041 ac. Imp
Out-F	0.8	0.8		0.933023 ac. Till-G
Out-P	0.67	0.67		
Out-G	5.28	5.28		
Sat	0	0		
Water	0	0		
Totals	25.59	25.59		

Tacoma Power Easement Outfall

	EF010	EF020	EF025	Total	Power*	SR-3 Area	3.047521 ac
Imp	4.51	33.96	12.82	51.29	*50.17*	Remove	2.743 ac. Imp
Till-F	3.08	1.49	0.64	5.21	5.21		0.305 ac. Till-G
Till-P	3.08	1.35	0.64	5.07	5.07		
Till-G	11.11	12.31	1.31	24.73	*25.85*	Replace	1.625344 ac. Imp
Out-F	0	0	0.15	0.15	0.15		1.422176 ac. Till-G
Out-P	0	0	0.15	0.15	0.15		
Out-G	0	0	0.12	0.12	0.12		
Sat	0	0	0	0.00	0.00		
Water	0	0	0	0.00	0.00		
Totals	21.78	49.11	15.83	86.72	86.72		

Wade Street Outfall

	EF030	EF035	Total	Wade*
Imp	40.02	3.57	43.59	*42.829*
Till-F	1.26	0	1.26	1.26
Till-P	1.26	0	1.26	1.26
Till-G	7.08	0.4	7.48	*8.241*
Out-F	0.03	0	0.03	0.03
Out-P	0.03	0	0.03	0.03
Out-G	0.02	0	0.02	0.02
Sat	0	0	0.00	0
Water	0	0	0.00	0
Totals	49.70	3.97	53.67	53.67

SR-3 Area	2.076446 ac
Remove	1.869 ac. Imp
	0.208 ac. Till-G
Replace	1.107 ac. Imp
	0.969 ac. Till-G

Evans St. / Lakeland Drive Outfall

	EF040	EF050	Total	Evans*
Imp	39.75	29.07	68.82	*68.38*
Till-F	10.26	0	10.26	10.26
Till-P	15.88	0	15.88	15.88
Till-G	30.86	0.72	31.58	*32.02*
Out-F	0	0	0.00	0
Out-P	0	0	0.00	0
Out-G	0.12	0.79	0.91	0.91
Sat	0.06	0.08	0.14	0.14
Water	0	0	0.00	0
Totals	96.93	30.66	127.59	127.59

SR-3 Area	1.188 ac
Remove	1.069 ac. Imp
	0.119 ac. Till-G
Replace	0.634 ac. Imp
	0.554 ac. Till-G

Shoreline Subbasins

Existing Landuse - Allyn UGA
RESULTANT PERLND/TABLE FORMAT

	EE090	EE100	Totals
Imp	0.47	9.7	10.17
Till-F	0.19	7.36	7.55
Till-P	0.16	3.65	3.81
Till-G	0.27	7.03	7.3
Out-F	0.23	6.2	6.43
Out-P	0.59	4.89	5.48
Out-G	1.23	6	7.23
Sat	0.69	4.36	5.05
Water	0	1.75	1.75
Totals	3.83	50.94	54.77

Sum of Existing Till 18.66

Sum of Ex Outwash 19.14

Future Landuse - Allyn UGA
RESULTANT PERLND/TABLE FORMAT

	EF090	EF100	Total
Imp	1.73	32.29	34.02
Till-F	0	0	0
Till-P	0	0	0
Till-G	0.31	9.02	9.33
Out-F	0	0	0
Out-P	0	0	0
Out-G	1.42	7.12	8.54
Sat	0.37	2.54	2.91
Water	0	0	0
Totals	3.83	50.97	54.80

Sum of Future Till 9.33

Sum of Fut Outwash 8.54

Appendix D—Construction Cost Estimates

Summary of CIP Costs
Prepared by Laura Rupper, 6/28/07

CIP	Location	Cost	% of Total
1	Kayak Park	$ 170,000	7%
2	Evans	$ 830,000	33%
3	Wade	$ 1,020,000	40%
4	Power Easement	$ 510,000	20%
	Total	$ 2,530,000	

K:\project\30700\30784\Data\Cost\AllynFinal_062807Update\Summary.xls

This page is used to estimate the length and size of the system needed to collect and convey stormwater runoff to the proposed outfalls.
Pipe diameters are estimates only. Pipe diameters have NOT been verified with a hydraulic model.

Outfall: The pipe required to convey flow from the west side of SR3 to North Bay
Conveyance Improvements: This includes capacity improvements to existing WSDOT ditches for conveyance of increased flows
This also includes the extention of a conveyance trunk line to the west. The trunk line has structures every 150-ft with stub outs 20' long in each direction for developers to connect.

Outfall				Conveyance Improvements (LF)						
Location	HDPE (LF)	Conc. (LF)	Diam (in)	*Ditch	42-in	36-in	30-in	24-in	18-in	**Structure
Kayak	100	200	18	1450	0	0	0	0	0	2
Evans	100	250	42	1050	150	300	200	200	0	7
Wade	100	450	30	0	0	0	300	780	530	11
Power	100	700	36	3350	0	0	0	0	0	3

*Re-grade Existing Ditch for increased capacity
**Structures required where HDPE connects to Concrete, as needed to cross SR3, and every 150' where conveyance improvements

Evans / Conveyance Improvements:
650 LF trunk line along Lakeland Drive (reduces in size from 42-in to 30-in as it extends west)
200 LF 24-in laterals extending north and south from E Lakeland Drive in 20' lengths
1050 LF ditch improvements along E Wheelwright and E Sellegren Rd

Wade / Conveyance Improvements:
1250 LF trunk line along Wade (reduces in size from 30-in to 18-in as it extends west)
360 LF laterals extending north and south from Wade in 20' lengths (half 24-in, half 18-in diameter)

Preliminary Cost Opinion - CIP #1 New Outfall at Kayak Park

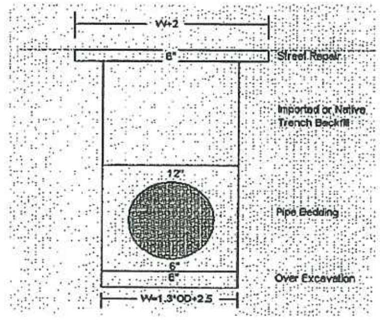
Project No.:30784
Client: Mason County
Date:6/29/2007

Item No.	Plan Quantity	Unit	Item Description	Unit Price	Estimated Cost
			GRADING		
1	135	TON	GRAVEL BORROW	$25	$3,375
2	150	CY	REGRADE EXISTING DITCH	$35	$5,250
			SURFACING		
3	50	TON	ASPHALT TREATED BASE	$145	$7,250
4	25	TON	PAVEMENT, ASPHALT CONCRETE CL B {QTY, <500}	$145	$3,625
			DRAINAGE		
5	100	LF	HDPE 18-INCH I.D. WATER SIDE IN TRENCH	$195	$19,500
6	200	LF	REINF. CONC. PIPE 18-INCH	$65	$13,000
7	1	EA	HDPE PIPE TERMINUS CONC. ANCHOR	$1,000	$1,000
8	2	EA	CATCH BASIN TYPE 2, 48-INCH	$5,000	$10,000
9	3,700	SF	SHORING OR EXTRA EXCAVATION CLASS B	$1.00	$3,700
				SUBTOTAL	$66,700
			EROSION & SEDIMENT CONTROL	5%	$3,335
			TRAFFIC CONTROL	8%	$5,336
			CONTINGENCY AND RIGHT OF WAY ACQUISITIONS (if needed)	30%	$20,010
				SUBTOTAL	$95,381
			MOBILIZATION	10%	$9,538
			CONSTRUCTION SUBTOTAL (Rounded)		$105,000
			STATE SALES TAX	8.3%	$8,715
			ENGINEERING/LEGAL/ADMIN	25%	$26,250
			CONSTRUCTION MANAGEMENT	20%	$21,000
			PERMITTING	5%	$5,250
			PROJECT SUBTOTAL (Rounded)		$166,300
2007 dollars			**TOTAL ESTIMATED PROJECT COST (Rounded)**		**$170,000**

Notes:

1. The order-of-magnitude cost opinion has been prepared for guidance in project evaluation from the information available at the time of preparation and for the assumptions stated. The final costs of the project will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, final project scope and schedule, and other variable factors. As a result, the final project costs will vary from those presented above. Because of these factors, funding needs for individual projects must be scrutinized prior to establishing the final project budgets.

Quantity Calcs
New Outfall at Kayak Park
18-Inch Outfall and ditch conveyance system



Pipe Excavation

	18-IN	36-in	30-in	24-in
pipe dia (ID)	1.5	3.0	2.5	2.0
pipe dia (OD) = 1.2*ID	1.8	3.6	3.0	2.4
trench width pipe = OD + 2'	3.8	5.6	5.0	4.4
street repair width = trench width + 2'	5.8	7.6	7.0	6.4
average depth to pipe invert	4.5	6.0	5.5	4.0
total trench depth	5.7	7.3	6.8	5.2
trench length	300	0	0	0
Pavement Disturance Width	8.2	5.8	5.8	5.8

	area SF	area SF	area SF	area SF	volume CF	volume CY	TON		
trench excavation	21.5	40.9	33.8	22.9	6,441	240			
pipe area (using OD)	2.5	10.2	7.1	4.5				add 10%	USE
pipe bedding	11.9	21.2	17.9	14.8	3,569	140			
trench backfill	5.1	6.7	6.3	1.3	1,539	60	120	132	135
shoring	3390	0	0	0				3,729	3,700

Pavement Repair	18-IN	36-in	30-in	24-in				
Pavement Disturbance Width	8.2	5.8	5.8	5.8				
Trench Length (no repair over HDPE)	200	0	0	0				
	SF	SF	SF	SF	SY		add 10%	USE
Removal	1640	0	0	0	183		201.30	200
	CF	CF	CF	CF	CY	Ton	add 10%	USE
HMA (2" thick)	273	0	0	0	10.12	21	23.10	25
ATB (4" thick)	547	0	0	0	20.25	42	46.20	50

Ditch Re-Grading	Lenth (ft)	Area (sf)	CY	add 10%	USE
(assumes 6" off WP for length of ditch)	1450	2.5	134.26	147.69	150.00

Preliminary Cost Opinion - CIP #2 New Outfall at Evans Street

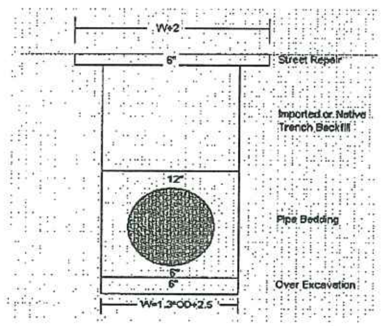
Project No.:30784
Client: Mason County
Date:6/29/2007

Item No.	Plan Quantity	Unit	Item Description	Unit Price	Estimated Cost
			GRADING		
1	550	TON	GRAVEL BORROW	$25	$13,750
2	110	CY	REGRADE EXISTING DITCH	$35	$3,850
			SURFACING		
3	200	TON	ASPHALT TREATED BASE	$145	$29,000
4	100	TON	PAVEMENT, ASPHALT CONCRETE CL B {QTY, <500}	$145	$14,500
			DRAINAGE		
5	100	LF	HDPE 42-INCH I.D. WATER SIDE IN TRENCH	$510	$51,000
6	400	LF	REINF. CONC. PIPE 42-INCH	$170	$68,000
7	300	LF	REINF. CONC. PIPE 36-INCH	$130	$39,000
8	200	LF	REINF. CONC. PIPE 30-INCH	$120	$24,000
9	200	LF	REINF. CONC. PIPE 24-INCH	$85	$17,000
10	1	EA	HDPE PIPE TERMINUS CONC. ANCHOR	$1,000	$1,000
11	3	EA	CATCH BASIN TYPE 2, 72-INCH	$8,000	$24,000
12	4	EA	CATCH BASIN TYPE 2, 60-INCH	$7,000	$28,000
13	18,800	SF	SHORING OR EXTRA EXCAVATION CLASS B	$1.00	$18,800
				SUBTOTAL	$331,900
			EROSION & SEDIMENT CONTROL	5%	$16,595
			TRAFFIC CONTROL	8%	$26,552
			CONTINGENCY AND RIGHT OF WAY ACQUISITIONS (if needed)	30%	$99,570
				SUBTOTAL	$474,617
			MOBILIZATION	10%	$47,462
			CONSTRUCTION SUBTOTAL (Rounded)		$522,100
			STATE SALES TAX	8.3%	$43,334
			ENGINEERING/LEGAL/ADMIN	25%	$130,525
			CONSTRUCTION MANAGEMENT	20%	$104,420
			PERMITTING	5%	$26,105
			PROJECT SUBTOTAL (Rounded)		$826,500
2007 dollars			**TOTAL ESTIMATED PROJECT COST (Rounded)**		**$830,000**

Notes:

1. The order-of-magnitude cost opinion has been prepared for guidance in project evaluation from the information available at the time of preparation and for the assumptions stated. The final costs of the project will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, final project scope and schedule, and other variable factors. As a result, the final project costs will vary from those presented above. Because of these factors, funding needs for individual projects must be scrutinized prior to establishing the final project budgets.

Quantity Calcs
New Outfall at Evans Street
42-Inch Outfall and trunk line conveyance system



Pipe Excavation

	42-in	36-in	30-in	24-in
pipe dia (ID)	3.5	3.0	2.5	2.0
pipe dia (OD) = 1.2*ID	4.2	3.6	3.0	2.4
trench width pipe = OD + 2'	6.2	5.6	5.0	4.4
street repair width = trench width + 2'	8.2	7.6	7.0	6.4
average depth to pipe invert	6.5	6.0	5.5	4.0
total trench depth	7.9	7.3	6.8	5.2
trench length	500	300	200	200
Pavement Disturance Width	8.2	5.8	5.8	5.8

	area SF	area SF	area SF	area SF	volume CF	volume CY	TON		
trench excavation	48.7	40.9	33.8	22.9	47,925	1,780			
pipe area (using OD)	13.8	10.2	7.1	4.5				add 10%	USE
pipe bedding	24.6	21.2	17.9	14.8	25,207	940			
trench backfill	7.1	6.7	6.3	1.3	7,095	270	500	550	550
shoring	7850	4380	2700	2080				18,711	18,800

Pavement Repair	42-in	36-in	30-in	24-in				
Pavement Disturbance Width	8.2	5.8	5.8	5.8				
Trench Length (no repair over HDPE)	400	300	200	200				
	SF	SF	SF	SF	SY		add 10%	USE
Removal	3280	1740	1160	1160	816		897.60	900
	CF	CF	CF	CF	CY	Ton	add 10%	USE
HMA (2" thick)	547	290	193	193	45.31	93	102.30	100
ATB (4" thick)	1093	580	387	387	90.62	186	204.60	200

Ditch Re-Grading	Lenth (ft)	Area (sf)	CY	add 10%	USE
(assumes 6" off WP for length of ditch)	1050	2.5	97.22	106.94	110.00

K:\project\30700\30784\Data\Cost\AllynFinal_062807Update\Evans-CIP2.xls, Outfall Calc

Preliminary Cost Opinion - CIP #3 New Outfall at Wade Street

Project No.:30784
Client: Mason County
Date:6/29/2007

Item No.	Plan Quantity	Unit	Item Description	Unit Price	Estimated Cost
			GRADING		
1	700	TON	GRAVEL BORROW	$25	$17,500
			SURFACING		
2	340	TON	ASPHALT TREATED BASE	$145	$49,300
3	170	TON	PAVEMENT, ASPHALT CONCRETE CL B {QTY, <500}	$145	$24,650
			DRAINAGE		
4	100	LF	HDPE 30-INCH I.D. WATER SIDE IN TRENCH	$360	$36,000
5	750	LF	REINF. CONC. PIPE 30-INCH	$120	$90,000
6	780	LF	REINF. CONC. PIPE 24-INCH	$85	$66,300
7	530	LF	REINF. CONC. PIPE 18-INCH	$65	$34,450
8	1	EA	HDPE PIPE TERMINUS CONC. ANCHOR	$1,000	$1,000
9	5	EA	CATCH BASIN TYPE 2, 54-INCH	$6,000	$30,000
10	6	EA	CATCH BASIN TYPE 2, 48-INCH	$5,000	$30,000
11	28,150	SF	SHORING OR EXTRA EXCAVATION CLASS B	$1.00	$28,150
				SUBTOTAL	$407,350
			EROSION & SEDIMENT CONTROL	5%	$20,368
			TRAFFIC CONTROL	8%	$32,588
			CONTINGENCY AND RIGHT OF WAY ACQUISITIONS (if needed)	30%	$122,205
				SUBTOTAL	$582,511
			MOBILIZATION	10%	$58,251
			CONSTRUCTION SUBTOTAL (Rounded)		$640,800
			STATE SALES TAX	8.3%	$53,186
			ENGINEERING/LEGAL/ADMIN	25%	$160,200
			CONSTRUCTION MANAGEMENT	20%	$128,160
			PERMITTING	5%	$32,040
			PROJECT SUBTOTAL (Rounded)		$1,014,400
2007 dollars			**TOTAL ESTIMATED PROJECT COST (Rounded)**		**$1,020,000**

Notes:

1. The order-of-magnitude cost opinion has been prepared for guidance in project evaluation from the information available at the time of preparation and for the assumptions stated. The final costs of the project will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, final project scope and schedule, and other variable factors. As a result, the final project costs will vary from those presented above. Because of these factors, funding needs for individual projects must be scrutinized prior to establishing the final project budgets.

Preliminary Cost Opinion - CIP #4 New Outfall at the Tacoma Power Easement

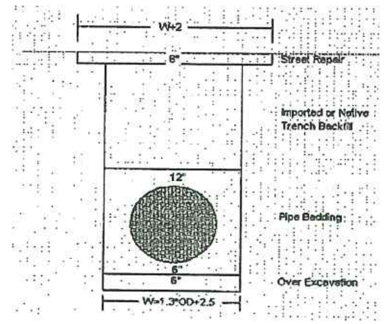
Project No.:30784
Client: Mason County
Date:6/29/2007

Item No.	Plan Quantity	Unit	Item Description	Unit Price	Estimated Cost
			GRADING		
1	410	TON	GRAVEL BORROW	$25	$10,250
2	350	CY	REGRADE EXISTING DITCH	$35	$12,250
			SURFACING		
3	120	TON	ASPHALT TREATED BASE	$145	$17,400
4	60	TON	PAVEMENT, ASPHALT CONCRETE CL B {QTY, <500}	$145	$8,700
			DRAINAGE		
5	100	LF	HDPE 36-INCH I.D. WATER SIDE IN TRENCH	$390	$39,000
6	700	LF	REINF. CONC. PIPE 36-INCH	$130	$91,000
7	1	EA	HDPE PIPE TERMINUS CONC. ANCHOR	$1,000	$1,000
8	3	EA	CATCH BASIN TYPE 2, 60-INCH	$7,000	$21,000
9	1,300	SF	SHORING OR EXTRA EXCAVATION CLASS B	$1.00	$1,300
				SUBTOTAL	$201,900
			EROSION & SEDIMENT CONTROL	5%	$10,095
			TRAFFIC CONTROL	8%	$16,152
			CONTINGENCY AND RIGHT OF WAY ACQUISITIONS (if needed)	30%	$60,570
				SUBTOTAL	$288,717
			MOBILIZATION	10%	$28,872
			CONSTRUCTION SUBTOTAL (Rounded)		$317,600
			STATE SALES TAX	8.3%	$26,361
			ENGINEERING/LEGAL/ADMIN	25%	$79,400
			CONSTRUCTION MANAGEMENT	20%	$63,520
			PERMITTING	5%	$15,880
			PROJECT SUBTOTAL (Rounded)		$502,800
2007 dollars			**TOTAL ESTIMATED PROJECT COST (Rounded)**		**$510,000**

Notes:

1. The order-of-magnitude cost opinion has been prepared for guidance in project evaluation from the information available at the time of preparation and for the assumptions stated. The final costs of the project will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, final project scope and schedule, and other variable factors. As a result, the final project costs will vary from those presented above. Because of these factors, funding needs for individual projects must be scrutinized prior to establishing the final project budgets.

Quantity Calcs
New Outfall at Tacoma Power Easement
36-Inch Outfall and trunk line conveyance system



<u>Pipe Excavation</u>

	42-in	36-in	30-in	24-in
pipe dia (ID)	3.5	3.0	2.5	2.0
pipe dia (OD) = 1.2*ID	4.2	3.6	3.0	2.4
trench width pipe = OD + 2'	6.2	5.6	5.0	4.4
street repair width = trench width + 2'	8.2	7.6	7.0	6.4
average depth to pipe invert	6.5	6.0	5.5	4.0
total trench depth	7.9	7.3	6.8	5.2
trench length	0	800	0	0
Pavement Disturance Width	8.2	5.8	5.8	5.8

	area SF	area SF	area SF	area SF	volume CF	volume CY	TON		
trench excavation	48.7	40.9	33.8	22.9	32,704	1,220			
pipe area (using OD)	13.8	10.2	7.1	4.5				add 10%	USE
pipe bedding	24.6	21.2	17.9	14.8	16,949	630			
trench backfill	7.1	6.7	6.3	1.3	5,376	200	370	407	410
shoring	0	11680	0	0				12,848	1,300

Pavement Repair	42-in	36-in	30-in	24-in				
Pavement Disturbance Width	8.2	5.8	5.8	5.8				
Trench Length (no repair over HDPE)	0	700	0	0				
	SF	SF	SF	SF	SY		add 10%	USE
Removal	0	4060	0	0	452		497.20	500
	CF	CF	CF	CF	CY	Ton	add 10%	USE
HMA (2" thick)	0	677	0	0	25.06	52	57.20	60
ATB (4" thick)	0	1353	0	0	50.12	103	113.30	120

Ditch Re-Grading	Lenth (ft)	Area (sf)	CY	add 10%	USE
(assumes 6" off WP for length of ditch)	3350	2.5	310.19	341.20	350.00

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