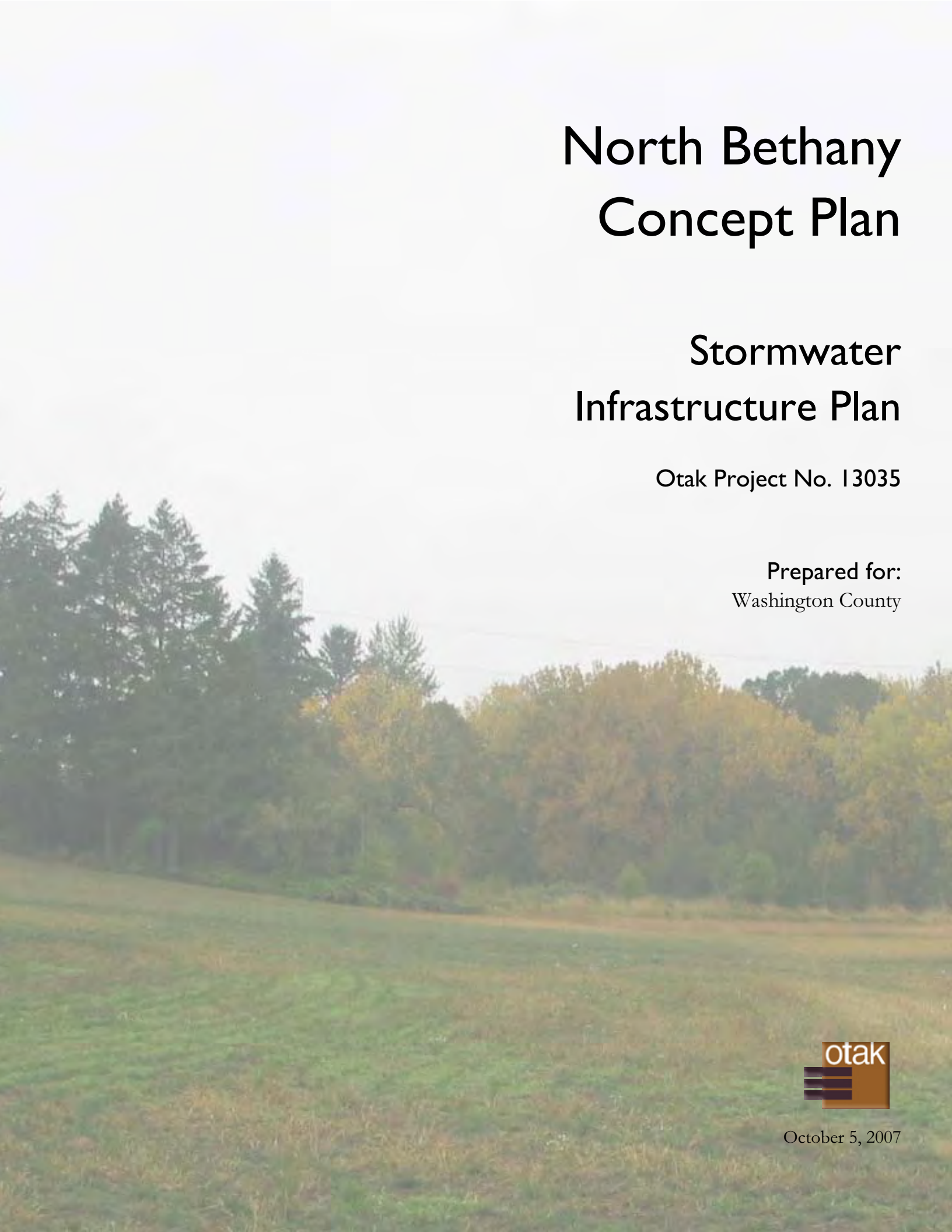

North Bethany Concept Plan

Stormwater Infrastructure Plan

Otak Project No. 13035

Prepared for:
Washington County

otak

October 5, 2007

Acknowledgements

North Bethany Concept Plan

Stormwater Infrastructure Plan

Otak Project No. 13035

Prepared for:
Washington County

Prepared by:
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Project Manager

Kevin Timmins, P.E.
Stormwater Engineer

Terry Soltz, E.I.
Stormwater Designer

Otak, Inc.
17355 SW Boones Ferry Road
Lake Oswego, OR 97035

October 5, 2007

North Bethany Concept Plan
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North Bethany Concept Plan
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Continued

Attachments

Tables

Introduction

Otak has completed the Stormwater Infrastructure Plan (SWIP) for the North Bethany Concept Plan Area. The SWIP addresses the strategies presented in the "*Infrastructure Availability - Stormwater and Water Quality Existing Conditions and Needs*" memorandum prepared by Otak last fall, and subsequent discussions with the project design team. The purpose of the infrastructure plan is to:

- Describe the stormwater management strategy for North Bethany.
- Show how the strategy would be applied to the concept plan.
- Provide a cost estimate for the stormwater management infrastructure.
- Provide recommendations for implementation.
- Provide recommendations for maintenance.
- Document supporting calculations.

The SWIP is based on the version of the North Bethany Concept Plan presented in Attachment A. This version of the Concept Plan is not expected to match the final Plan. The SWIP may need to be updated once the final Concept Plan has been adopted.

Stormwater Management Strategy

The project Stakeholders endorsed the following goal for the North Bethany Concept Plan Area:

> "INTEGRATION WITH URBAN AND NATURAL AREAS - A variety of parks, protected open spaces, and water quality facilities will result in a designed and coordinated system that is integrated with the urban fabric."

The Stormwater Management Strategy describes the recommended stormwater management tools to be applied within the North Bethany Concept Plan Area to help achieve this goal and make North Bethany a Community of Distinction.

Stormwater management infrastructure is needed to protect the water quality of downstream natural resource areas and to protect the built environment from flood damage during large storm events. The recommended Stormwater Management Strategy takes a comprehensive approach to incorporating stormwater management into the landscape of North Bethany. The SWIP makes use of existing site topography, natural systems, and site design to efficiently and effectively manage stormwater quantity and quality.

The Stormwater Management Strategy can best be described as it is applied at three different scales: Site, Street, and Regional. Site scale refers to the buildable land shown in the Concept Plan that is expected to develop into residential, civic, and mixed uses. Street scale refers to the public street rights-of-way. Regional refers to a stormwater management facility located downstream of site scale and street scale facilities prior to stormwater discharge to a natural receiving water body.

Site

Best management practices (BMPs) would be used to reduce the transport of pollutants from North Bethany Concept Plan Area. Source control measures that reduce or eliminate the possibility of stormwater contact with pollutants are the best BMP.

Low-impact development applications (LIDA) such as rain gardens, vegetated swales, eco-roofs, and pervious surface treatments, etc., can be engineered to manage stormwater runoff water quality and reduce the quantity (flow and volume) by encouraging retention/infiltration. Photographs of examples are shown in Table 1.1.

Low Impact Development Applications (LIDA) would be required throughout North Bethany to manage site runoff from each lot. The LIDA should be sized per *Clean Water Services Design and Construction Standards* and designed to manage site runoff from all impervious surfaces generated by the water quality event. Each lot would behave as if there

is zero effective impervious area. LIDA should be designed with an overflow that directs larger storm flows to a safe location, such as an open space area, the street gutter, or some other engineered stormwater conveyance feature.

Table 1.1: Examples of Site Scale LIDA

Eco-roof

Rain Garden

Flow-Through Planter

The illustrations provided in Attachment B suggest ideas for how LIDA might be applied, but would need to be designed when the site is developed and the appropriate combination of LIDA are applied to the specific site.

Street

Streets are a major source of urban stormwater pollution. LIDA would be required throughout North Bethany to manage runoff from the street rights-of-way. The LIDA should be sized per *Clean Water Services Design and Construction Standards* and designed to manage street runoff from all impervious surfaces generated by the water quality event.

LIDA stormwater facilities can be located within the sidewalk furnishing zone, a planter strip, or in a curb extension. LIDA facility types would include a vegetated swale, street swale, infiltration planter, or flow-through planter adjacent to the street with curb cuts that allow runoff to pass through the curb into the LIDA facility. Photographs of examples are shown in Table 1.2.

Table 1.2: Examples of LIDA in the Street

Planter Box

Curb Extension

Vegetated Swale

The public rights-of-way would also operate as a collection and conveyance system to transport stormwater from both streets and adjacent sites to a downstream destination. The conveyance facilities need to be capable of managing large storm events that exceed the capacity of the LIDAs and route them to a safe location for discharge to the natural drainage system.

The conveyance system would be a combination of street gutters, pipes, culverts and open channels. The use of street gutters and open channel conveyances should be maximized.

Selected streets throughout the community are designated for incorporation of a vegetated open channel conveyance. The selected streets provide connectivity between neighborhoods, parks, and open space areas. The vegetated open channel conveyance is a unique feature that would highlight these key pedestrian routes and enhance the pedestrian experience.

Washington County should adopt specific street standards for North Bethany that include LIDA for stormwater management. It is recommended that the standards include:

- Vegetated infiltration basins located in curb extensions and/or planter strips for streets through the low density residential areas.
- Infiltration or flow-through style planter boxes between the curb and the sidewalk for mixed-use/commercial/high density residential areas, and
- Vegetated swales on the streets that are selected for open channel conveyance.

Recommendations for street standards are illustrated in Attachment E.

Regional

Regional stormwater facilities manage runoff from larger storms that overwhelm LIDAs used on the sites and in the streets. In some locations they would be designed for stormwater detention. In all instances they would be designed to provide backup water quality treatment of LIDA facilities that become damaged or are not well maintained over the long-term. Regional stormwater facilities are the last line of defense before stormwater is discharged to a natural drainage system.

Design of the regional stormwater facilities should be integrated with the urban and natural areas to provide additional habitat value or public open space for recreation. Photograph examples of integrated facilities are shown in Table 1.3.

Table 1.3: Examples of Multi-functional Regional Stormwater Facilities

		
Stormwater Wetland	Terraced outdoor seating	Water Feature along a Trail

It is envisioned that many of the regional stormwater facilities in North Bethany would be designed as linear features that are integrated with the natural stream corridors. The linear facilities would be located adjacent to the vegetated corridors, and be parallel to the stream and/or a regional trail. Illustrations of this type of integration between natural open space, stormwater infrastructure, and recreational facilities are provided in Attachment H.

It could be difficult to ensure long-term operation of the site LIDA, since they will be privately owned and maintained. All regional facilities should be sized to provide backup water quality treatment for the long-term failure of private LIDA due to damage or lack of maintenance. An assumed 50 percent rate of failure is recommended for sizing regional facilities. The water quality event should be calculated per *Clean Water Services Design and Construction Standards*.

A downstream analysis is required by *Clean Water Services Design and Construction Standards* to determine when stormwater detention should be constructed to regulate stormwater flow rates to the downstream drainage system. A partial downstream analysis was performed as part of this SWIP to estimate which Regional stormwater facilities would be required to provide stormwater detention in addition to backup water quality. Explanation of the partial downstream analysis is provided later in the Stormwater Calculations section of this memorandum, but the results suggest that Regional Stormwater Facilities discharging to Bethany Creek tributaries should be sized for detention. The conceptual design of a linear Regional Stormwater Facility sized for detention is illustrated in Attachment F.

Regional facilities sized for detention should be sized per *Clean Water Services Design and Construction Standards*. Currently, the standards require that the 2, 10, and 25-year post-development runoff rates will not exceed there respective 2, 10, and 25-year pre-development runoff rates.

Section 2—Stormwater Concept Plan & Infrastructure Costs

The Stormwater Concept Plan represents the application of the recommended stormwater management strategy to the current version of the North Bethany Concept Plan. The Stormwater Concept Plan offers a schematic representation of the recommended stormwater system in North Bethany and is used to document assumptions made about the Stormwater Infrastructure Cost Estimate. Additional assumptions and calculations performed to determine facility sizes are presented later in the Stormwater Calculations section of this memorandum.

The North Bethany Concept Plan continues to be refined and is expected to change. Attachment A shows the version of the Concept Plan that was used as a basis for developing this Stormwater Concept Plan.

Site

LIDA facilities applied at the site scale are not illustrated in the Stormwater Concept Plan and are not included in the Stormwater Cost Estimate. It is expected that Site Scale LIDA would be included in future individual development plans and be part of the cost of developing individual sites. This plan assumes storm management will occur on an individual site basis as previously described in the Stormwater Management Strategy.

Street

Street LIDA facilities were sized on the basis that the treatment area be equivalent to 9 percent of the impervious area treated. For local streets, each facility will treat about 5000 square feet, roughly 20 feet of paved width (half street) at 250 foot intervals. This results in a facility size of 450 square feet located on each side of the street. The application of Street LIDA is illustrated in Attachment C. The yellow circles were spaced approximately 200 – 300 feet apart. They represent the use of curb extensions or planter boxes to treat runoff from the rights-of-way. Streets identified for open channel conveyance are assumed to be designed so that the open conveyance facility will also provide treatment of runoff from the adjacent right-of-way.

Conveyance of stormwater runoff around the Concept Plan Area was assumed to follow closely with the street, trails, and public rights-of-way system. It was estimated that standard gutters can safely convey runoff generated by a 25-year storm from half the street for approximately 1,000 feet of roadway. However, a standard inlet would not receive this much water. It was assumed that gutter conveyance could be continuous for up to 1,000 feet if it discharges to an open conveyance feature. If the conveyance path to an open conveyance feature is greater than 1,000 feet, a piped conveyance was assumed to be necessary. Gutter flow was limited to approximately 300 feet if it discharges to a piped conveyance, and inlets were assumed to be necessary every 250 - 300 feet.

Conveyance of stormwater through the North Bethany area is illustrated in Attachment C. Much of the site runoff can be conveyed without the use of pipes. Stormwater runoff is conveyed to one of several regional swales or ponds.

Costs associated with stormwater management for Arterial and Collector roads are already included in the transportation infrastructure cost estimate. Therefore, the Stormwater Infrastructure Cost Estimate only includes stormwater infrastructure costs for the following elements in the street:

- LIDA on Local Streets
- Piped conveyance on local streets
- Other public conveyance elements, such as those along trails, parks, or open space areas.

Regional

The need for regional stormwater facilities varies between drainage basins. The need was determined based on preliminary downstream analysis presented later in the stormwater calculations.

The Northern portions of the North Bethany area that drain to Abbey Creek or directly to Rock Creek are assumed to not require detention facilities for flow control. The southern portion of the North Bethany area needs to provide detention to mitigate flows to Bethany Creek. The location of recommended regional stormwater facilities and the associated tributary drainage areas is illustrated in Attachment D.

Costs for Regional Stormwater Facilities were determined according to estimates for facility size (footprint and volume). Assumptions and calculations used to estimate facility sizes are presented later in the Stormwater Calculations section of this memorandum. The following standard assumptions were made about the geometry of the regional stormwater management facilities.

- Facility side slopes were assumed to be 4H:1V.
- Regional stormwater facilities for water quality were assumed to require 110 percent of the facility footprint to construct. Excavation volume estimates assumed a depth of 2.25 feet, accounting for a 1.25 foot swale depth and one foot of amended soil.
- Regional stormwater facilities (linear type) for detention were assumed to require an excavation volume based upon three feet of storage depth plus an additional one foot for freeboard. The footprints were assumed to be 110 percent of top surface area.

- Regional stormwater facilities (pond type) for detention were assumed to require an excavation volume based upon four feet of storage depth plus an additional one foot for freeboard. The footprints were assumed to be 110 percent of top surface area.
- Costs for inlet/outlet pipes, manholes, inlets, flow splitters, and flow control devices were based on recent bid tabulations for projects in the area.

Estimated Cost

The total estimated cost for Stormwater Infrastructure at North Bethany is summarized in Table 2.1.

Table 2.1: Stormwater Infrastructure Cost Summary	
Construction	$14,800,000
Engineering/Permitting	$7,400,000
Land Acquisition	$7,500,000
Total	**$29,700,000**

A detailed breakdown of the Stormwater Infrastructure Cost Estimate is provided in Attachment D.

Implementation

It is recommended that the portion of North Bethany that is constructed first be considered a test project and be evaluated to inform implementation of the stormwater management strategy in the rest of the area.

Since there are three companies with development rights to the land anticipated to develop most of the North Bethany area, it is recommended that Clean Water Services work with the developers to design regional stormwater management facilities and that the developers' construct the facilities as needed.

LIDA constructed on private lots should be recorded with the property title so they can be kept track of over time and required to be maintained as LIDA.

Maintenance

Operation and maintenance procedures should be required and documented for all stormwater management facilities.

The maintenance of LIDA on private lots would be the responsibility of the property owner. Washington County and Clean Water Services should develop a mechanism to ensure that new property owners are notified of proper operation and maintenance procedures for LIDA when property changes ownership. Washington County could require that operation and maintenance procedures are also recorded with the property title.

There should be active public education efforts in North Bethany to teach property owners about the function of LIDA, how it works, and how to maintain it. Property owners should be educated about the types of vegetation that work well and the types that do not work well.

LIDA in the street rights-of-way will be the responsibility of the local jurisdiction. Washington County and Clean Water Services should develop a plan for maintenance of the Street LIDA.

Maintenance of regional stormwater facilities will be the responsibility of Clean Water Services.

Section 3—Stormwater Calculations

There is a strong correlation between impervious area and stormwater runoff. The first step towards sizing water quality facilities and estimating site runoff is to estimate the amount of impervious area associated with the various types of development planned for the North Bethany Concept Plan area. Actual imperviousness will vary throughout North Bethany and will need to be recalculated as development occurs. Assumptions about impervious area used for the SWIP are documented in this section of the memorandum.

Several calculations were then made as part of developing the SWIP and cost estimate as documented in this section of the memorandum. The calculations include:

- A partial downstream analysis
- Sizing of Regional Stormwater Facility for Water Quality
- Sizing of Regional Stormwater Facility for Stormwater Detention

Impervious Area

At the concept planning stage, there are three types of residential land uses being mapped for the North Bethany community: low-density, high-density, and mixed-use with commercial. Actual housing densities have yet to be determined, but one set of values that would achieve the goal of 5,000 dwelling units in the allotted space is 10, 25, and 38 units per acre for low-density, high-density, and mixed-use, respectively. These values do not include street rights-of-way (ROW), but could include alleys. Non-residential land uses identified include parks, civic uses, and other open space areas.

After likely densities were determined for the various development zones in the project area, two sources were consulted to determine appropriate assumptions for percent impervious area relative to development densities. The multiple sources include:

- An impervious area study from Clackamas County
- Measurements for existing North Bethany neighborhoods based on aerial photography

Clackamas County Water and Environment Services (WES) published a study of impervious surfaces as part of the Damascus area UGB expansion. The WES study analyzed the impervious area percentages of a number of neighborhoods representative of current and future development in the Damascus area. Three of the neighborhoods studied are in a range similar to the 10 unit/acre figure assumed for North Bethany low-density residential zones, with densities ranging from 9.6 to 14.8 units/acre. These neighborhoods have a total average density of 10.9 units/acre and are 54 percent impervious. Only one neighborhood in the study had a density in the range of the 25 units/acre assumed for high-density residential zones, with a density of 25.5 units/acre and 62 percent impervious. Two neighborhoods in the study seem to correspond to the mixed use designation, although with much lower residential density than identified for North Bethany. These had an average density of 13.6

units/acre and 62 percent impervious area. Three areas were designated as schools, with an average of 31 percent impervious area.

For a reasonable local comparison, several blocks of homes in the existing Bethany neighborhood were analyzed using aerial photographs. One group of blocks had a density of 7 units/acre and 54 percent impervious area, while another had a density of 14.9 units/acre and 60 percent impervious area. The combined average was 9.6 units/acre with 56 percent impervious area. It was difficult to discern areas of higher density with sufficient precision.

A summary of the findings is presented in Table 3.1.

Table 3.1: Summary of Impervious Area Reference Calculations

Reference Source	Description	Density (units/acre)	Impervious Area (%)
Clackamas County WES	Low Density Residential	10.9	54
	High Density Residential	25.5	62
	Schools	N/A	31
	Mixed-Use	13.6	62
North Bethany Neighborhood	LD Residential	9.6	56

The complete list of land-use categories considered as part of the Concept Plan is shown in Table 3.2 alongside the actual percent impervious area assumed for stormwater calculations in support of this SWIP.

Table 3.2: Impervious Percentage by Land Use	
Land Use	Impervious Percentage
Parks	0
Open Space	0
Committed*	5
Civic/Schools	35
Residential – Low Density	50
Residential – High Density	65
Mixed Use/Commercial	80
Rights-of-way (Local Street)	72
Rights-of-way (Collector Street)	67.5
Rights-of-way (Arterial Street)	67.5
*There are several existing large parcels with estate homes on them that were assumed to remain and were identified as committed lands.	

Downstream Analysis

Stormwater from the North Bethany development area drains to four primary locations: two unnamed tributaries of Abbey Creek (referred to in this memorandum as east and west), a tributary of Bethany Creek, and directly to Rock Creek.

A partial downstream analysis was completed to determine which portions of the North Bethany Concept Plan Area are likely to require stormwater management to mitigate potential impacts to downstream drainages. The downstream analysis was limited to a comparison of predicted peak flow contributions from the North Bethany Area to existing peak flows in the receiving streams. Based upon the results of this comparison, additional evaluation of the Abbey Creek and Bethany Creek drainages downstream of the North Bethany Concept Plan area will need to be completed before development approval.

While Clean Water Services *Design and Construction Standards* encourages improvements to downstream conveyance capacity over the use of stormwater detention facilities, there was not sufficient analysis completed at the Concept Planning stage to determine downstream conveyance improvements. Instead, detention storage was assumed to be part of the solution and included in the infrastructure cost estimate. This assumption is expected to be tested in the future and may lead to a different solution.

Existing stream flows were estimated using drainage basin areas and peak stream flow data available in the Clean Water Services GIS data from the Watersheds 2000 study, as predicted

using HEC-HMS. Runoff rates for proposed conditions were estimated using the Santa Barbara Urban Hydrograph (SBUH) method. The differences in computed peak flows between existing and proposed conditions for each drainage basin were compared to peak flows listed for the closest node in the Clean Water Services GIS data set. Results of the partial downstream analysis are summarized in Table 3.3.

Table 3.3: 25-year Peak Flow Increase from North Bethany Relative to 25-year Peak Flow in Downstream Channels

Basin	Calculated Increase in 25-year peak flow (cfs)	Peak Flow in Downstream Channel (cfs)	Contribution to Stream (%)
Abbey Creek East	37	445	8
Abbey Creek West	87	485	18
Rock Creek	41	1314	3
Bethany Creek	104	149	70

Since peak flow contributions to Rock Creek are expected to be less than 5 percent of flows in Rock Creek, a visual downstream analysis would be necessary during development review. It was assumed that stormwater detention would not be required for portions of North Bethany draining directly to Rock Creek.

Since peak flow contributions to Abbey Creek (8 percent & 18 percent) are close to and slightly greater than 10 percent of peak flows in Abbey Creek that would trigger a more detailed downstream analysis, the downstream system should be modeled prior to development approval to assess potential downstream impacts. However, it was assumed that any downstream flow obstructions could be corrected in lieu of detention facilities based on the lack of development along Abbey Creek all the way to Rock Creek and the wide floodplain on Abbey Creek. The use of LIDA should minimize impacts to the Abbey Creek drainages during smaller, more frequent storms.

Peak flow contributions to Bethany Creek from the North Bethany Concept Plan area are shown to be significant if not mitigated. A detailed model of the downstream system should be completed to assess actual downstream impacts prior to development approval. It may be possible to demonstrate with a detailed downstream analysis that detention may not be necessary. However, as part of the SWIP it was assumed that regional stormwater facilities would be necessary for portions of the North Bethany Concept Plan Area that drain to Bethany Creek.

Regional Stormwater Facility for Water Quality

This SWIP calls for the treatment of site runoff to be handled using LIDA. It is expected, however, that a certain number of these residential facilities will eventually under perform or fail due to poor maintenance. Therefore, the SWIP includes regional treatment facilities to account for this future drop in efficiency.

For design purposes, the North Bethany development area was divided into 25 drainage basins, based on likely flow paths and potential facility sites. Treatment-only swales were designed for those basins not requiring detention and sized based on estimated impervious area in each basin. Only impervious areas outside of street rights-of-way (ROW) were considered, as it is assumed that street facilities will be properly maintained.

The impervious areas in each basin were summed and a water quality flow (WQF) determined according to the Clean Water Services water quality design storm of 0.36 inches over four hours. If a 50 percent potential drop in LIDA treatment efficiency is assumed, the regional facilities would need to treat 50 percent of the non-ROW impervious area in each basin, so one-half of the calculated WQF was used for sizing purposes.

Regional Stormwater Facility for Stormwater Detention

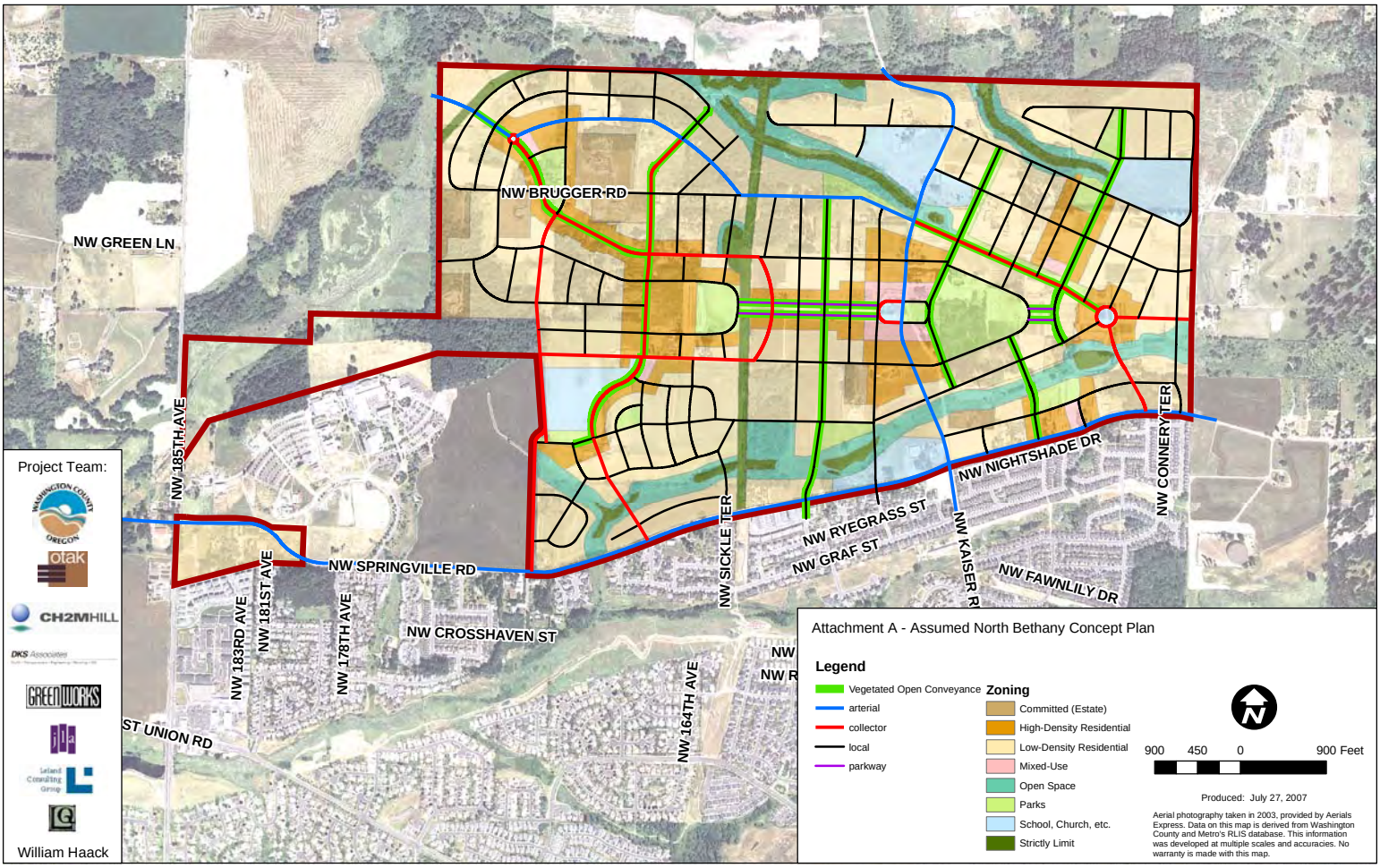
Regional Stormwater Facilities for drainage basins 6 and 15 were assumed to take the shape of a pond. For the remaining basins requiring detention, linear stormwater facilities incorporated into the drainage corridor along Bethany Creek were assumed. For these facilities, detention storage (not water quality) is the driving criteria. Sizing was based on matching peak flows for 2-, 10-, and 25-year recurrence interval storms under proposed conditions to those under existing conditions. Hydraflow Hydrographs 2004 software was used to estimate peak flows and required pond volumes in accordance with Santa Barbara Urban Hydrograph (SBUH) methodology. Hydrologic curve numbers (CN) of pervious areas were assumed to be 76 for existing conditions and 79 for proposed conditions, while impervious areas have a CN of 98. Table 3.4 summarizes area, time of concentration (TOC), and 2-, 10-, and 25-year peak flows for each basin under existing conditions. Table 3.5 summarizes impervious area, time of concentration, 25-year peak flow and estimated required storage volume for each drainage basin.

Table 3.4: Summary of Existing Condition Parameters					
Basin	Area (ac)	TOC (min)	2-yr Peak (cfs)	10-yr Peak (cfs)	25-yr Peak (cfs)
6	75.16	29.6	5.3	13.7	18.3
15	16.26	25.8	1.2	3.1	4.2
16	28.22	34.7	1.9	4.8	6.4
17	14.19	17.9	1.2	3.1	4.2
18	12.18	15.6	1.1	2.8	3.7
19	25.50	25.0	1.9	5.0	6.7
20	40.24	20.7	3.3	8.5	11.3
21	21.40	23.4	1.7	4.3	5.7
22	13.26	22.8	1.0	2.7	3.6
23	9.20	20.8	0.8	2.0	2.6
24	11.04	17.1	1.0	2.5	3.3
25	21.40	25.1	1.6	4.2	5.6

Table 3.5: Summary of Proposed Condition Parameters						
Basin	Impervious Area (ac)	Impervious TOC (min)	Pervious Area (ac)	Pervious TOC (min)	25-year peak flow (cfs)	Required Storage Volume (cf)
6	34.20	9.7	40.96	29.7	41.6	248,400
15	9.55	5.0	6.71	26.4	10.6	47,400
16	13.86	16.8	14.36	29.2	15.2	84,800
17	7.34	5.0	6.85	17.2	9.0	31,700
18	4.02	5.0	8.16	13.5	6.7	20,800
19	11.59	7.6	13.91	18.8	15.1	67,500
20	18.97	8.5	21.27	21.0	23.8	95,600
21	8.60	9.7	12.80	27.1	11.3	48,300
22	6.01	5.0	7.25	16.3	8.0	28,800
23	3.48	5.0	5.72	19.6	5.1	15,900
24	3.63	5.0	7.41	17.5	5.9	16,800
25	8.50	6.8	12.90	26.0	11.5	43,000

Effects of LIDA on detention sizes were not modeled. This could be done as part of the design phase to reduce the size of the regional stormwater facilities.

Attachment A — Assumed Version of North Bethany Concept Plan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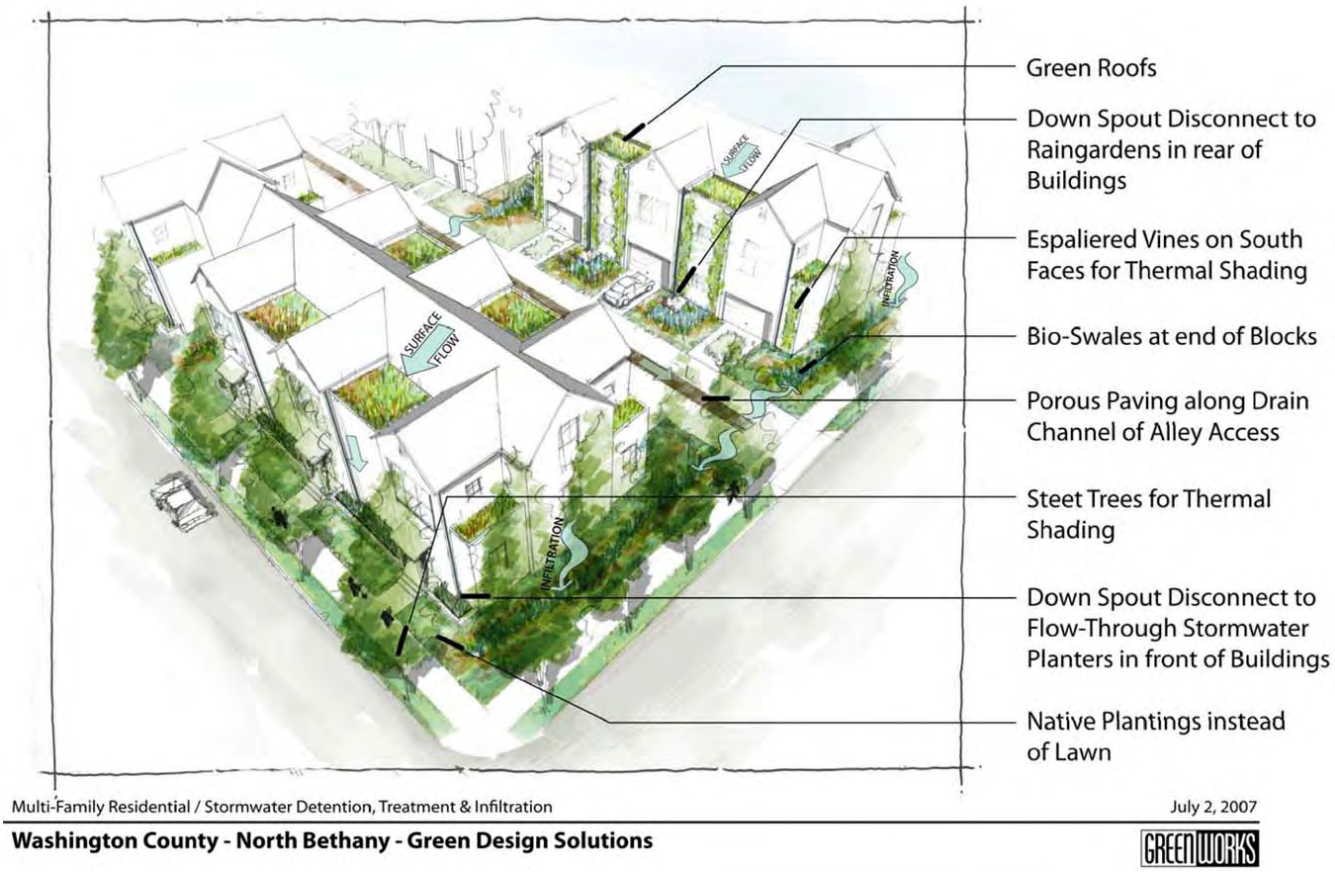
NW BRUGGER RD
NW 185TH AVE
NW SPRINGVILLE RD
NW 183RD AVE
NW 181ST AVE
NW 178TH AVE
NW CROSSHAVEN ST
ST UNION RD
NW 164TH AVE
NW SICKLE TER
NW RYEGRASS ST
NW GRAF ST
NW KAISER R
NW NIGHTSHADE DR
NW FAWNLILY DR
NW CONNERY TER
Project Team:
William Haack
Attachment A - Assumed North Bethany Concept Plan
Legend
Vegetated Open Conveyance
arterial
collector
local
parkway
Zoning
Committed (Estate)
High-Density Residential
Low-Density Residential
Mixed-Use
Open Space
Parks
School, Church, etc.
Strictly Limit
900 450 0 900 Feet
Produced: July 27, 2007
Aerial photography taken in 2003, provided by Aerials Express. Data on this map is derived from Washington County and Metro's RLIS database. This information was developed at multiple scales and accuracies. No warranty is made with this map.

Attachment B — Illustration Showing LIDA Applied to Residential Lots

Attachment B



Multi-Family Residential / Stormwater Detention, Treatment & Infiltration

July 2, 2007

Washington County - North Bethany - Green Design Solutions

GREENWORKS

Reduced Lawn Areas

Stormwater Reclamation -Irrigation and Laundry

Downspout Disconnect

On-Site Detention, Treatment & Infiltration Facilities

Stormwater Overflow To Public Conveyence & Treatment System

Bio-swales

Neighborhood or Regional Treatment Facilities

Reduce Paving; Smaller Stall Dimensions
- Standard: 8.5' x 15.5'
- Compact: 7.75' x 13.5'

Reduce Paving; Narrow Aisles
- 20' - 24' Aisle Width

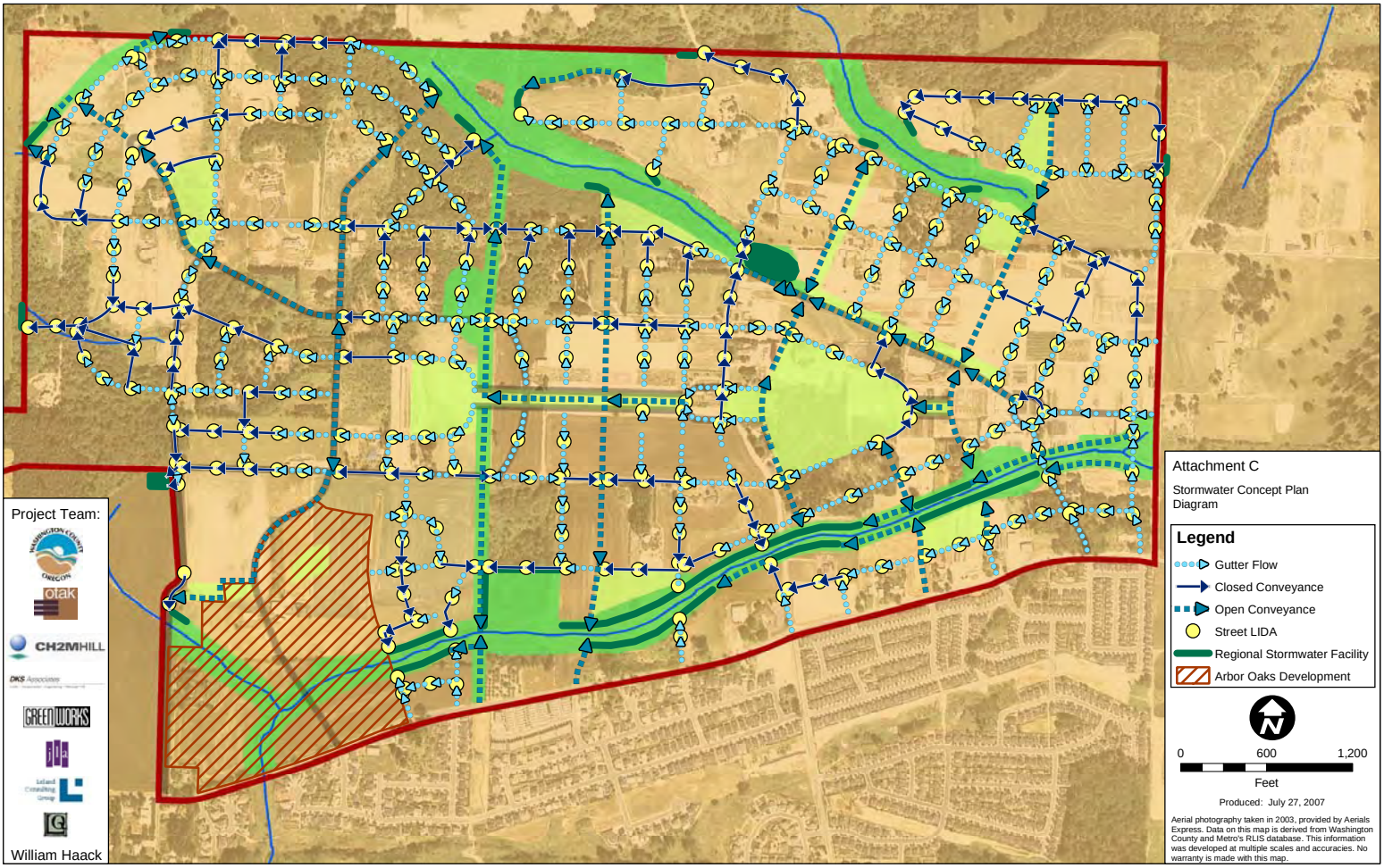
Bio-swales

Pervious Paving

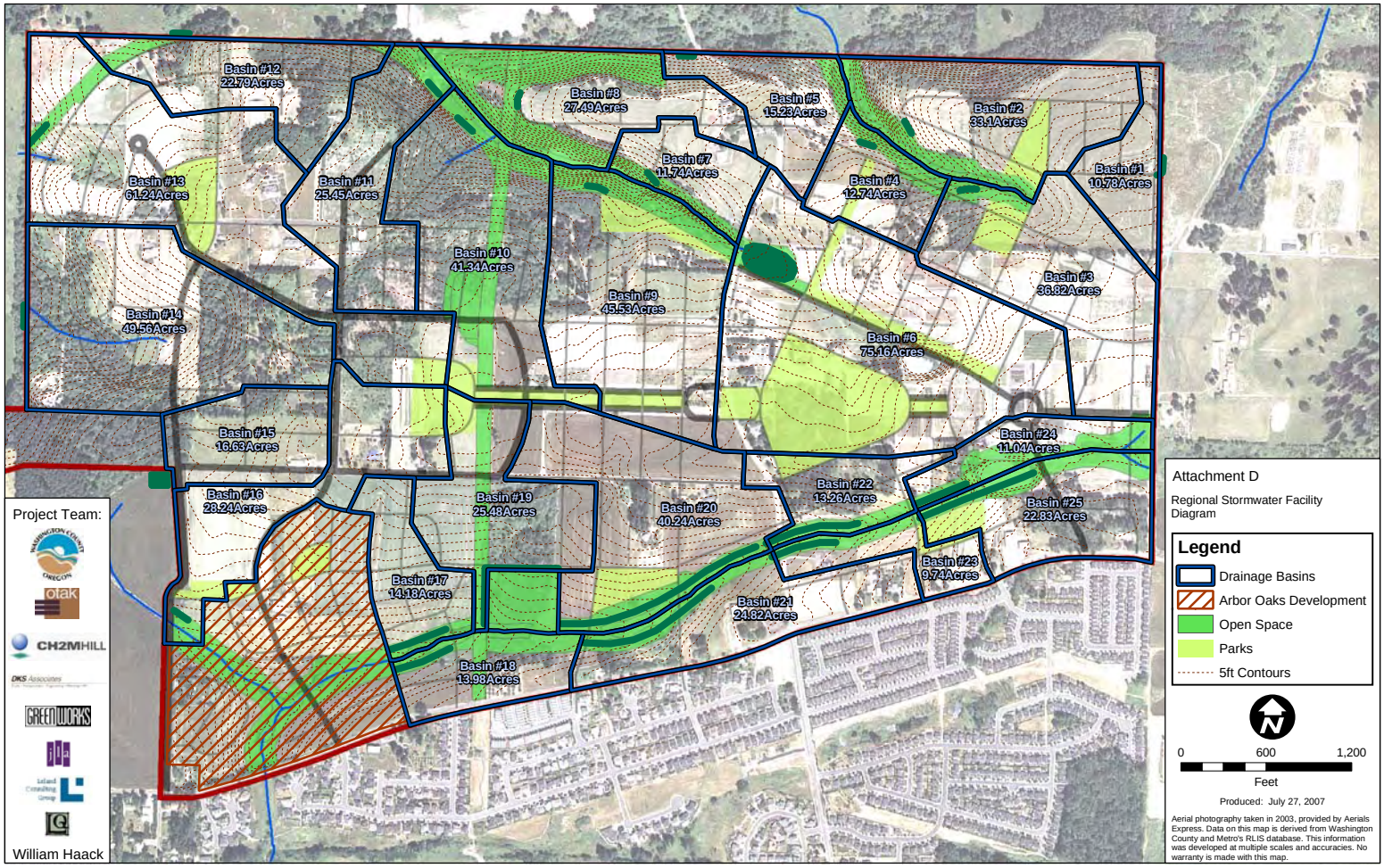
Connect Infiltration Basins Together For Greater Capacity

Infiltration Basins at End of Parking Aisles

Attachment C —
Stormwater Concept Plan


Project Team:
William Haack
Attachment C
Stormwater Concept Plan Diagram
Legend
Gutter Flow
Closed Conveyance
Open Conveyance
Street LIDA
Regional Stormwater Facility
Arbor Oaks Development
0
600
1,200
Feet
Produced: July 27, 2007
Aerial photography taken in 2003, provided by Aerials Express. Data on this map is derived from Washington County and Metro's RLIS database. This information was developed at multiple scales and accuracies. No warranty is made with this map.

Attachment D —
Regional Stormwater Facility Diagram



Project Team:

William Haack

Attachment D

Regional Stormwater Facility Diagram

Legend

- Drainage Basins
- Arbor Oaks Development
- Open Space
- Parks
- 5ft Contours

0 600 1,200

Feet

Produced: July 27, 2007

Aerial photography taken in 2003, provided by Aerials Express. Data on this map is derived from Washington County and Metro's RLIS database. This information was developed at multiple scales and accuracies. No warranty is made with this map.

Attachment E — Illustrations Showing LIDA Applied to Streets


PARKING
7'
TRAVEL LANE
7'
TRAVEL LANE
7'
PARKING
7'
5'
WIDTH VARIES
SIDEWALK
11'
CURB BUMP OUT/ INFILTRATION PLANTERS
11'
TRAVEL LANES
WIDTH VARIES
5'
CURB BUMP OUT/ INFILTRATION PLANTERS
SIDEWALK


8'
SIDEWALK
WIDTH VARIES
STORMWATER INFILTRATION PLANTERS
3'
PARKING ACCESS
7'
ON-STREET PARKING
9'
TRAVEL LANES
9'
7'
ON-STREET PARKING
PARKING ACCESS
3'
WIDTH VARIES
STORMWATER INFILTRATION PLANTERS
8'
SIDEWALK

GREEN STREET CONCEPTS | 3-LANE ARTERIAL (Future 5-Lane Arterial)
North Bethany

July 26, 2007

GREENWORKS

GREEN STREET CONCEPTS | 3-LANE COLLECTOR w/ Optional Open Conveyance

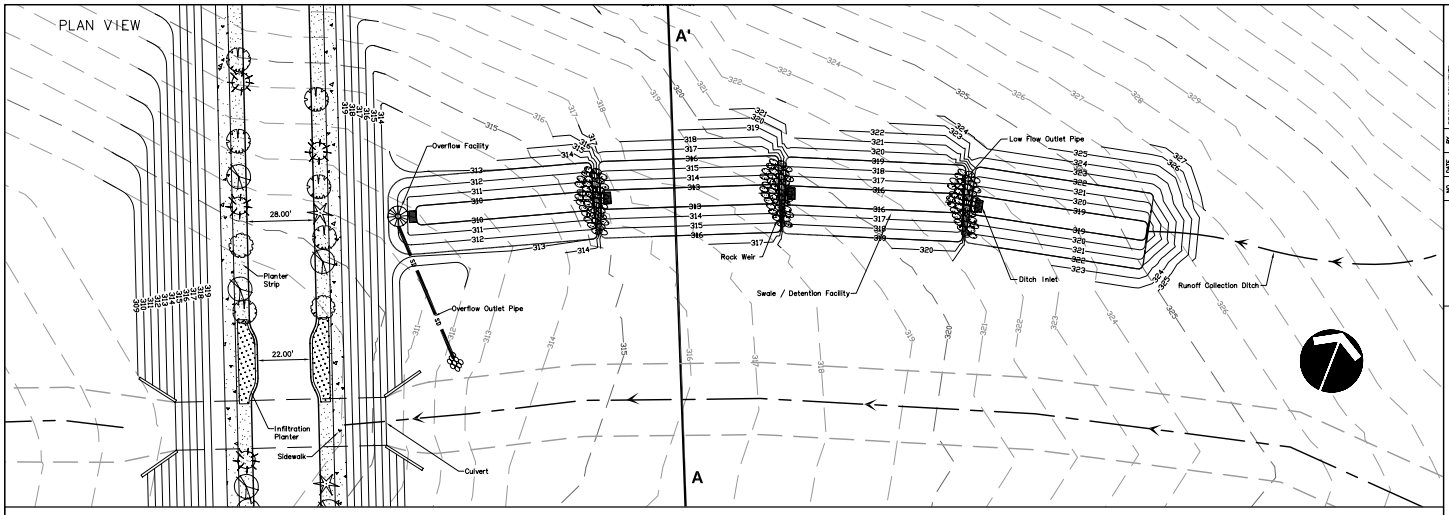
North Bethany

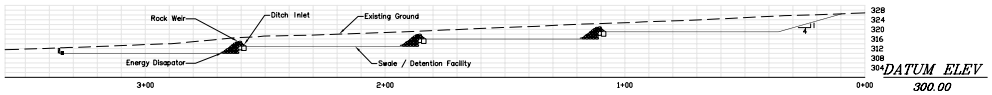
July 26, 2007

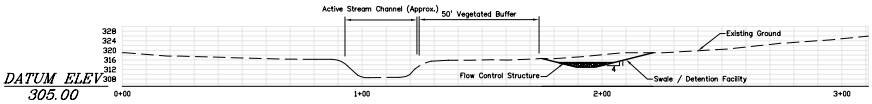
GREENWORKS

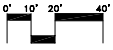

SIDEWALK
TREE / FURNITURE ZONE
PARKING
TRAVEL LANES
STORMWATER SWALE
SIDEWALK
OPEN SPACE
SIDEWALK
OPEN SPACE
TRAVEL LANES
PARK BLOCK COUPLET
PARK BLOCKS 100'
PARK BLOCK COUPLET

Attachment F — Regional Stormwater Swale Illustration









NOT FOR CONSTRUCTION

NORTH BETHANY CONCEPT PLAN

Attachment F - Regional Stormwater Swale Illustration

NO.	DATE	BY	REVISION COMMENTS

Design: Drawn: Checked: Date: Initial Issue Date: July, 26, 2007

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Lake Oswego, OR 97035-5317
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Project No. 13035 Drawing No. Attachment F

Sheet No.

Attachment G — Cost Estimate

CONCEPTUAL PLAN CONSTRUCTION COST ESTIMATE

North Bethany Concept Plan Stormwater Infrastructure

CITY: Unincorp. Washington County

TYPE OF WORK: Stormwater Management Infrastructure | AREA | DATE: 10/9/2007 | Drainage System Designer: Terry Soltz

	ITEM DESCRIPTION	UNIT	AMOUNT	UNIT COST	TOTAL
	Base Construction Items (Mobilization, Traffic Control, Erosion Control, etc.)			**20%**	**$2,958,069**
	Local Street Drainage Infrastructure				
	12 INCH STORM CONDUIT, CP	LF	12,540	$55	$689,700
	15 INCH STORM CONDUIT, CP	LF	8,670	$65	$563,550
	18 INCH STORM CONDUIT, CP	LF	3,380	$70	$236,600
	24 INCH STORM CONDUIT, CP	LF	1,840	$90	$165,600
	30 INCH STORM CONDUIT, CP	LF	560	$105	$58,800
	CONC INLET STRUCTURE, CATCH BASIN	EA	180	$1,500	$270,000
	MANHOLE STRUCTURE	EA	90	$3,000	$269,900
	OPEN CONVEYANCE	LF	7,007	$25	$175,175
	24 INCH CULVERT CROSSINGS	LF	2,336	$90	$210,240
	STREET LIDA FACILITIES	EA	556	$5,000	$2,780,000
	Regional Stormwater Management Facilities				
	EXCAVATION & GRADING	CY	33,097	$12	$397,164
	LANDSCAPING	AC	7.3	$50,000	$363,100
	PRE-TREATMENT DEVICE	EA	24	$15,000	$360,000
	FLOW SPREADER	EA	13	$1,000	$13,000
	DITCH INLET	EA	52	$2,000	$104,000
	RIPRAP STEP TRANSITIONS	EA	52	$1,500	$78,000
	FLOW CONTROL MANHOLE	EA	11	$10,000	$592,400
	Open Space Conveyance				
	OPEN CONVEYANCE	LF	7,969	$25	$199,225
	24 INCH CULVERT CROSSINGS	LF	889	$90	$80,010
SUBTOTAL, Construction					$10,564,533
	CONSTRUCTION CONTINGENCIES			40%	$4,225,813
SUBTOTAL, Total Construction Cost					$14,790,347
	PRELIMINARY ENGINEERING			25%	$3,697,587
	PERMITTING			5%	$739,517
	CONSTRUCTION ENGINEERING			20%	$2,958,069
SUBTOTAL, Implementation					$22,185,520
	LAND ACQUISITION for Regional Stormwater Facilities	SF	360000	$17	$6,120,000
	STAFFING COSTS			17%	$1,040,400
	APPRAISAL COSTS			5%	$306,000
GRAND TOTAL					**$29,651,920**

Assumptions: 1) Unit Costs are presented in 2007 U.S. Dollars

2) Infrastructure quantities do not include *Site Scale Stormwater Management*

3) Infrastructure quantities do not include *Street Scale Stormwater Management* for Arterial and Collector Streets. The Transportation Cost Estiamte includes stormwater management costs for Arterials and Collectors.

4) All Street Scale facilitieswill be on land acquired through right-of-way for roads and open space purchases

North Bethany Concept Plan Stormwater Infrastructure
Detailed Quantity Calculations

Street LIDA Facilities (Each)

ITEM DESCRIPTION	UNIT	AMOUNT	UNIT COST	TOTAL
EXCAVATION	CY	46	$12	$552
PLANTER MEDIA	CY	46	$35	$1,610
PERIMETER CURB	LF	80	$15	$1,200
LANDSCAPING	SF	495	$3.00	$1,485
TOTAL				$4,847

Regional Stormwater Facilities For Water Quality

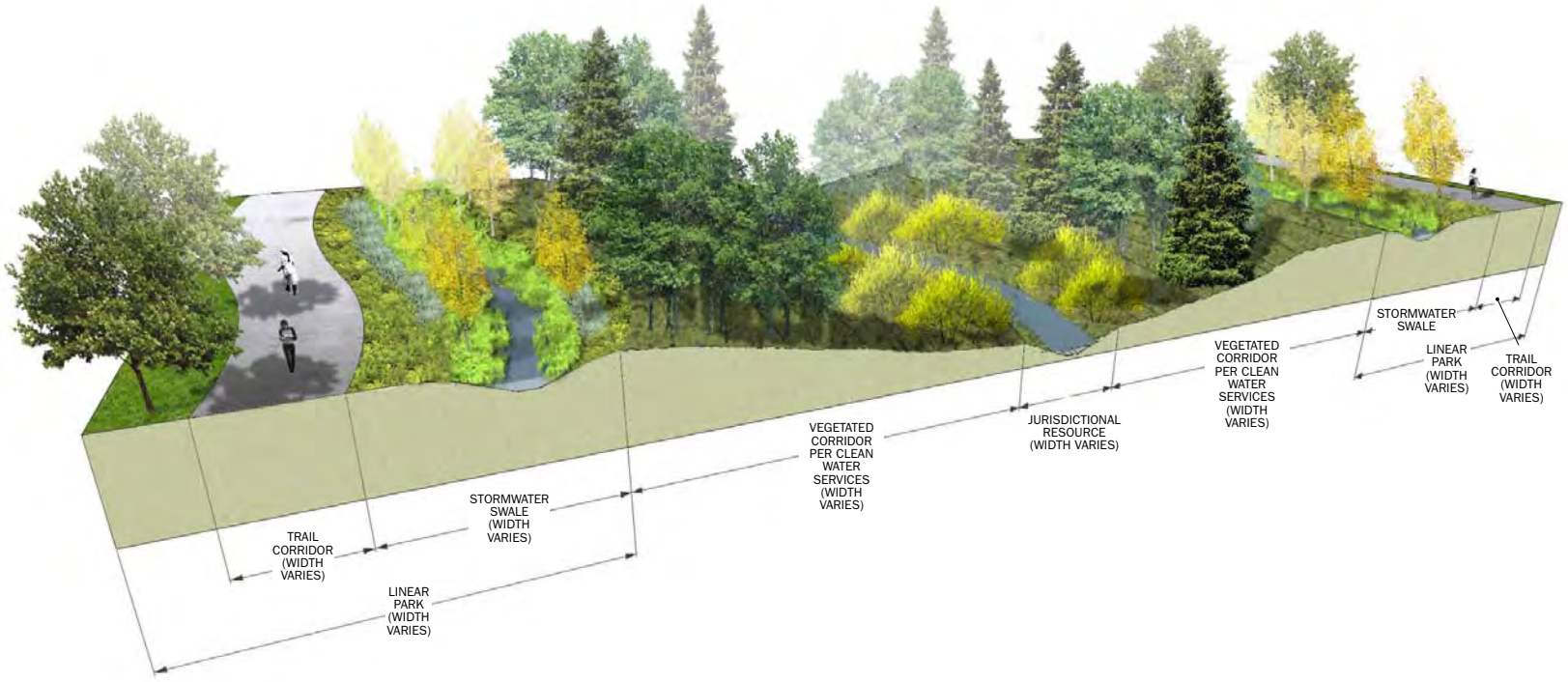
ITEM DESCRIPTION	UNIT	AMOUNT	Swale													Pond	
			Basin 1	Basin 2	Basin 3	Basin 4	Basin 5	Basin 7	Basin 8	Basin 9	Basin 10	Basin 11	Basin 12	Basin 13	Basin 14	Basin 6	Basin 15
EXCAVATION & GRADING	CY	14,897	60	105	105	60	67	60	67	135	105	81	81	146	135	11,500	2,190
LANDSCAPING	AC	2.7	0.042	0.063	0.063	0.042	0.046	0.042	0.046	0.077	0.063	0.054	0.054	0.083	0.077	1.66	0.33
FLOW SPREADER	EA	13	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
PRE-TREATMENT DEVICE	EA	15	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
FLOW CONTROL MANHOLE	EA	2														1	1

Regional Stormwater Facilities For Stormwater Detention

ITEM DESCRIPTION	UNIT	AMOUNT	Linear Pond								
			Basin 17	Basin 18	Basin 19	Basin 20	Basin 21	Basin 22	Basin 23	Basin 24	Basin 25
EXCAVATION & GRADING	CY	18,200	1,570	1,030	3,330	4,720	2,390	1,420	790	830	2,120
LANDSCAPING	AC	4.5	0.36	0.27	0.77	1.15	0.63	0.37	0.21	0.22	0.54
PRE-TREATMENT DEVICE	EA	9	1	1	1	1	1	1	1	1	1
DITCH INLET	EA	52	3	3	8	14	9	4	2	2	7
RIPRAP STEP TRANSITIONS	EA	52	3	3	8	14	9	4	2	2	7
FLOW CONTROL MANHOLE	EA	9	1	1	1	1	1	1	1	1	1

Attachment H —
Illustrations Showing Linear Park Concepts with Regional Stormwater Facilities

otak

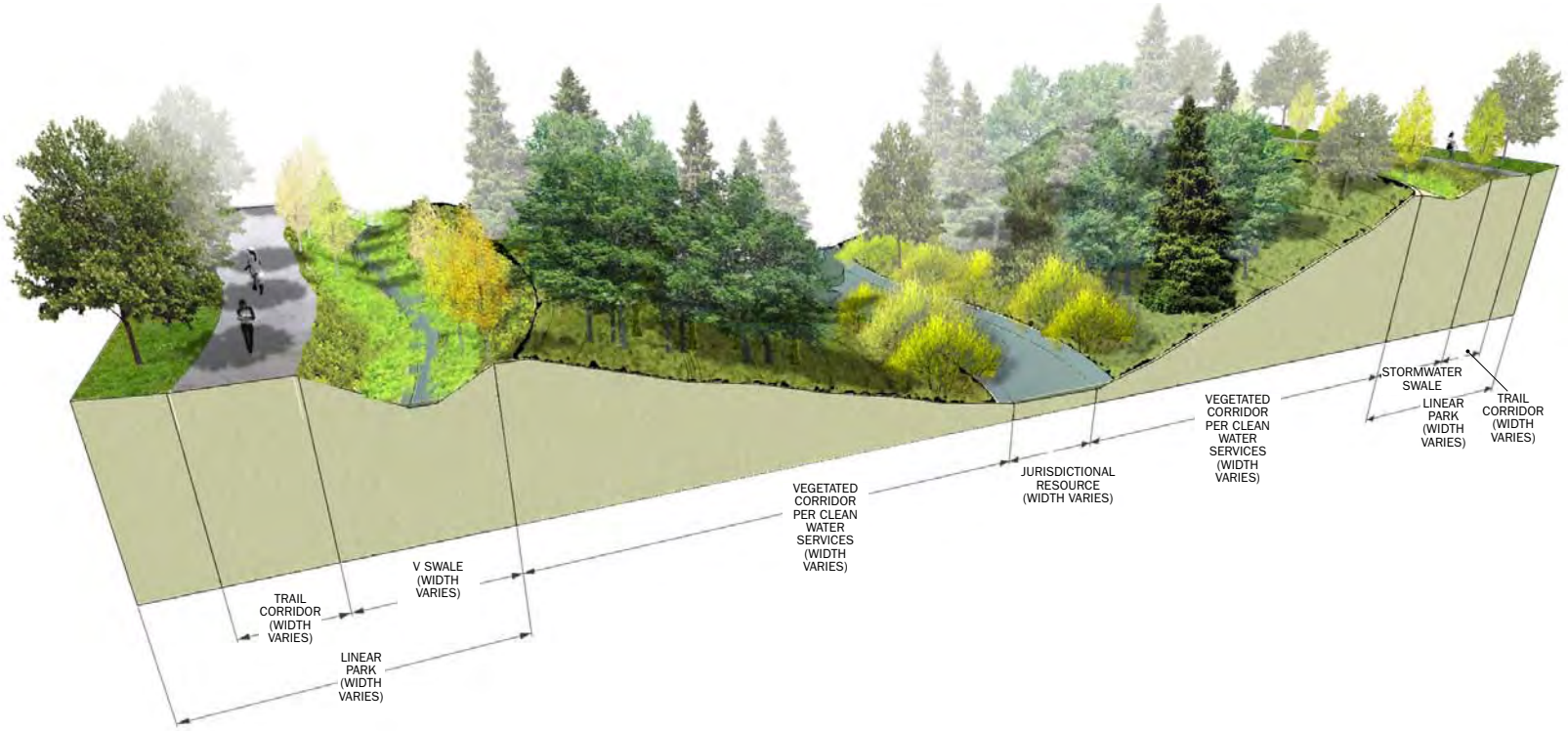


GREEN STREET CONCEPTS | LINEAR PARK - Bethany Creek

North Bethany

July 26, 2007

GREENWORKS


TRAIL CORRIDOR (WIDTH VARIES)
V SWALE (WIDTH VARIES)
LINEAR PARK (WIDTH VARIES)
VEGETATED CORRIDOR PER CLEAN WATER SERVICES (WIDTH VARIES)
JURISDICTIONAL RESOURCE (WIDTH VARIES)
VEGETATED CORRIDOR PER CLEAN WATER SERVICES (WIDTH VARIES)
STORMWATER SWALE
LINEAR PARK (WIDTH VARIES)
TRAIL CORRIDOR (WIDTH VARIES)