WOLFE CREEK DAYLIGHTING CONCEPT FEASIBILITY STUDY

TECHNICAL SUMMARY MEMORANDUM

May 15, 2008

Prepared for Heron Habitat Helpers by the WR Consulting, Inc. Project Team under a grant from The Russell Family Foundation

WR Consulting, Inc.

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1. Executive Summary

This Concept Feasibility Study is an additional step towards daylighting Wolfe Creek which in the future can provide estuarine salmon habitat in Salmon Bay – where little exists now – and reduce surface water flows to the West Point Treatment Plant. This FS was conducted by the WR Consulting, Inc. Team for Heron Habitat Helpers (HHH) under a grant from The Russell Family Foundation.

Project Background

HHH, a non-profit neighborhood parks group formed in 2001 to restore and preserve Kiwanis Ravine, has been the principal proponent of Wolfe Creek daylighting since 2005. HHH's vision of the Kiwanis Ravine natural area and wildlife corridor is a sustainable urban preserve for a thriving population of great blue herons and other wildlife, including a daylighted Wolfe Creek from the ravine to Salmon Bay, with a natural watershed to support it.

Wolfe Creek is located several blocks east of Discovery Park in the Magnolia neighborhood of Seattle, Washington (see Figure 1). The project area consists of the Wolfe Creek Drainage Basin which includes Kiwanis Ravine down through Commodore Park to Salmon Bay. Kiwanis Memorial Reserve Park Natural Area and Wildlife Corridor (Kiwanis Ravine) is a 16-acre park composed of primarily steep, unstable, and slide-prone wooded slopes eroded by Wolfe Creek.

Drainage in the Wolfe Creek watershed has been significantly modified over the past 100 years. The upper reaches of the creek, south of Government Way, have been filled and diverted into underground pipes. Only a small section remains daylighted (i.e., in a natural channel) through Kiwanis Ravine prior to reaching the Burlington Northern Santa Fe (BNSF) Railway tracks south of West Commodore Way. At the tracks, it flows into the combined sewer system and is conveyed to the King County sewer trunk line in West Commodore Way that flows to the West Point Treatment Plant.

A number of studies and conceptual designs have previously been prepared for the proposed daylighting of Wolfe Creek. In this Concept Feasibility Study, ten alternatives, some of which are only partial alternatives or concepts of portions of an alternative, plus several new concepts, are evaluated. The alternatives have various attributes, with all generally meeting the intent of daylighting the creek. It has been assumed that site constraints and associated costs preclude the construction of passage for fish.

Project Benefits and Support

The benefits of daylighting and restoration of Wolfe Creek as an open channel in Commodore Park include:

- Improving salmonid food supply to Salmon Bay;

- Enhancing the salmon refuge area by improving shoreline vegetation and creating a pocket estuary in Salmon Bay;
- Adding freshwater to improve estuarine conditions and reduce the abrupt and physiologically stressful freshwater-saline transition zone for salmon in Salmon Bay (during the summer months, the amount of freshwater flowing over the Locks spillway is limited and a freshwater lens is not maintained below the lock complex);
- Providing an added attraction to Commodore Park and the Locks/fish ladder complex for education about streams, watersheds, salmon, herons, and other wildlife; and
- Removing Wolfe Creek water that doesn't need to be conveyed and treated from the West Point Treatment Plant.

Various local, regional and federal programs and studies support daylighting Wolfe Creek and/or the benefits associated with daylighting the creek including:

- Wolfe Creek in Kiwanis Ravine ranked in the top 10 of a list of daylighting project opportunities SPU reviewed (Chris May, Pers. Comm., 2008). Seattle Resolution 30850 directs SPU to assess and prioritize which publicly owned creeks/pipes/culverts/ and streams could be daylighted and contribute towards salmon recovery. SPU and other city departments ranked these projects based on several scientific and socio-economic criteria (economic, environmental, social i.e. fishery benefit, environmental education, etc.). Daylighting projects are also prioritized by SPU because of development opportunities such as mitigation money, community support, or cost sharing opportunities with various agencies (e.g. U.S. Army Corps of Engineers, King County, etc.).
- This project is in the Action Start List of the WRIA 8 Chinook Salmon Conservation Plan (WRIA 8 Steering Committee and Forum, 2005.). This list is the highest priority of the actions that will work toward salmon recovery. The Wolfe Creek Restoration (project # 250) is combined with restoration at Commodore Park.
- Wolfe Creek Daylighting meets the goal of expanding habitat for migrating Chinook by increasing shoreline complexity and riparian vegetation and restoring the shoreline to a gentler vegetated slope as indicated in the Scientific Framework for Ecological Health (SPU, 2007), Restore Our Waters Strategy Report (City of Seattle, 2005), the Puget Sound Salmon Recovery Plan Watershed Work Plans (WRIA 8 Steering Committee, 2006), and 2004 Comprehensive Drainage Plan (City of Seattle, 2005).
- Fish ladder redesign and reconstruction is recommended to aide survival of both the endangered Puget Sound Chinook salmon and the Puget Sound steelhead by the National Marine Fisheries Service (NMFS, 2008).
- The City of Seattle and the U.S. Army Corps of Engineers are also considering options to restore the west end of Commodore Park to enhance the shoreline for habitat (Stakeholder's Site Tour, 2006). The options can include removal of a portion of the concrete seawall, construction of a sloping beach and addition of native vegetation. A retaining wall would likely be constructed further upland,

because of the steep topography. These options may also include creation of a cove, public access viewing trails, and benches and signs. Daylighting Wolfe Creek through Commodore Park would enhance these options as discussed below in Section 6 on Potential Future Project Phases.

- In addition, there is a recent precedent for daylighting and restoration of a many regional creeks including Ravenna Creek, Madrona Creek, Thornton Creek, among others.

Daylighting Wolfe Creek on the south side of Salmon Bay also would complement the restoration project already in progress on the north side of Salmon Bay. It is called the Salmon Bay Natural Area – a shoreline native plant restoration project initiated by Groundswell NW and assisted by Seattle Public Utilities and donors. Together, these two projects on the south and north sides of Salmon Bay form part of the restoration efforts identified for Salmon Bay as a whole in the "Greater Salmon Bay Concept Plan".

Project Objectives

The following six objectives were identified for this project:

1. Promote the development of a viable plan for daylighting Wolfe Creek to provide a source of freshwater in the estuarine mixing zone for salmon migrating through the Ship Canal;
2. Coordinate the input and documentation of the various stakeholders' objectives for the project;
3. Summarize and establish project objectives to provide a basis for evaluating the alternatives;
4. Complete technical review of ten design alternatives including additional geomorphological, biological, and hydrologic/hydraulic assessment of the creek system. Identify information gaps and evaluate alternatives using the project objectives to select three preferred alternatives; and
5. Prepare updated construction costs of the three preferred alternatives, summarize permitting requirements, next steps and identify funding options. Document the results of the study in a technical summary memorandum.
6. Draft initial pages of Project Development Plan (PDP) forms for SPU use in project assessment.

Stakeholder Input

Stakeholder input was summarized into the following six main design objectives:

- Aesthetic-Recreational,
- Habitat/Fisheries/Wildlife,

- Water Quality/Watershed Protection,
- Engineering,
- Education, and
- Cost-Benefit.

Each design objective has several subcriteria that further define it. These project design objectives were used to qualitatively evaluate the ten daylighting alternatives and provide the framework for selecting the preferred creek daylighting alternatives. In addition, pertinent technical information relevant to the alternative evaluation addressed site geomorphology, hydrologic/hydraulic considerations, biological considerations and water quality data.

Alternatives Analysis

The ten daylighting alternatives were qualitatively compared using a matrix evaluation approach. The alternatives provide a range of options with various advantages and disadvantages depending on the design criteria. Some alternatives have unique characteristics. Each of the design objectives (and associated subcriteria) was used to analyze and create a relative rank for each daylighting alternative.

Based upon the comparative alternative analysis shown in Table 1, Alternative H ranks as the highest scoring, and therefore, most preferred alternative. Alternatives D, I, G and J all rank similarly within the middle tier and Alternatives A, B, C and E rank in the lowest tier, or as the least preferred alternatives. Alternative F has an even lower rank because it does not meet the project objective of daylighting the creek.

The overall objective of narrowing the ten alternatives to three preferred alternatives is to provide alternatives that span the spectrum of objectives of the stakeholders and combine or modify the alternatives to simplify further daylighting assessment. The selection of the preferred daylighting alternatives was based on the comparative evaluation of each alternative using the design criteria identified by stakeholders. This comparative evaluation was difficult because the ten alternatives provided varying degrees of completeness and levels of detail.

In order to resolve the variability between alternatives, the proposed alternatives have been reconfigured to address the daylighting in two parts: 1) separating the creek flow from the combined sewer between the BNSF Railway tracks and West Commodore Way (south of West Commodore Way), and 2) designing a daylighted channel through Commodore Park (north of West Commodore Way). The reconfiguration allows the comparison and evaluation of the key concepts presented in alternatives A through J, and provides a basis for moving forward with viable comparable alternatives.

Preferred Alternatives

Revised alternatives with lower costs and impacts were developed for the two preferred alternatives south of West Commodore Way:

- Alternative 1 South – Pipe Diversion, consists of a manhole structure that intercepts Wolfe Creek south of West Commodore Way and delivers the Wolfe Creek water to Commodore Park on the north slope of West Commodore Way.
- Alternative 2 South – Directional Drilling, involves installation of a 12 inch diameter tightline pipe from the north side of the BNSF Railway tracks to the north side of West Commodore Way.

The two preferred alternatives selected for further assessment north of West Commodore Way in Commodore Park span the spectrum of costs, benefits and impacts for the daylighted creek:

- Alternative 1 North – Short Daylight consists of the construction of a short daylighted steep cascading water feature that discharges to Salmon Bay.
- Alternative 2 North – Long Daylight consists of the construction of a longer daylighted channel through Commodore Park that meanders with pools and drops west toward the small cove at the downstream or west end of Commodore Park.

These four preferred alternatives identified for the south and north of West Commodore Way daylighting segments may be combined in any way to form a selected alternative and meet the project objective of reducing the 10 alternatives to fewer preferred alternatives. Each of these preferred alternatives are also readily comparable in terms of costs, benefits, and technical feasibility for future evaluations. HHH has accepted that these four alternatives meet the initial objective of identifying "three preferred alternatives".

Future Phases

In addition to these four preferred alternatives, elements from several of the 10 alternatives and new concepts were developed for future phases of work:

- Future Phase South – Complete Wolfe Creek Daylighting, consists of the long-range or ultimate vision for the complete daylighting of the creek and would result in a complete natural riparian corridor from the wetlands in Kiwanis Ravine just south of the railroad tracks to Salmon Bay.
- Future Phase North –Western Estuary and Fish Ladder Enhancement, consists of the long-range or ultimate vision for the Commodore Park enhancements for salmon migration that include a marsh or estuarine enhancement at the outlet of the creek at the west end of Commodore Park and a fish-friendly reconstruction of the fish ladder to include natural open-air pools and drops.

These future phases would integrate with any combination of the selected north and south Wolfe Creek daylighting options. Further development of these future concepts could be the focus of future studies.

Conclusions and Recommendations

The process followed in this Concept Feasibility Study has successfully narrowed the broad range of ten daylighting alternatives to four -- two south of West Commodore Way and two north of West Commodore Way. This was accomplished by separating the daylighting work into two parts, south and north of West Commodore Way. The concepts south of West Commodore Way address the separation of creek flows from the sewer trunk line, and were narrowed to two alternatives. The concepts north of West Commodore Way focus on the alignment and features of the daylighted creek in Commodore Park and were also narrowed to two alternatives.

All four of these alternatives (two south and two north of West Commodore Way) are feasible to implement and their feasibility has been adequately studied during this phase of work. These four alternatives may be combined into a single preferred alternative (including a segment both north and south of West Commodore Way) to carry forward. Although a number of data gaps have been identified only the key items are recommended information needed prior to the selection of the preferred alternative. The remaining data gaps could be filled, as needed, at the time of project implementation (i.e. as part of permitting for or environmental assessment of the preferred alternative initiated by a sponsoring agency).

Based on this study, the recommended next step is to obtain stakeholder input on these four alternatives and select a preferred alternative. Following that, pre-design work on the preferred alternative can be completed. Thus, the next phase for the project could be an Alternative Selection and Pre-Design report. If adequate funding is not obtained to complete such a study, then available funds can be spent on filling the key data gaps, followed by other remaining data gaps.

2. Project Authorization and Purpose

This Concept Feasibility Study (FS) is an additional step towards daylighting Wolfe Creek which in the future can provide estuarine salmon habitat in Salmon Bay -- where little exists now – and reduce surface water flows to the West Point Treatment Plant. This FS was conducted by the WR Consulting, Inc. Team for Heron Habitat Helpers (HHH) under a grant from The Russell Family Foundation. The team included: WR Consulting, Inc., Resolvent LLC, J.A. Brennan and Associates, Taylor Associates, and Jacobs Associates.

Project Background

Project Area

Wolfe Creek is located several blocks east of Discovery Park in the Magnolia neighborhood of Seattle, Washington (see Figure 1). The project area consists of the Wolfe Creek Drainage Basin which includes Kiwanis Ravine down through Commodore Park to Salmon Bay. Kiwanis Memorial Reserve Park Natural Area and Wildlife Corridor (Kiwanis Ravine) is a 16-acre park composed of primarily steep, unstable, and slide-prone wooded slopes.

The Wolfe Creek Diversion Feasibility Analysis indicates that Wolfe Creek drains an estimated 90-acre watershed, although runoff from portions of the upper watershed is diverted into City of Seattle combined sewers (SvR Design Company, 2003). Our estimates for this study indicate a somewhat smaller watershed size (see Figure 2) as discussed in Section 4. Wolfe Creek first surfaces near West Elmore St and 35th Avenue West and flows northward through open channels for approximately 3,100 feet. The creek flows through a ravine and then through a culvert under West Government Way before entering Kiwanis Ravine. A small tributary that originates near West Jameson St and West Government Way flows in from the east.

The depth of the ravine ranges from 30 to 40 feet at the south end to over 100 feet at the north end. There are 11 separate wetlands totaling 1.1 acres within the ravine. Some wetlands are located along the stream and others are “perched,” deriving from springs on the slopes.

At the north end of Kiwanis Memorial Reserve Park, the creek enters a pipe that crosses under the Burlington Northern-Santa Fe (BNSF) Railway tracks, passes near several homes, and connects to the 12-foot diameter sewer trunk line located under West Commodore Way. This pipe is approximately 500 feet in length. The transition from daylighted creek to the underground pipe is at the south side of the BNSF right-of-way. The creek enters a large wood box inlet structure and drops approximately 6 feet inside this structure prior to flowing through the pipe under the BNSF Railway tracks. Continuing to the north, the pipe crosses residential lots at

3307, 3319, and 3321 West Commodore Way, connecting to a deep manhole in the front yard of 3321 West Commodore Way. From there the pipe connects directly to the sewer trunk line in the center of West Commodore Way.

The sewer trunk line eventually discharges to the West Point Sewage Treatment Plant. The pipe alignment appears to follow the historical path of the creek until it reaches the sewer trunk line. The location of the historic creek mouth is in Commodore Park which has been obscured by the construction of a concrete seawall that protects the Commodore Park shoreline. At the west end of Commodore Park, the seawall transitions to a sandy beach just east of the railroad bridge.

Side sewers from the three residences noted above connect into the pipe as it passes near the homes. City sewer records indicate the culvert pipe diameter is 18 inches (sewer card #3725). However, a City survey of the pipe in 1968 indicates the culvert diameter is 27 inches and is made of concrete (see City survey field book FB2235-J).

According to anecdotal accounts, the creek maintains a relatively constant base flow throughout the year. Visual inspections indicate that the creek is fed primarily by groundwater. At the time of the site visit on January 17, 2003, the width of the water surface in the creek channel ranged from 1 to 2 feet and the depth of water ranged from 1 to 4 inches (SvR Design Company, July 2003).

Project Benefits and Support

The benefits of daylighting and restoration of Wolfe Creek as an open channel in Commodore Park include:

- Improving salmonid food supply to Salmon Bay;
- Enhancing the salmon refuge area by improving shoreline vegetation and creating a pocket estuary in Salmon Bay;
- Adding freshwater to improve estuarine conditions and reduce the abrupt and physiologically stressful freshwater-saline transition zone for salmon in Salmon Bay (during the summer months, the amount of freshwater flowing over the Locks spillway is limited and a freshwater lens is not maintained below the lock complex);
- Providing an added attraction to Commodore Park and the Locks/fish ladder complex for education about streams, watersheds, salmon, herons, and other wildlife; and
- Removing Wolfe Creek water from the West Point Treatment Plant sewage system.

Daylighting Wolfe Creek on the south side of Salmon Bay would complement the restoration project already in progress on the north side of Salmon Bay. It is called the Salmon Bay Natural Area – a shoreline native plant restoration project initiated by Groundswell NW and assisted by Seattle Public Utilities and donors. Together, these two projects on the south and north sides of Salmon Bay form part of the restoration efforts identified for Salmon Bay as a whole in the "Greater Salmon

Bay Concept Plan" (J.A. Brennan Associates, 2006).

Salmon Bay estuary is the only estuary in the greater Lake Washington watershed. Historically, Salmon Bay that Wolfe Creek originally discharged to was a saltwater estuary during high tide and was essentially dry at low tide. This estuary is important to juvenile salmon during their smoltification process as they transition from freshwater to saltwater. Estuaries are also important rearing areas for juveniles, whose marine survival is influenced by their early life habitat conditions (NMFS, 2008).

In Salmon Bay, the presence of the Hiram Chittenden Locks creates an abrupt barrier between the freshwater and saltwater environments in the estuary, limiting the ability of juvenile and adult salmonids to choose favorable temperature and salinity levels as they transition between the two areas. This project is even more important in light of the widespread declines in abundance and productivity in most natural salmon species populations. These declines have been caused by multiple primarily anthropogenic factors including: changes in flow regime, estuarine loss; and loss of habitat including pools, vegetated shorelines and large woody debris (NMFS, 2008).

Various local, regional and federal programs and studies support daylighting Wolfe Creek and/or the benefits associated with daylighting the creek including:

- Wolfe Creek in Kiwanis Ravine ranked in the top 10 of a list of daylighting project opportunities SPU reviewed (Chris May, Pers. Comm., 2008). Seattle Resolution 30850 directs SPU to assess and prioritize which publicly owned creeks/pipes/culverts/ and streams could be daylighted and contribute towards salmon recovery. SPU and other city departments ranked these projects based on several scientific and socio-economic criteria (economic, environmental, social i.e. fishery benefit, environmental education, etc.). Daylighting projects are also prioritized by SPU because of development opportunities such as mitigation money, community support, or cost sharing opportunities with various agencies (e.g. U.S. Army Corps of Engineers, King County, etc.).
- This project is in the Action Start List of the WRIA 8 Chinook Salmon Conservation Plan (WRIA 8 Steering Committee and Forum, 2005.). This list is the highest priority of the actions that will work toward salmon recovery. The Wolfe Creek Restoration (project # 250) is combined with restoration at Commodore Park.
- Wolfe Creek Daylighting meets the goal of expanding habitat for migrating Chinook by increasing shoreline complexity and riparian vegetation and restoring the shoreline to a gentler vegetated slope as indicated in the Scientific Framework for Ecological Health (SPU, 2007), Restore Our Waters Strategy Report (City of Seattle, 2005), the Puget Sound Salmon Recovery Plan Watershed Work Plans (WRIA 8 Steering Committee, 2006), and 2004 Comprehensive Drainage Plan (City of Seattle, 2005).
- Fish ladder redesign and reconstruction is recommended to aide survival of both the endangered Puget Sound Chinook salmon and the Puget Sound

steelhead by the National Marine Fisheries Service (NMFS, 2008).

- The City of Seattle and the U.S. Army Corps of Engineers are also considering options to restore the west end of Commodore Park to enhance the shoreline for habitat (Stakeholder's Site Tour, 2006). The options can include removal of a portion of the concrete seawall, construction of a sloping beach and addition of native vegetation. A retaining wall would likely be constructed further upland, because of the steep topography. These options may also include creation of a cove, public access viewing trails, and benches and signs. Daylighting Wolfe Creek through Commodore Park would enhance these options as discussed below in Section 6 on Potential Future Project Phases.
- In addition, there is a recent precedent for daylighting and restoration of a many regional creeks including Ravenna Creek, Madrona Creek, Thornton Creek, among others.

Heron Habitat Helpers (HHH) Involvement in Kiwanis Ravine

HHH is a volunteer, neighborhood group, [a non-profit 501-c-3 affiliate of the Associated Recreation Council (ARC)] formed in February, 2001 by Donna Kostka and Heidi Carpine as a committee of Friends of Discovery Park. The group was founded with the vision of restoring and preserving Kiwanis Ravine natural area and wildlife corridor as a sustainable urban preserve for a thriving population of great blue herons and other wildlife, including a free-flowing Wolfe Creek to Salmon Bay, with a watershed that supports it.

HHH became the official "Adopt-a-Park" steward for Kiwanis Ravine, committed to maintaining this critical habitat to support Seattle's largest nesting colony of Great Blue Herons (supporting 65 active nests in 2007) and other wildlife. HHH's conservation goals include restoration of aquatic habitat and forests; slope stabilization; water quality improvement; creation of backyard wildlife habitat adjacent to the preserve; influencing adjacent real estate development that compromises wildlife and habitat; involving the public in hands-on removal of invasives, planting native plants; and conducting educational events.

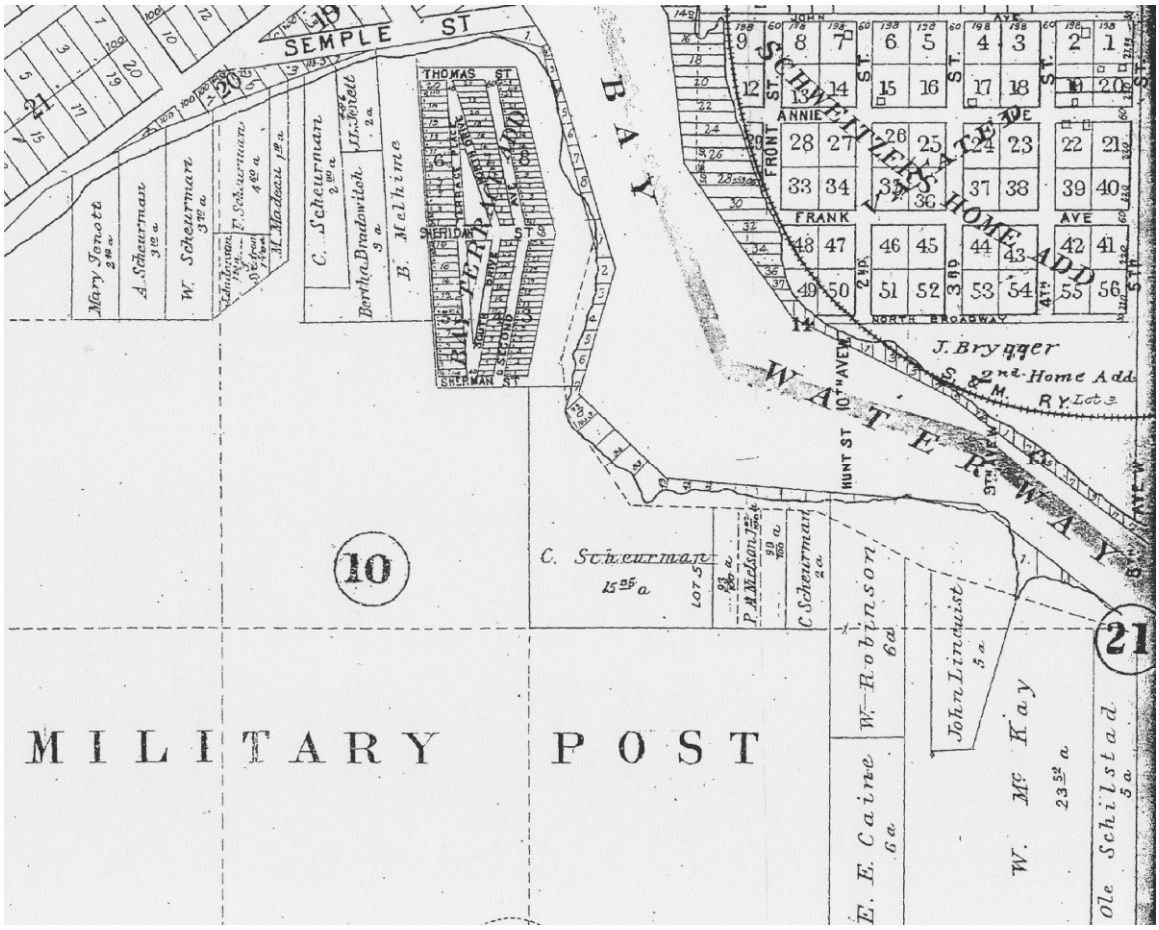
Daylighting Efforts to Date

In October 2005, a Wolfe Creek daylighting public meeting was held by People for Puget Sound, HHH and Groundswell Northwest. Since July 2006, HHH has been meeting quarterly with stakeholders to examine the feasibility of daylighting Wolfe Creek including: Groundswell Northwest, King County Wastewater Treatment Division, People for Puget Sound, Seattle Parks and Recreation Department, Seattle Public Utilities, Suquamish Tribe, and the U.S. Army Corps of Engineers. The King County Wastewater Treatment Division recently completed three rounds of water quality monitoring (for fecal coliform bacteria, dissolved oxygen, temperature and flow) at three locations in Wolfe Creek (main stem, East Fork and West Fork).

Project Site History

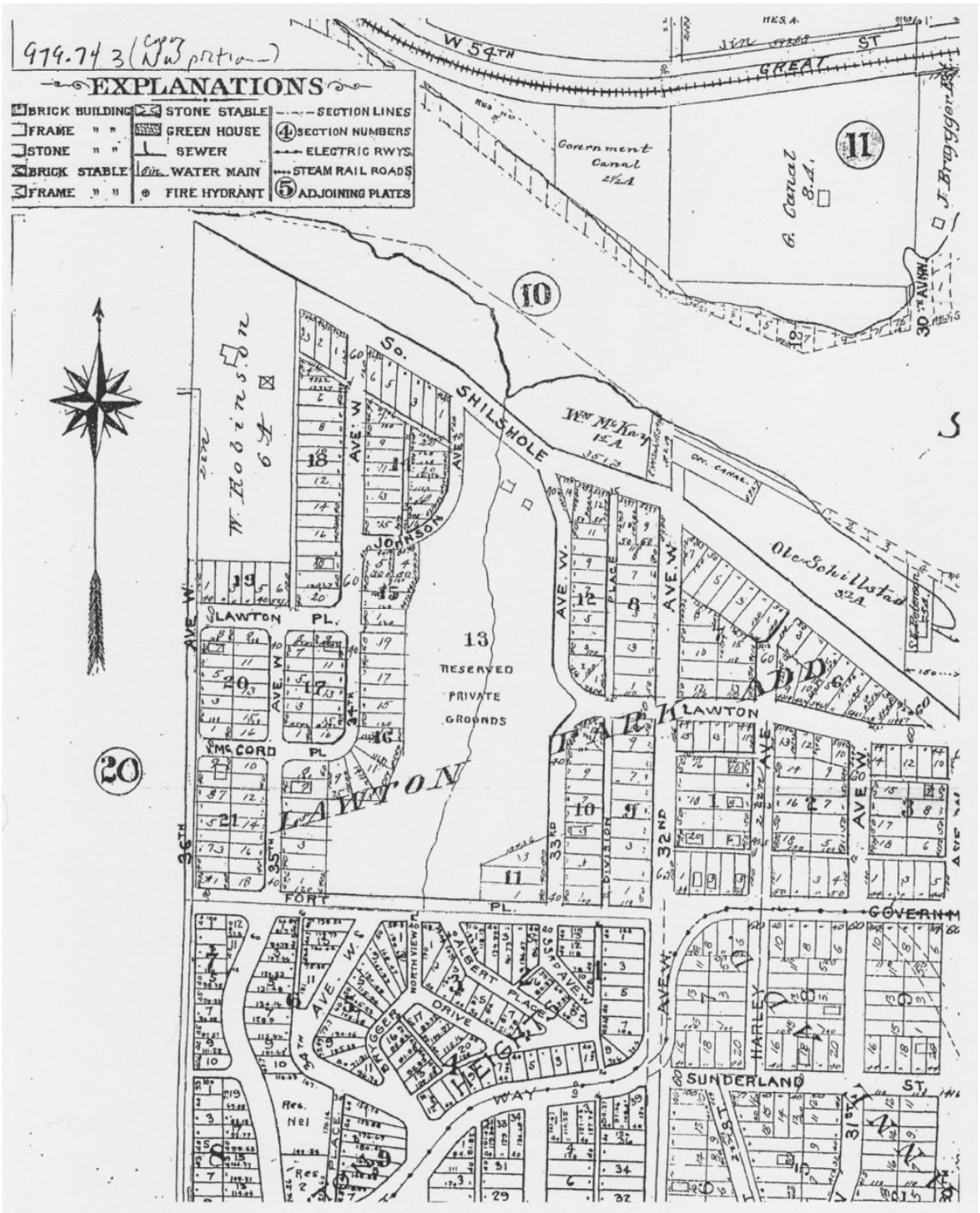
Originally, Wolfe Creek drained most of the north half of the Seattle neighborhood of Magnolia into a small inlet on Salmon Bay not far from the current location of the Hiram M. Chittenden Locks. Large wetlands in the middle of Magnolia are presumed to have provided an abundant year-round supply of cool and clean water for the creek.

A map from about 1905 shows the mouth of Wolfe Creek on the south side of the Salmon Bay Waterway. It is located on the W. McKay property at the northeast corner of the John Lincuist property (see the lower right corner of the map below).



Historical Map No. 1 - 1905 Map showing mouth of Wolfe Creek

Another map from the same period (below) shows the approximate creek alignment relative to the platted lots surrounding it. The street adjacent to the future park, "So. Shilshole", which is now West Commodore Way, has been established. The map notes that the ravine is on "Reserved Private Grounds". The mouth of the creek is still shown on Wm. McKay's property and shows "Schillstad" retaining ownership of the property along the waterfront to the east. A smaller parcel identified as "Government Canal" is shown and indicates progress on the construction of the locks. A very small parcel located between the "Government Canal" and the McKay parcel is labeled "E.W. Schillstad".



Historical Map No. 2 - Early Plat Map showing the Location of Wolfe Creek and mouth on Salmon Bay

The following photograph was provided by Chris Townsend, who is the grandson of the Oli Shillestad noted on the 1905 map. Chris' grandfather settled near the mouth of Wolfe Creek and the image is a copy of his framed picture. When Chris' mother was a girl, her family had a curio shop called the Sealth Shop which they think was near where the salmon ladder is now located. This may be the small lot labeled E.W. Shillstad on the 1905 plat map. They sold hot dogs, had a collection of native artifacts (which Chris now has) and a big totem pole or carved figure out front rigged with a speaker so that it could "talk" to unsuspecting visitors. According to family accounts, the mouth of the creek is just to the west (right) of the view in the photograph. This description is consistent with the layout of the lots shown in the 1905 plat maps.

Photograph No. 1 - Oli Shillestad's House on Salmon Bay

In the early 1900's, West Government Way was constructed to provide a link to Fort Lawton. The East and West Forks of Wolfe Creek were truncated with large quantities of fill, and additional fill was placed on the street edges to provide lots for building. In addition, large-scale filling was conducted along the edges of the ravine, particularly on Brygger Way West. The result is that the stream valley today is full of sediment, and slopes are steeper and more slide prone than they were in the past.

Also in the early 1900's, construction of the Locks and the BNSF Railway tracks caused the City to divert Wolfe Creek into a pipe which carried the creek waters to Salmon Bay. The pipe that originally carried the creek water to Salmon Bay was abandoned and may be encountered during future daylighting construction work. Records indicate that the creek waters were then connected to the sewer trunk line on West Commodore Way when the West Point Treatment Plant was constructed in the 1960s as described above in the Project Area section.

The following photograph is a view looking east toward the Locks. The box highlighted on this photograph shows the location of the mouth of the creek and the original beach area relative to the locks.

Photograph No. 2 - Locks and mouth of Wolfe Creek

Watershed Alteration

The old East Fork ravine valley is still traceable along 31st Ave. W. On the West Fork, there is a portion of the old ravine preserved on a street right of way south of West Government Way. A culvert carries the stream water north under West Government Way, with the water bubbling up in a pool on the north side of the street. To the southwest, the landscape was highly altered by grading to construct military buildings at the former Fort Lawton. The Wolfe Creek West Fork valley has been obliterated relative to its former condition. Storm drains on the east side of Discovery Park divert surface water that originally drained into Wolfe Creek into pipes. Also, sewer pipes are supported on trestles above ground along the East Fork and in the ravine south of West Government Way.

Drainage in the Wolfe Creek watershed has been significantly modified over the past 100 years. Major sections of the creek have been blocked by fill and street construction. The upper reaches of the creek, south of West Government Way, have been filled and diverted to underground pipes that daylight only a small section prior to reaching West Government Way. The creek is daylighted through Kiwanis Ravine, and at the north end, it flows into the sewer trunk line and is conveyed to the West Point Treatment Plant.

Although much of the original Wolfe Creek watershed surface water now flows into combined sewers in the area, a portion of the original watershed including a number of street ends and rooftops drain directly into Kiwanis Ravine. The remaining tributary area of the creek watershed is highly impacted by urbanization and contributes to higher peak flows in the creek as well as affecting water quality.

Wolfe Creek is a perennial stream fed by numerous seeps and base flows are likely lower than in the past due to the loss of upstream wetlands. Peak flows are also higher due to increased runoff from surrounding street end drains and added impervious surfaces in the urbanized watershed. These higher peak flows typically accelerate channel erosion and can result in slope instability and surficial sloughs in the ravine. The eroded sediments and soils that slough into the creek channel are transported downstream until they are trapped at the inlet structure on the south side of the BNRSF tracks. Sediments not retained upstream of the inlet structure are conveyed in the sewer trunk line to the treatment plant.

3. Concept Feasibility Study Objectives

The six objectives of this Wolfe Creek Daylighting Concept Feasibility Study are as follows:

1. Promote the development of a viable plan for daylighting Wolfe Creek to provide a source of freshwater in the estuarine mixing zone for salmon migrating through the Ship Canal;
2. Coordinate the input and documentation of the various stakeholders' objectives for the project;
3. Summarize and establish project objectives to provide a basis for evaluating the alternatives;
4. Complete technical review of ten design alternatives including additional geomorphological, biological, and hydrologic/hydraulic assessment of the creek system. Identify information gaps and evaluate alternatives using the project objectives to select three preferred alternatives; and
5. Prepare updated construction costs of the three preferred alternatives, summarize permitting requirements, next steps and identify funding options. Document the results of the study in a technical summary memorandum.
6. Draft initial pages of Project Development Plan (PDP) forms for SPU use in project assessment.

Summary of Ten Daylighting Alternatives

A number of studies and concept designs have been prepared for the proposed daylighting of Wolfe Creek. The intent is to promote the development of a viable plan for daylighting Wolfe Creek to provide a source of freshwater in the estuarine mixing zone for salmon migrating through the Ship Canal. The following ten alternatives (see Table 1), some of which are only partial alternatives or concepts of portions of an alternative, have various attributes with all generally meeting the intent of daylighting the Creek. It has been

assumed that site constraints and associated costs preclude the construction of passage for fish upstream into Kiwanis Ravine (see Appendix A).

Table 1 – Summary of Ten Daylighting Alternatives			
Number	Alternative Name	Description	Cost
A	SvR Option A	New Outlet Culvert to Elev. 24; results in 80 ft of new channel	$535,000
B	SvR Option B	Long pipe, follows easements to Elev. 33; 140 feet of new channel	$1.7M
C	SvR Option C	Longer pipe, deep manholes, follows Right of Way to Elev. 33; 140 feet of new channel	$2.9M
D	Ken Nilson Mgmt. Plan 2003	Extend channel from north side of West Commodore Way west to outlet near the RR Bridge	
E	Brennan Alt. #1	Extend channel from north side of West Commodore Way north to outlet in Salmon Bay; Marsh near RR Bridge	
F	Brennan Alt. #2	Marsh near RR Bridge, clarify daylighting?	
G	Brennan Alt. #3	Extend channel from north side of West Commodore Way west to outlet near the RR Bridge; fish passage/estuary through park.	
H	Brennan Alt. #4	Extend channel from north side of West Commodore Way west to outlet near the RR Bridge; fish passage/estuary through park; combine with Fish Ladder flow.	
I	Robin Clark Concept	Extend channel from north side of West Commodore Way north to outlet in Salmon Bay at COE stairs into water.	
J	Clayton Beaudoin's MS Plan	Extend channel from north side of West Commodore Way west with switchback to outlet near the RR Bridge; fish passage/wet meadow through park	

Summary of Project Design Objectives and Stakeholder Input

Project stakeholder input was obtained using a project questionnaire and follow-up emails and phone calls. The questionnaire was sent out to 1 or 2 people in 20 potentially interested stakeholder groups (see Appendix B). Nine surveys were completed and

returned by stakeholders and two stakeholders responded that they would wait until a later stage of the project to provide input.

Stakeholder input was summarized into the following six main design objectives based on stakeholder questionnaire input supplemented by Wolfe Creek Daylighting quarterly meeting notes in the Task 2 Technical Memorandum (February 8, 2008):

- Aesthetic-Recreational,
- Habitat/Fisheries/Wildlife,
- Water Quality/Watershed Protection,
- Engineering,
- Education, and
- Cost-Benefit.

Each design objective has several subcriteria that define it. These project design objectives were used to qualitatively evaluate the ten daylighting alternatives and provide the framework for selecting the preferred creek daylighting alternatives: (for a complete summary of stakeholder input – see Appendix B).

4. Technical Considerations for Alternatives Analysis

The following describes pertinent technical information relevant to the alternative evaluation including site geomorphology, hydrologic/hydraulic considerations, biological considerations and water quality data.

Site Geomorphology

The geomorphology of the site is relatively uniform and is described in more detail in Appendix C. The most significant consideration is that the native soils are likely alluvial deposits from the Wolfe Creek basin. These soils are likely to consist of unevenly graded and compacted silts, sands and gravels. Due to the construction of the Burlington Northern Santa Fe (BNSF) Railway line, Locks and Ship Canal, and Commodore Park, areas of fill may also be encountered. Thus, depending on the soils found along the proposed alignment, the final channel will likely need to be lined with an impermeable liner. Typically the liner would be a buried HDPE or PVC membrane or a clay (bentonite) layer beneath the channel invert.

Another consideration is channel stability. The soils described above are erodible, so stabilization measures, particularly on the steeper gradient sections, will be needed for a daylighted channel. These measures are expected to consist of selected native plantings, woody debris, and profile grade control points such as pools created by log step-downs or rock weir and channel armor using natural stone lining.

Thus, geomorphologically, all ten alternatives are similar and the requirement for lining and stabilization will likely increase as the length of the daylighted channel increases. As

a result, alternatives with longer daylighted segments will incur higher costs. Otherwise, the alternatives are essentially similar with respect to geomorphological considerations.

Hydrologic/Hydraulic Considerations

The primary hydrologic/hydraulic consideration with respect to the daylighted section is the impact of high flow rates in the daylighted segment. Only three of the 10 alternatives detailed the approach to bring Wolfe Creek to a daylighted channel in Commodore Park. Each of these three alternatives showed different pipe alignments that carried the entire creek flow to the daylighted channel. This approach results in significant hydrologic and hydraulic concerns for the daylighted reach since it would be subjected to the wide range of flows generated by various rainfall events. Specifically, extreme rainfall events could result in high flows that could cause significant damage to the channel structure and riparian plantings.

The SPU report estimated a base flow of 0.4 cfs measured on January 17, 2003 and subsequently used the 0.4 cfs value as an estimated average flow. The SPU study notes that for the preceding summer and fall of 2002, there were unusually low amounts of precipitation. Although these estimates may under-estimate the base flow, this study has not made any further investigation regarding the base flow indicated. We made an approximation of peak flows from the creek using a simple Santa Barbara Urban Hydrograph (SBUH) model (Springer Netherlands, 1998) based on a sub-basin area of approximately 50 acres.

The original sub-basin was much larger, but a brief review of the SPU ditch and drain system shown in the GIS data supplied by the City indicates that much of the runoff is now diverted from the creek. The SBUH model of a 50 acre basin using a Type 1A storm for a 24-hour event yielded estimates of a range of peak flow from 4 cfs for 2-year event to 18 cfs for a 100-year event. Figure 2 shows the topography defining the Wolfe Creek basin and the approximated basin limits used in this analysis. A summary of the hydrologic results are included in Appendix D.

A continuous simulation model such as the Western Washington Hydrology Model, Version 3.0 (WWHM3) (WDOE, 2008) could be used in place of the SBUH model to estimate flows and may provide a more accurate basis for future design efforts. A more careful delineation of the tributary basin including identifying discharge points of piped flows and street-end runoff would also improve the accuracy. Since the schemes that are proposed for further analysis are expected to only divert base flows and runoff from smaller events, more accurate estimates of extreme event flows are not required for this study. It is assumed that the existing pipe would continue to convey the higher event flows to the sewer trunk line as it currently functions. Future, more comprehensive design efforts would be expected to include more complete hydrologic modeling to refine the diversion structure components and confirm that the existing pipe has sufficient capacity.

Since the extreme event flows could be damaging to the restored creek channel, the proposed diversion is assumed to divert only the creek base flows and peak flows up to a 2-year event. The concept for the diversion weir has been designed to provide diversion of the low flows to the daylighted creek channel and maintain the higher flows in the existing combined sewer. The following table summarizes the flows and distribution of the flow in the daylighted creek and the combined sewer that discharges to the King County sewer trunk line in West Commodore Way.

Table 2 - Summary of Flows with Diversion to Daylighted Creek			
Storm Event	Creek Flow (cfs)	Flow to Daylighted Creek (cfs)	Flow to King Co. Sewer (cfs)
Base Flow	0.4	0.4	0.0
2-year, 24-hour	4	4	0
10-year, 24-hour	9	5	4
100-year, 24-hour	18	6	12

Since the proposed preferred alternatives are intended to only divert flows up to a selected maximum, the proposed channel section can be designed for this maximum flow rate without concern of the damage from higher flow rates. This will minimize the extent of measures required for stabilization. As noted above, this approach assumes that the peak flows from extreme events would continue to overflow to the existing King County sewer trunk in West Commodore Way. Further hydrologic analysis is needed to confirm these peak flow assumptions for the design of the diversion structure, piping and channel sizing. A more detailed delineation of the sub-basin boundary, additional discharge from street runoff and impacts of longer duration or multiple events could result in much higher estimates of flow. A more detailed analysis could also study the effects of natural channel obstructions and flow attenuation that can be expected in the restored Kiwanis Ravine wetlands.

Further work on recapturing tributary flows from the east side of Discovery Park (an area that was formerly part of the Wolfe Creek watershed, but that currently drains into a culvert at approximately 36th Ave. W., about a block south of W. Govt. Way) and from areas east of the Locks is needed to determine the feasibility of expanding the existing tributary drainage area. Additional runoff from City right of way and residential areas could also be introduced if adequate measures for peak flow control and water quality treatment are provided. An analysis of the potential benefits, impacts, and costs for implementation of these concepts is not included in this study.

The sizing of the conveyance elements was based on the estimate of peak flows for the existing sub-basin runoff. Although we only found limited information on the as-built condition of the existing pipe system, it appears that the total drop in elevation for the culvert that runs north from the daylighted portion of Wolfe Creek under the BNSF Railway tracks to its discharge to the King County trunk sewer is only about 12 feet (not the 40 feet as previously reported). This represents an average slope of approximately 2% - 3%. If the creek were daylighted through this section, this slope would allow the construction of a fish passable profile, although the low flow will likely limit the size of

fish that could gain access to areas upstream of this section. Daylighting the creek in this section would likely require a new culvert under the BNSF Railway tracks to raise the flow line closer to the ground surface; the higher channel would also result in the benefit of a shallower crossing under West Commodore Way and daylighting at a higher elevation in Commodore Park on the north side of West Commodore Way.

The hydraulic analysis for the proposed concepts was based on the flows as noted above. Pipe and channel capacities were calculated using Manning's equation (Clark, et al, 1977) for the circular pipe and trapezoidal shaped channels. A roughness factor of 0.013 was assumed for concrete pipe and 0.030 for the new daylighted channel sides and bottom. The proposed pipe and channels are generally larger than needed for the flows indicated and may be adjusted as the design is further defined.

Biological Considerations

Because this project does not include the assessment of fish passage within the daylighted portion of the creek, biological considerations are limited to the beneficial impacts of additional freshwater and import of additional food resources to Salmon Bay. These considerations are explained in more detail in Appendix E. Since all ten daylighting alternatives (with the exception of Alternative F that doesn't daylight the creek) add freshwater to Salmon Bay equivalently, this parameter has limited bearing on the alternative selection.

Much of the increase in food production by the daylighting is expected to be from the transport of food that falls from the overhead canopy into the creek in the forested ravine. Accordingly, all of the daylighting alternatives will provide this same benefit and new food source to Salmon Bay. The daylighted portion will provide additional substrate for the growth of food, and opportunity for planting of riparian vegetation parallel to the daylighted channel that could also be a food source, so a small portion of the addition of food resources is proportional to the length of daylighted creek. Thus, the longer the daylighted segment, the better the alternative is for the health of fish. Additional considerations include disruption of the biological function (including the healthy population of bull trout, an ESA listed species, currently using the small beach area [Chuck Ebel, Pers. Comm., 2006]) and the potential impacts to a small portion of the last remnant of the natural shoreline in the area.

The general assessment of flow is that there is not enough water in the creek for many fish. Flows are too low for salmon spawning or similar sized fish. However, cutthroat trout and other smaller sized fish have been observed in very small creeks throughout the Puget Sound basin, so their ability to live in Wolfe Creek should not be underestimated. As such, the design of the daylighted channel should include measures for fish passage to the extent that it is feasible. Preliminary review of the stream profile suggests a steep section on the north side of West Commodore Way could be a barrier to passage.

Preliminary studies of the profile show a significant vertical drop (up to 10 feet vertical over 20-30 feet horizontally) immediately north of West Commodore Way which would be a barrier to fish if the drop between pools is too great. There is limited space in that area so it may be difficult or too costly to construct enough pools (or "steps") for fish to climb to reach the grade of the creek on the south side of West Commodore Way. In addition to the steep profile, long sections of pipes are also considered barriers to fish passage so the limitations on the extent of daylighting could also result in a barrier to fish passage.

Further information is required to determine if there is sufficient creek flow to create viable estuarine conditions. However, this is one of the few readily available sources of freshwater that can be used to improve estuarine conditions in Salmon Bay. The size of the estuarine marsh would depend on the site topography, creek flow, and whether or not the design limits impacts to the existing beach function.

Water Quality Considerations

King County Wastewater Division conducted sampling and analyses on three occasions for basic water quality parameters at three locations along Wolfe Creek (the culvert located at the north end of the main stem channel, and in the East Fork and the West Fork, see Appendix F). Samples were collected on September 8 and November 13, 2007, and on January 23, 2008 and analyzed for nitrogen (ammonia and nitrite/nitrate), E. coli and fecal coliform bacteria. Field measurements of dissolved oxygen, pH, and temperature were collected at all three sampling stations. Stream flow was measured only on the main stem of Wolfe Creek (station WC001, the location where the creek goes into the King County sewer trunk line).

The sampling results for each parameter are within the typical ranges found in other urban creeks in and near Seattle. Parameters at all stations on all sampling dates were relatively consistent with the exception of temperature, dissolved oxygen and bacterial counts. Dissolved oxygen was relatively consistent amongst sampling stations and was lowest in the September sampling event and highest in the January sampling event. Temperature was also reasonably consistent amongst sampling stations and was significantly higher in the September sampling event, becoming progressively lower in the subsequent sampling events. Both E. coli and fecal coliform bacteria counts were highest in September and progressively lower in the subsequent sampling events. The East Fork sampling station (WC002) bacterial counts (both E. coli and fecal coliform) in September were significantly higher than all other recorded counts. Field observations indicated high turbidity and organic matter in the creek during the September sampling event, however these parameters were not measured and there is no indication of conditions regarding turbidity and organic matter on subsequent sampling dates.

The elevated bacterial counts at the East Fork sampling station may be associated with septic systems, side sewer leakages or animal wastes. The improvements in both the E. coli and fecal coliform bacteria counts at all sampling stations between the September

and January sampling events may relate to the first flush of dry season build up of residential yard contaminants that comes with the September rains, followed by dilution during the rainy season. Water quality testing is hoped to be continued at the same locations to improve this initial dataset in future years. In addition, some form of flow measurement device such as a staff gage (rating curves will need to be developed) may be installed to improve flow data collection efforts. Inspection of side sewers by video and smoke testing could help identify leaking pipes or illicit drains that may be affecting water quality.

5. Comparative Analysis of Daylighting Alternatives

The ten daylighting alternatives were qualitatively compared using a matrix evaluation approach that is frequently applied in feasibility studies (for example, the Gas Works Sediment Eastern Study Area Remedial Investigation and Feasibility Study, The RETEC Group, Inc., 2006). The alternatives provide a range of options with various advantages and disadvantages depending on the design criteria. Some alternatives have unique characteristics. Each of the design objectives (and associated subcriteria) was used to analyze and create a relative rank for each daylighting alternative.

This qualitative method results in a relative rank (high, medium, or low) for each alternative. This rank corresponds to how favorably or unfavorably that alternative scored under each subcriterion. Each subcriterion under each design objective was first given a "weight" of 1 to 3, with 1 being the least important and 3 being the most important. For example the subcriterion for removing the creek flow from the sewer system was given a weight of 1, or least important, because of the relatively limited flow removed compared to the overall volume of flow in the King County trunk. In comparison, maximizing length of stream daylighted was given a weight of 3 to reflect the importance of open channel length. Alternatives were also scored for effectiveness from 0 (least effective) to 5 (most effective) relative to each subcriterion. A total was then calculated by multiplying the weight times the score. The scores for each subcriterion were then summed to develop a total rank for each alternative. This analysis of each of the ten daylighting alternatives is presented in Table 3.

Based upon the comparative alternative analysis shown in Table 3, Alternative H ranks as the highest scoring most preferred alternative. Alternatives D, I, G and J all rank similarly within the middle tier and Alternatives A, B, C and E rank in the lowest tier, or as the least preferred alternatives. Alternative F has an even lower rank because it does not meet the project objective of daylighting the creek.

Following the table is a summary of how the alternatives ranked and a brief discussion of their advantages and disadvantages with respect to the design criteria.

Table 3 - Alternative Evaluation Spreadsheet
Wolfe Creek Daylighting Feasibility Study

Daylighting Options	Wt	A		B		C		D		E		F		G		H		I		J	
		Scr	Tot.	Scr	Tot.	Scr	Tot.	Scr	Tot.	Scr	Tot.	Scr	Tot.	Scr	Tot.	Scr	Tot.	Scr	Tot.	Scr	Tot.
Design Objectives																					
Aesthetic/Recreational																					
Neighborhood amenity	2	1	2	2	4	2	4	3	6	1	2	2	4	3	6	3	6	3	6	3	6
Protect/enhance Parks resources and activities	3	1	3	1	3	1	3	3	9	1	3	2	6	3	9	3	9	3	9	3	9
Minimize impacts to Commodore Park infrastructure	2	3	6	3	6	3	6	2	4	3	6	2	4	2	4	2	4	2	4	2	4
Habitat/Fisheries/Wildlife																					
Promote healthy/sustainable environment & shoreline	3	1	3	1	3	1	3	2	6	1	3	2	6	2	6	2	6	2	6	2	6
Improve/restore/enhance fish habitat in creek	2	0	0	1	2	1	2	2	4	0	0	0	0	2	4	2	4	2	4	2	4
Provide nearshore/estuarine habitat for migrating salmon	3	1	3	1	3	1	3	2	6	1	3	2	6	2	6	2	6	2	6	2	6
Support GBH colony (nesting especially)	3	1	3	1	3	1	3	2	6	5	15	4	12	4	12	4	12	2	6	3	9
Coordinates with future fish ladder improvements/reconstruction	2	2	4	2	4	2	4	2	4	5	10	5	10	2	4	5	10	2	4	2	4
Water Quality/Watershed Protection																					
Provide freshwater input to restore/improve salinity transition	3	5	15	5	15	5	15	5	15	5	15	0	0	5	15	5	15	5	15	5	15
Maximize length of stream daylighted	3	1	3	2	6	2	6	3	9	1	3	0	0	3	9	3	9	3	9	3	9
Improve Wolfe Creek and Salmon Bay water quality	2	1	2	2	4	2	4	3	6	1	2	0	0	3	6	3	6	3	6	3	6
Engineering																					
Remove the flow of the creek from the sewer system	1	5	5	5	5	5	5	5	5	5	5	0	0	5	5	5	5	5	5	5	5
Simplify pipeline/infrastructure to minimize costs	3	2	6	1	3	0	0	n/a	0	n/a	0	n/a	0	n/a	0	n/a	0	n/a	0	n/a	0
Technically feasible and constructable	3	4	12	3	9	2	6	n/a	0	n/a	0	n/a	0	n/a	0	n/a	0	n/a	0	n/a	0
Adapts to existing geomorphology and soils	2	0	0	1	2	1	2	2	4	0	0	n/a	0	2	4	2	4	2	4	2	4
Education																					
Improves connection between people and water at Commodore Pa	2	1	2	2	4	2	4	3	6	1	2	2	4	4	8	5	10	3	6	4	8
Educate citizens about urban watersheds	2	1	2	2	4	2	4	3	6	1	2	1	2	4	8	4	8	3	6	4	8
Opportunities for public education throughout the site	2	1	2	2	4	2	4	3	6	1	2	2	4	4	8	4	8	3	6	4	8
Cost-Benefit																					
Minimize costs	3	4	12	0	0	0	0	n/a	0	n/a	0	n/a	0	n/a	0	n/a	0	n/a	0	n/a	0
Minimize impacts to private property	3	0	0	0	0	3	9	n/a	0	n/a	0	n/a	0	n/a	0	n/a	0	n/a	0	n/a	0
Reduce long term maintenance costs	2	1	2	1	2	1	2	n/a	0	n/a	0	n/a	0	n/a	0	n/a	0	n/a	0	n/a	0
TOTAL Rank			76		86		89		102		73		58		114		122		102		111

Comments:
n/a indicates insufficient information to complete for alternative analysis.
D, E, G, H, and I are not complete options because they do not show the infrastructure required to daylight the creek on the north side of Commodore Way as F does not appear to daylight Wolfe Creek
Color Key:
Top Tier Option - Grand Scheme Coordinating with Fish Ladder
Middle Tier Options - Moderate extent of daylighting Creek
Bottom Tier Options - Minimal extent of daylighting
Does not meet Project Criteria - No portion of daylighting

Notes: Weight can be 1-3 (one is least important, 3 is most important); Score is 0-5 (0 is least effective, 5 is most effective); and Total is weight times score

Aesthetic-Recreational

Alternatives D, G, H, I, and J followed by F ranked highest for neighborhood amenities and enhancing park activities because of their longer daylighted length, or in the case of F, its enhanced wetland area to the west and the fish ladder improvements. However, these same alternatives ranked lower for impacts to park infrastructure due to their extensive modifications and reconstruction of elements within Commodore Park. Alternatives A, B, C and E ranked high for protecting park infrastructure, but because of the shorter daylighted length, they ranked lower for the other two aesthetic/recreational subcriteria.

Habitat/Fisheries/Wildlife

Alternatives D, G, H, I and J rank the highest for most of the subcriteria under this design objective because of their longer daylighted length and/or more complex habitat benefit to fish and wildlife. Conversely, Alternatives A, B, and C ranked lowest for most of the subcriteria under this design objective. Alternative E ranks in the middle overall because it has a low rank for the first few subcriteria, but a high rank for the last few. Note that Alternatives A, E and F scored zero for restoring fish habitat in the creek because of their short (or non-existent for Alternative F) daylighted alignment.

Water Quality/Watershed Protection

All of the alternatives that would daylight the creek (i.e., all but F) ranked high for the first subcriteria of providing freshwater to Salmon Bay. Alternatives D, G, H, I and J rank the highest for maximizing daylighted length and improving water quality in Salmon Bay. The reason the longer daylighted alternatives provide better water quality is due to the ability of wetland areas and stream channels to sequester and thereby reduce typical urban pollutant loads. Alternatives B and C rank in the middle, followed by A and E ranking the lowest for these two subcriteria due to their progressively shorter daylighted sections. Alternative F has no ranking for any of these criteria as it would not daylight the creek.

Engineering

All of the alternatives that entail daylighting the creek (i.e., all but F) ranked high for the first engineering subcriteria because they removed the creek flow from the wastewater system. Alternatives A, B, and C ranked low for pipeline infrastructure, feasibility and constructability. Alternatives D through J ranked zero for these two subcriteria because they do not include an alignment south of West Commodore Way. Alternatives D, G, H, I and J adapt best to the morphology of the existing park contours.

Education

Alternatives D, G, H, I and J, ranked higher for educational opportunities, again because of their longer daylighted length. Alternatives B, C and F, followed by A, ranked lower for the educational subcriteria because of the shorter, or in the case of F nonexistent daylighted length. Note that Alternative F ranks somewhat higher due to its enhanced wetland area to the west and fish ladder enhancement.

Cost-Benefit

Alternative A ranked highest for this suite of subcriteria because of its short daylighted length, followed by C which has the lowest impacts to private property and B; however, the high cost of B and C lowered their ranking. Further comparison of Alternatives A through C with the other alternatives was not possible because the other alternatives did not indicate how the creek water could be daylighted north of West Commodore Way. Furthermore, these other alternatives (D through J) did not include any estimates of construction costs so there was no basis for making any cost comparisons. The costs associated with Alternatives A, B, and C are considered excessive and as a result these alternatives as originally conceived are deemed as not warranting further consideration. As described below, elements of these alternatives were considered for inclusion in the more cost-effective recommended alternatives.

6. Preferred Daylighting Alternatives

The overall objective of narrowing the ten alternatives to three preferred alternatives is to provide alternatives that span the spectrum of objectives of the stakeholders and combine or modify the alternatives to simplify further daylighting assessment. The selection of the preferred daylighting alternatives was based on the comparative evaluation of each alternative using the design criteria described above. This comparative evaluation was difficult because the ten alternatives provided varying degrees of completeness and levels of detail.

Only Alternatives A, B and C represented complete concepts because they show how the creek flow would be removed from the sewer trunk line south of West Commodore Way in addition to showing the daylighting configuration north of West Commodore Way in Commodore Park. Although generally complete in terms of infrastructure, Alternatives A through C provide little detail of the daylighted creek channel and associated amenities north of West Commodore Way. Conversely, Alternatives D, E, G, H, I, and J showed more channel and daylighted features, but are not complete concepts because they do not show the infrastructure on the south side of West Commodore Way that is required to daylight the creek in Commodore Park. In addition, several alternatives show alterations to the fish ladder and wetland enhancement areas in Commodore Park that are not included in most alternatives. Some of the alternatives showed only a line representing the creek alignment with little other details regarding the work.

In order to resolve the variability between alternatives, the proposed alternatives have been reconfigured to address the daylighting in two parts. The reconfiguration also allows the comparison and evaluation of the key concepts presented in Alternatives A through J, and provides a basis for moving forward with viable comparable alternatives. The reconfiguration consists of dividing the daylighting components into two parts: 1) separating the creek flow from the sewer trunk line (this will be implemented south of West Commodore Way), and 2) designing a daylighted channel through Commodore Park (north of West Commodore Way).

These two parts generally correspond to the geographical division of segments south and north of West Commodore Way. The concepts south of West Commodore Way address the separation of creek flows from the sewer trunk line, and the concepts north of West Commodore Way focus on the alignment and features of the daylighted creek in Commodore Park. This restructuring and reordering of elements results in a clearer comparison of the features and will support the advancement of the project. Schematic plans and renderings of these alternative configurations are included in Figures 3-10. A summary of the resulting preferred daylighting alternatives is presented below in the order that they would need to be implemented to daylight the creek. Because the creek flows from south to north, the alternatives are described in that order. HHH has accepted that these four alternatives meet the initial objective of identifying "three preferred alternatives".

Preferred Alternatives South of West Commodore Way

Revised alternatives are proposed as the preferred alternatives for the area south of West Commodore Way, between the Kiwanis Ravine (BNSF Railway tracks) and West Commodore Way. These two new alternatives develop the infrastructure required to daylight the creek in the future. While these alternatives do not actually daylight the creek in this section, they provide the separation of the sanitary flows of the three residences from the creek flows, with the intent that full daylighting of the channel could more easily occur in the future.

As noted above, Alternatives A, B and C were dropped from further consideration due to the combination of excessive excavation depths and associated costs for the piping routes and disruption to private property. Similar to Alternative A, two new lower cost alternatives outlining piping schemes for the diversion of creek flows with minimal disruption to private property were developed, and result in the following two preferred alternatives for further assessment:

- Alternative 1 South – Pipe Diversion
- Alternative 2 South – Directional Drilling

Alternative 1 South – Pipe Diversion consists of a new manhole diversion structure that intercepts the combined sewer containing the Wolfe Creek flow just upstream of the existing manhole in the front yard of 3321 West Commodore Way (on the south side of West Commodore Way). A new pipe from the new manhole would cross West Commodore Way to deliver the Wolfe Creek water to Commodore Park on the north slope of West Commodore Way (Figure 3). The proposed new manhole diversion structure would contain a weir or other control device that would limit flows that would be diverted across West Commodore Way to a selected maximum. Any flows exceeding the designed maximum would be directed to the existing manhole at 3321 West Commodore Way and be allowed to flow into the King County sewer trunk line as they do today. This alternative requires building new side sewers for homes at 3307 and 3319 West Commodore Way to remove the sewage from the combined sewer. Thus the

existing pipe connection to the sewer trunk line would remain for sewer flows and creek flows that exceed the maximum design. The advantages and disadvantages of this alternative include:

Advantages:

- Conventional cut and cover pipe installation outside the right of way has limited risk of unforeseen difficulties;
- Proposed jacking of casing under the roadway will reduce impacts to the street traffic; and
- Diversion structure located near West Commodore Way is readily accessible for inspection and maintenance.

Disadvantages:

- The construction of a new side sewer will disrupt private property;
- It discharges on the north side of West Commodore Way lower on the slope, resulting in a shorter daylighted creek channel; and
- The length of the proposed pipe configuration is likely a barrier to fish passage.

Alternative 2 South – Directional Drilling would involve installation of a 12-inch diameter tightline pipe from the south side of the BNSF Railway tracks to the north side of West Commodore Way (Figure 4). Similar to Alternative 1, the connection to the existing pipe containing the creek would also have a flow control feature. Again, the flow into the tightline pipe would be limited to selected maximum and all excess flows would remain in the existing sewer trunk line. Since this diversion would be located upstream of the connections of the residential side sewers, these side sewers do not need to be modified. The advantages and disadvantages of this alternative include:

Advantages:

- The small access pits require minimal disruption to existing private property;
- The existing combined sewer pipe (18-inch culvert) can remain in service and does not require modifications to the side sewers; and
- It discharges on the north side of West Commodore Way higher on the slope, which gives slightly more length of daylighted creek channel.

Disadvantages:

- Directional drilling may not be feasible in the alluvial soils if they are not sufficiently consolidated or too permeable (drill fluid "leaks out" and drilled hole collapses);
- Directional drilling has higher risk of difficulties (and cost impacts) if buried logs or large boulders are encountered or if the drilling unit becomes lodged and is lost in the hole;
- The length of the proposed pipe configuration is likely a barrier to fish passage; and

- The diversion structure located to the north of the BNSF Railway tracks is not readily accessible for inspection and maintenance.

Preferred Alternatives North of West Commodore Way

Similar to the south portion, on the north side of West Commodore Way, amalgamations of the alternative concepts result in the following two preferred alternatives for further assessment. The following two alternatives for daylighting Wolfe Creek north of West Commodore Way span the spectrum of costs, benefits and impacts for the daylighted creek:

- Alternative 1 North – Short Daylight
- Alternative 2 North – Long Daylight

Alternative 1 combines the daylighted creek concepts from Alternatives A, B, C and E which ranked as least preferred alternatives. These represent the lowest cost and least impact to existing park infrastructure and therefore need to be retained as a baseline alternative for further consideration. Alternative 2 combines concepts from Alternatives D, G, I and J which all overlapped somewhat and had a secondary or middle tier ranking. Alternative 2 can also be readily integrated with a future phase of enhancement of the western estuary and the fish ladder (see below) which would make it equivalent to Alternative H, the highest ranked or most preferred alternative.

Alternative 1 North – Short Daylight consists of the construction of a short daylighted channel due north to Salmon Bay. The channel would be steep and would primarily function as a cascading water feature before it discharges to the Bay as shown in Figure 5 and illustrated in Figure 6. The advantages and disadvantages of this alternative include:

Advantages:

- Lower cost;
- Fewer park infrastructure and user impacts; and
- May be easier to approve and implement.

Disadvantages:

- Steep channel is has limited habitat function and educational opportunities;
- Steeper, shorter channel will produce less fish food; and
- Does not coordinate well with potential future project phases (described below).
- Discharges through a pipe in the bulkhead instead of a natural daylighted channel to the beach.

The following photograph shows the short daylight channel alignment looking upstream from the sidewalk just south of the bulkhead at the edge of Salmon Bay. It shows the steeper "cascade" reach to the left of the stairs and the flatter section in the foreground before it would enter the pipe and flow out into Salmon Bay.

Photograph No. 3 - Alternative 1-Short Daylight alignment looking south (upstream) from the ACOE bulkhead

Alternative 2 North – Long Daylight consists of the construction of a longer daylighted channel through Commodore Park west toward the small cove at the downstream or west end of Commodore Park. The alignment generally follows the sidewalk just above the concrete shelter and would discharge onto the small beach in the cove at the west end of the concrete bulkhead (See Figure 7 and illustration in Figure 8). The sidewalk above the shelter would be removed and the slope regraded to provide some visual interest on the hillside above the creek and to provide more space for the creek meander pattern and pools. The sidewalk would be replaced with a path that follows the daylighted creek and would include stepping stone or bridge crossings to allow park visitors to interact with the creek. A three sided box culvert and a small pedestrian bridge structure would maintain the other sidewalks serving Commodore Park at the creek crossings. The advantages and disadvantages of this alternative include:

Advantages:

- Longer channel has more habitat function and educational opportunities;
- Longer, meandering channel will produce more fish food; and
- Readily coordinates with potential future project phases (described below).
- Provides fresh water discharge at a location that can provide more estuarine conditions.

Disadvantages:

- Higher cost;
- More park infrastructure and user impacts; and
- May take longer to approve and implement.

The following picture shows the lower portion of the long daylight option alignment. The view is looking downstream (toward the west) and shows the sidewalk that would be removed for the proposed channel.

Photograph No. 4 - Alternative 2-Long Daylight alignment looking west

Preferred Alternative Preliminary Concept-Level Cost Estimates

The four preferred alternatives were evaluated with respect to estimated capital costs. Preliminary concept-level construction cost estimates for each of the four preferred alternatives are provided in Appendix G. Cost estimates used for this phase of the process are based on current (2008) unit prices for similar types of work in the Puget

Sound region. They include allowances for mobilization, erosion control, traffic control and other activities associated with the various work items. The unit prices are assumed to include all contractors' costs for equipment, labor and materials with overhead and profit. The cost estimates include a 30% contingency to reflect the many unknowns and possible cost impacts that may be discovered as the design progresses. The estimates do not include Washington State Sales Tax, or allowances for administrative, permitting, survey, design or construction administration costs. Costs for construction easements, permanent easements and land acquisition are not included. The following table summarizes the estimated construction cost for each alternative.

Table 4 - Summary of Estimated Construction Costs	
Alternative 1 South – Pipe Diversion	$440,000
Alternative 2 South – Directional Drilling	$460,000
Alternative 1 North – Short Daylight	$270,000
Alternative 2 North – Long Daylight	$790,000

Combined Preferred Alternatives

The preferred alternatives identified for the south and north of West Commodore Way daylighting segments may be combined in any way to form a selected alternative. For example Alternative 1 South may be combined with Alternative 1 North or it could be combined with Alternative 2 North. Similarly, combined alternatives could be developed for Alternative 2 South. These combined south and north preferred alternatives result in a total of four possible preferred alternatives (Alternative 1 South plus Alternative 1 North; Alternative 1 South plus Alternative 2 North; Alternative 2 South plus Alternative 1 North; Alternative 2 South plus Alternative 2 North). These four preferred alternatives meet the project objective of reducing the 10 alternatives to fewer preferred alternatives. In addition, each of these preferred alternatives are readily comparable in terms of costs, benefits, and technical feasibility for future evaluations. HHH has accepted that these four alternatives meet the initial objective of identifying "three preferred alternatives".

In addition to these four preferred alternatives, elements from several of the 10 alternatives and new concepts were developed for future phases of work. These are briefly described in the following section. Development of these future concepts could be the focus of future studies.

Potential Future Project Phases

Some elements of the ten alternatives considered in this study are more closely associated with extensive modifications to Commodore Park and were beyond the scope of this report to evaluate. However, because they are important concepts, they are retained as considerations for future phases of work. In addition, the above alternatives for both

South and North of West Commodore Way have been developed to enable coordination with these potential future phases of work. The future phases are shown on Figure 9 (see illustration in Figure 10) and described briefly here:

- Future Phase South – Complete Wolfe Creek Daylighting Between BNSF Railway and West Commodore Way
- Future Phase North –Western Estuary and Fish Ladder Enhancement

Future Phase South – Complete Wolfe Creek Daylighting consists of the long-range or ultimate vision for the complete daylighting of the creek. This potential future phase would involve, over time, acquiring private property or easements along the former creek bed between the BNSF Railway tracks and West Commodore Way. This segment of daylighted channel would add to either Alternative 1 or 2 South to form a completely daylighted corridor that connects to the selected alternative north of West Commodore Way. The residences currently constructed adjacent to the pipe would need to be removed to provide space for the daylighted channel. If the property is acquired, the daylighted reach between the BNSF Railway tracks and the street could include wetland restoration adjacent to the creek and would result in a nearly complete natural riparian corridor from Salmon Bay to the railroad tracks.

This plan would require significant financial support and approval for purchase of the residences and/or acquisition of necessary easements for the work. An additional element of this future phase could include completion of the daylighting under the BNSF Railway tracks to connect with Wolfe Creek in Kiwanis Ravine. This portion of the project would require extensive coordination with BNSF Railway for crossing under the tracks with a large three-sided box culvert or replacing the earthen berm supporting the tracks with a bridge structure that would allow the complete "daylighting" of the creek. A large box culvert would not provide as much "daylighting" as a bridge but it may be more acceptable to BNSF Railway and would provide sufficient light for fish passage and movement of other wildlife along the corridor.

Future Phase North –– Western Estuary/Fish Ladder Enhancement consists of the long-range or ultimate vision for the Commodore Park enhancements for salmon migration that integrate with the daylighted Wolfe Creek. This potential future phase for north of West Commodore Way includes two additional elements that can be added to either Alternative 1 or 2 North and implemented in phases. If the additional section of creek between the BNSF Railway tracks and West Commodore Way is daylighted (see Future Phase - South), the new channel at a higher elevation could result in additional daylighted channel within Commodore Park. The second element is the construction of a marsh or estuarine enhancement at the outlet of the creek at the west end of Commodore Park. Nearshore riparian enhancement along with a high and low brackish estuarine area would be created. This work would need to address concerns of impacts to the small portion of the beach environment and park use.

Finally, the long-term improvements could include the coordination of the reconstruction of the fish ladder at the Hiram Chittenden Locks with the Wolfe Creek daylighting

project for improved habitat function, aesthetic benefit and educational opportunities. Fish ladder redesign and reconstruction is recommended to aide survival of both the endangered Puget Sound Chinook salmon and the Puget Sound steelhead by the National Marine Fisheries Service (NMFS, 2008). Fish ladder reconstruction would include an extended series of open-air concrete rocky pools and drops to replace the existing fish ladder. This extended set of pools will provide a more gradual salinity transition for migrating salmon, replacing the more abrupt salinity change of the existing fish ladder. Separation of these elements into phases could help facilitate funding and implementation of the work.

7. Potential Permitting Requirements and Funding Sources

The following subsections describe the potential permitting requirements and funding sources for the daylighting project.

Potential Permitting Requirements

The permits required for each of the preferred alternatives will vary, depending on property ownership where construction will occur and the extent of work that will occur in wetland and shoreline areas. The project permitting requirements are numerous and will be determined by the specific alignment, design, and components of the selected alternative. The permits required for each alternative may include:

- City of Seattle Department of Planning and Development (DPD) may require the following permits (Joe Berentsen, Pers. Comm., March, 2008): Grading, Drainage, Building permits for retaining walls, bridges or other structures, street use, and a Shoreline Substantial Development permit. Environmentally Critical Areas (ECA) development standards will have to be met. Seattle Parks and Recreation Department approval is required (park property and review and construction permitting procedure, they also specify SEPA requirements in their code). Parks may also require a permit for "Non-park use of Park Property" due to work in the Kiwanis Ravine (handled by Seattle Parks and Recreation's Real Estate Department).
- King County – no permits, but will have to coordinate with the Wastewater Treatment Divisions regarding re-routing of flows out of West Point sewer main.
- Washington Department of Fish and Wildlife (WDFW) Habitat Program - Hydraulic Project Approval (HPA);
- State Fish Habitat Enhancement Projects
- Washington State Department of Ecology - Section 401 Water Quality Certification
- Washington State Department of Ecology Coastal Zone Management Certification
- NEPA/SEPA review

- U.S. Army Corps of Engineers Discharge of Dredge or Fill Material into Water (Section 404 Permit)
- U.S. Army Corps of Engineers Permit for Work in Navigable Waters (Section 10 permit)
- National Oceanic and Atmospheric Administration (NOAA)-National Marine Fisheries Service (NMFS) Biological Assessment (BA) (listed salmonid, orca, essential fish habitat, and other marine resource concerns).
- Wetlands permitting requirements. For work in or near wetlands, Federal, State, and Local governments may all have specific permit requirements. At the Federal level, the Army Corps of Engineers regulates wetlands under the Clean Water Act and Coastal Zone Management Act. Aspects of this authority have been delegated to Washington's Department of Ecology. Washington State agencies regulate wetlands under the Hydraulic Code, State Water Pollution Control Act, Shoreline Management Act, and the Forest Practices Act. King County or the City of Seattle regulates wetlands under the Growth Management Act and the Shoreline Management Act.

Many of the permits listed above would be applied for via a Joint Aquatic Resources Permit Application (JARPA).

If the project receives funding through the Salmon Recovery Funding Board or other government funding source, there may be options for streamlining the permitting process.

Potential Funding Sources

Implementation of this project will require the development of various funding sources. To leverage funding, the project will need to continue to build community and agency support, in addition to conducting the next steps to select a preferred alternative as discussed below. Building multiple partnerships and continuing to advocate for prioritization of the project in the Water Resource Inventory Area 8 (WRIA8) planning process is critical to funding.

Seattle Resolution 30850 asks SPU to prioritize which publicly owned creeks/streams could be daylighted. SPU and other city departments have developed criteria, assessed and prioritized these publicly owned creeks/pipes/culverts/ and streams that would contribute towards salmon recovery. Wolfe Creek/Kiwanis Ravine ranked in the top 10 of a list of daylighting project opportunities SPU reviewed based on several scientific and socio-economic criteria (Chris May, Pers. Comm., 2008).

SPU has also developed a Scientific Framework for Ecological Health which supports the previously completed Restore Our Waters report, and the WRIA work. SPU has a triple bottom line: 1) Economic; 2) Environmental; 3) Social (i.e. fishery benefit, environmental education, etc.). SPU will complete a cost-benefit analysis of each proposed project. Daylighting projects are prioritized because of development opportunities such as mitigation money; community support of a daylighting project; or cost sharing opportunities with various agencies (e.g. U.S. Army Corps of Engineers, King County, etc.). The SPU scientific framework report can be used to substantiate a need for grant

funding.

Phasing of the project is another important consideration that will facilitate funding and implementation. A plan should be developed to determine the project funding strategy, i.e., which funding sources will most likely fund different portions of the project. Strategies for City of Seattle funding include: leveraging dollars, getting on the City budget, framing the project to compete with other high impact projects, building a "triple bottom line" analysis, and having a federal/city split of costs (studies split 50/50, Design/Construction split 75/25, Operation/Maintenance – usually 100% City, but because the Locks is involved, federal funding may support O&M).

Potential funding sources for the project may include:

Local and Regional Sources

- Salmon Recovery Funding Board (SRFB) Grant Program
- Community Salmon Funds (King County)
- King Conservation District Funds (KCD)
- King County Drainage Grants
- City of Seattle
    - General fund
    - Seattle Parks (Parks Levy)
    - Seattle City Light
    - Seattle Department of Transportation
    - Real estate excise tax
    - Seattle Public Utilities
    - WRIA8 Salmon Recovery Funds
    - Neighborhood Matching Fund
- Puget Sound Nearshore Partnership Estuary and Salmon Restoration Program (ESRP)
- Puget Sound Cleanup funding
- Puget Sound Coastal Protection Fund
- Tribal funds
- Regional Project Mitigation Funding, i.e. for the new State Route 520 floating bridge replacement project.

State and National Sources

- Washington State Recreation and Conservation Office – Outdoor Recreation and Habitat Conservation Grant Programs - Aquatic Lands Enhancement Account (ALEA)
- Washington State Recreation and Conservation Office – Outdoor Recreation and Habitat Conservation Grant Programs - Washington Wildlife Recreation Program (WWRP)
- Community Salmon Funds (statewide)
- NOAA Coastal Restoration Grants
- NOAA Community Based Restoration Grants
- U.S. ACOE match, for example, federal budget for Locks (2010 construction), the ACOE arboretum could plan for and donate trees and shrubs to the replanting effort in Commodore Park areas

- National Fish and Wildlife Foundation - MoreFish
- National Park Service - Rivers & Trails Program
- National Land and Water Conservation Fund
- Natural Resources Conservation Service
- National Tree Trust
- U.S. Fish and Wildlife Service - Challenge Cost-Share Program
- U.S. Fish and Wildlife Service – Partners for Wildlife Program

Other Sources

- Private foundation grants
- Corporate grants
- Individual donor grants
- Community fundraisers
- Develop citizen-science projects with local Universities
- Volunteer match labor

8. Conclusions

The following subsections discuss the data gaps, next steps and conclusions of the report.

Data Gaps Identified

A number of data gaps were identified during the course of this study. The development of additional information to fill these gaps may aid in the selection of a preferred alternative or implementation of the selected alternative. Recommended areas for additional study have been segregated into those that are key to the selection and design of the preferred alternative and other elements that may be filled as needed prior to project implementation.

Key Data Gaps

- Detailed topographic survey to assist in the technical analysis of the engineering requirements of the preferred alternatives for pipe and channel design;
- Geotechnical Assessment of the preferred alternatives including soil borings and/or test pits to confirm the preliminary assessment provided in Appendix C, as well as to assist in design development and refinement of costs;
- 'Potholing' of the existing pipe (approximately 500 lineal feet) and videocamera survey of pipe interior condition to verify pipe size, assess pipe condition, and locate side sewer connections;
- Research of West Commodore Way sewer trunk line to determine pipe elevation and crossing requirements for a new line; and
- Development of an implementation plan including refined permitting, funding,

public input and phasing considerations for the preferred alternatives including windows for construction relative to fish runs and heron nesting.

Other Data Gaps

- Measurements of Wolfe Creek flow rates at the existing pipe culvert inlet to verify baseflow and peak flow rates;
- Assess impacts of construction on Suquamish Tribal fishing above the Locks;
- Biological Assessment or equivalent study of advantages and disadvantages of the preferred alternatives for specific impacted wildlife species primarily focused on fisheries including existing and modeled future fish use (adult tag detectors) and the effects on various salmon runs. The study would also include heron and other wildlife species (such as design requirements to prevent herons from eating excess fish attracted to the daylighted Wolfe Creek vicinity). A study of benthic macroinvertebrate populations of the currently daylighted portions of Wolfe Creek could also be included;
- Mixing zone assessment of the impacts of the freshwater addition to Salmon Bay including an assessment of the sedimentation, temperature, dissolved oxygen, and pollutant load to the Bay using the Wolfe Creek water quality and flow data. This could also include an evaluation of fish ladder salinity gradient requirements;
- Evaluation of recreational user and infrastructure impacts to Commodore Park; and
- Evaluation effects of wave dynamics, boat traffic effects, westward currents, tide, and/or potential deeper dredging of Locks in future on selected alternative.

Other data gaps may be identified during further assessment and selection of the preferred alternative.

Proposed Next Steps for Selecting a Preferred Alternative

The process followed in this Concept Feasibility Study has successfully narrowed the ten daylighting alternatives to four. Establishing a preferred alternative will require selection of one of the two alternatives south of West Commodore Way (the infrastructure for daylighting the creek) and one of the two alternatives north of West Commodore Way (alignment of daylighted channel through Commodore Park). The recommended approach to selection of a preferred alternative is as follows:

- Obtain stakeholder input and necessary review of the four alternatives identified in this study to determine whether a single preferred alternative may be selected;
- Fill the key data gaps identified above;
- Select a single preferred alternative and obtain stakeholder/public support for the selected alternative.

Following the selection of a single preferred alternative, stakeholder support and requirements should be further developed. In addition design-level documents including permitting, cost, funding, and phasing schedule should be developed for the preferred alternative.

Conclusions

This Wolfe Creek Daylighting Concept Feasibility Study has completed each of the six contract objectives. The final contract objective – to initiate draft PDP forms for Seattle Public Utility use in project assessment – has been completed independently of this report. This project successfully narrowed the broad range of 10 alternatives for daylighting Wolfe Creek by separating the work into two parts, south and north of West Commodore Way. The concepts south of West Commodore Way address the separation of creek flows from the sewer trunk line, and were narrowed to two alternatives. The concepts north of West Commodore Way focus on the alignment and features of the daylighted creek in Commodore Park and were also narrowed to two alternatives.

All four of these alternatives (two south and two north of West Commodore Way) are feasible to implement and their feasibility has been adequately studied during this phase of work. These four alternatives may be combined into a single preferred alternative (including a segment both north and south of West Commodore Way) to carry forward. Although a number of data gaps have been identified only the key items are recommended information needed prior to the selection of the preferred alternative. The remaining data gaps could be filled, as needed, at the time of project implementation (i.e. as part of permitting for or environmental assessment of the preferred alternative initiated by a sponsoring agency).

Based on this study, the recommended next step is to obtain stakeholder input on these four alternatives and select a preferred alternative. Following that, pre-design work on the preferred alternative can be completed. Thus, the next phase for the project could be an Alternative Selection and Pre-Design report. If adequate funding is not obtained to complete such a study, then available funds can be spent on filling the key data gaps, followed by other remaining data gaps.

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Note: For additional references refer to appendices

Figures

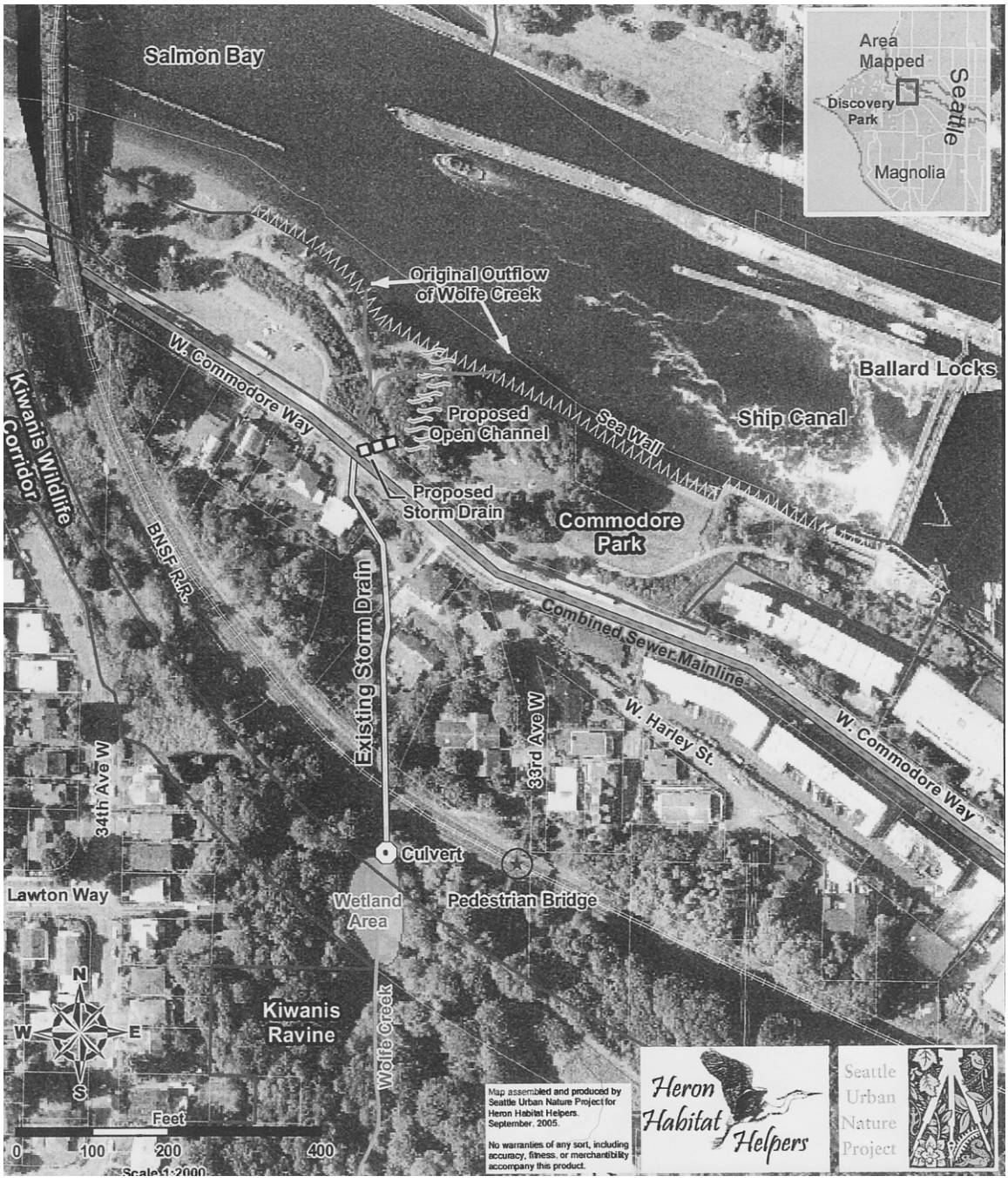
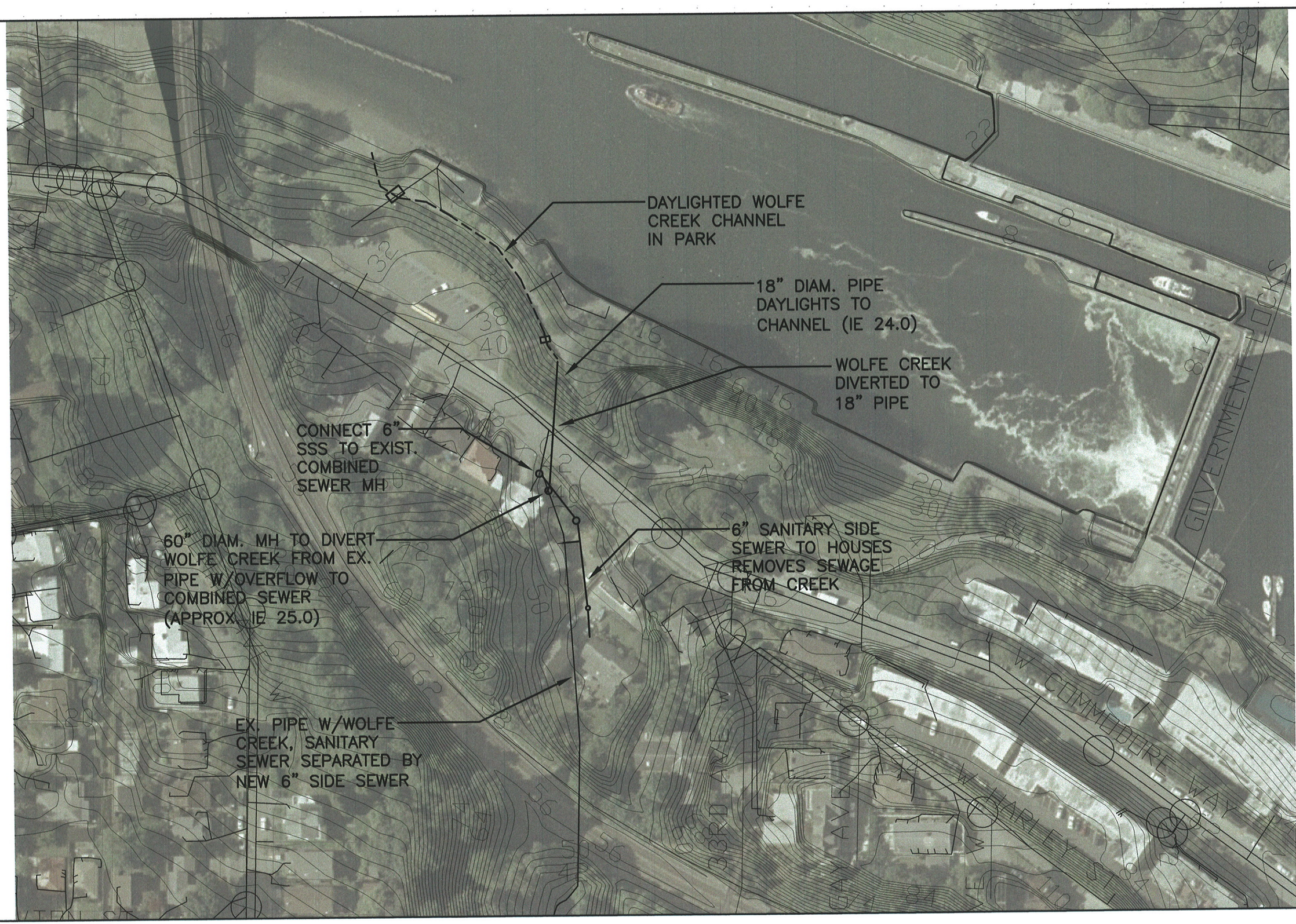


Figure 1 – Vicinity Map and Project Overview

WOLFE CREEK DAYLIGHTING

FEASIBILITY STUDY
Prepared for Heron Habitat Helpers

SCALE:	1" = 300'
DATE:	APRIL 2008
WOLFE CREEK DRAINAGE BASIN	
Fig. 2	



WOLFE CREEK DAYLIGHTING

FEASIBILITY STUDY

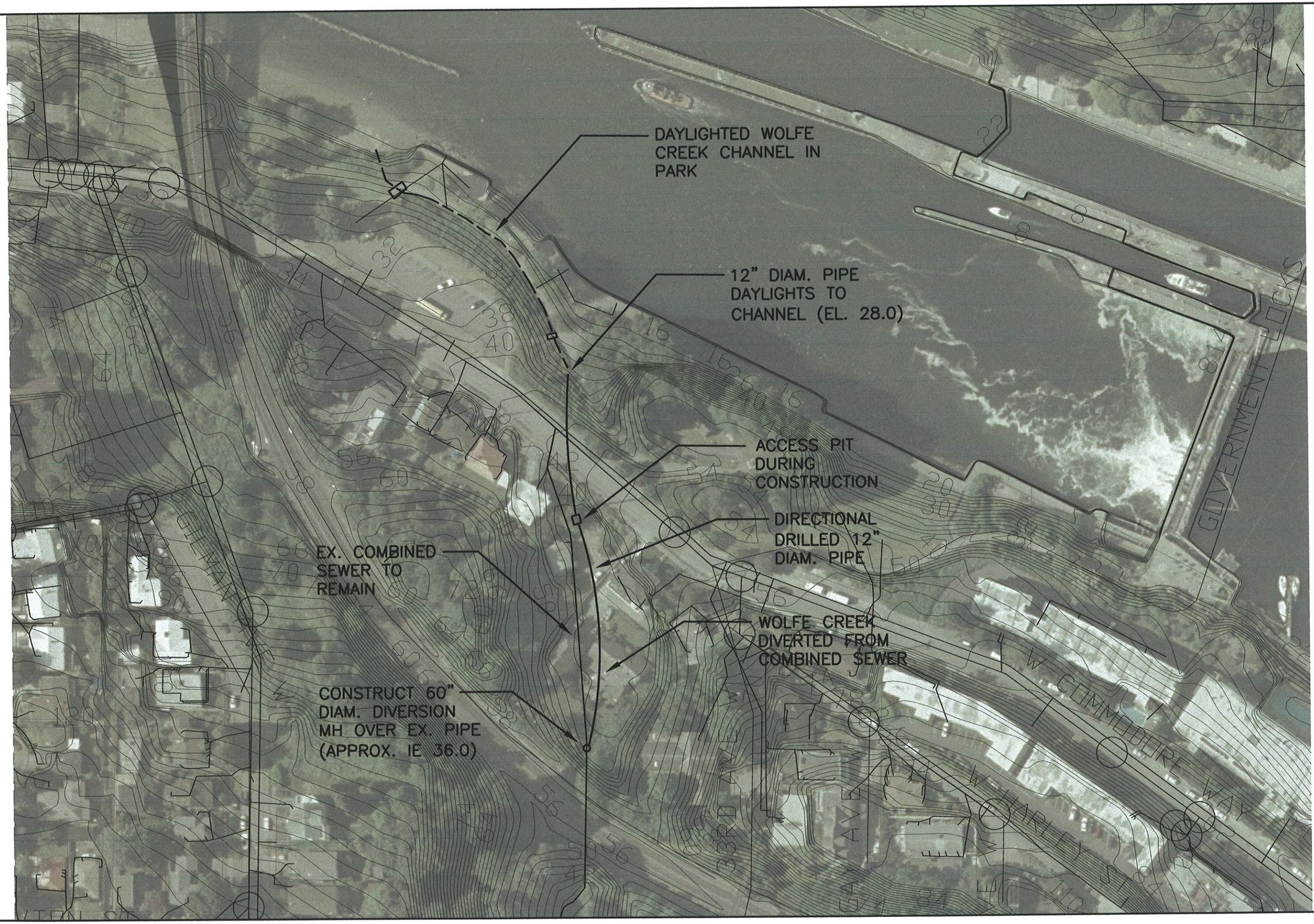
Prepared for Heron Habitat Helpers

SCALE: 1"=100'

DATE: APRIL 2008

ALT 1 (SOUTH) PIPE DIVERSION

Fig. 3

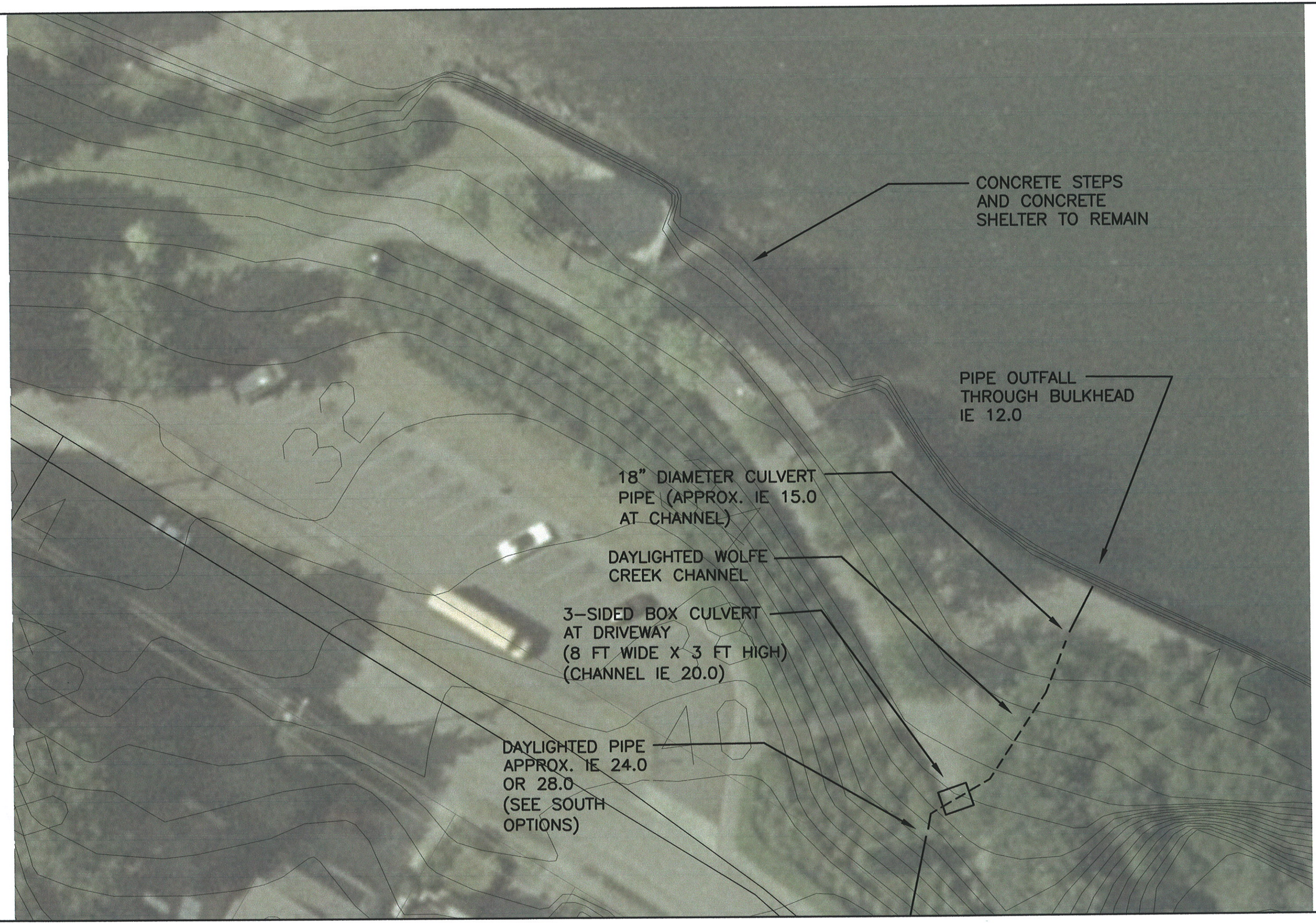


WOLFE CREEK DAYLIGHTING

FEASIBILITY STUDY

Prepared for Heron Habitat Helpers

SCALE: 1"=100'
DATE: APRIL 2008
ALT 2 (SOUTH) DIRECT DRILLING
Fig. 4



WOLFE CREEK DAYLIGHTING

FEASIBILITY STUDY

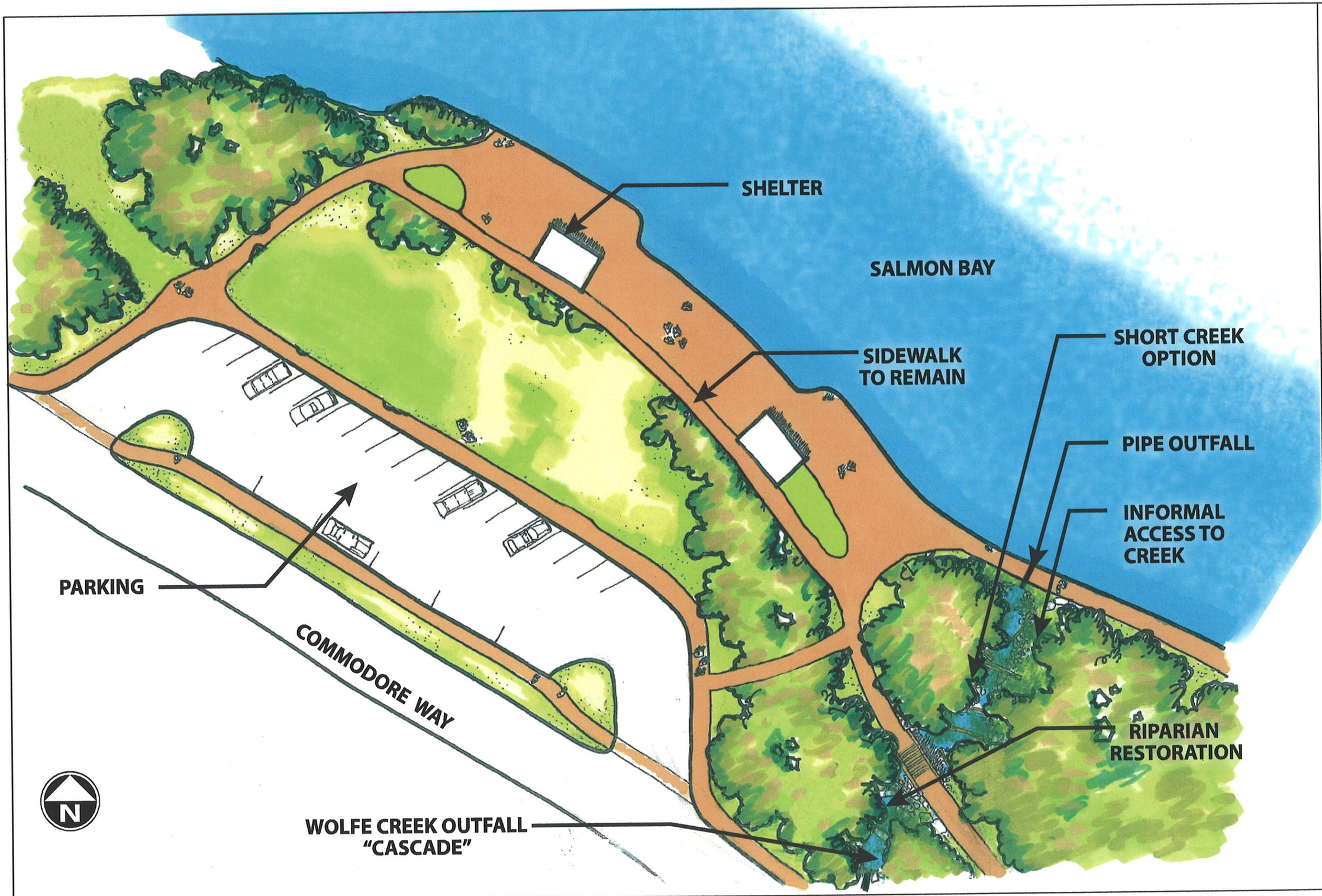
Prepared for Heron Habitat Helpers

SCALE: 1"=30'

DATE: APRIL 2008

ALT 1 (NORTH) SHORT CHANNEL

Fig. 5



WOLFE CREEK DAYLIGHTING

FEASIBILITY STUDY

Prepared for Heron Habitat Helpers

j.a. brennan

SCALE:

DATE:
APRIL 23, 2008

ALT 1
(NORTH)
SHORT
CHANNEL

Fig. 6

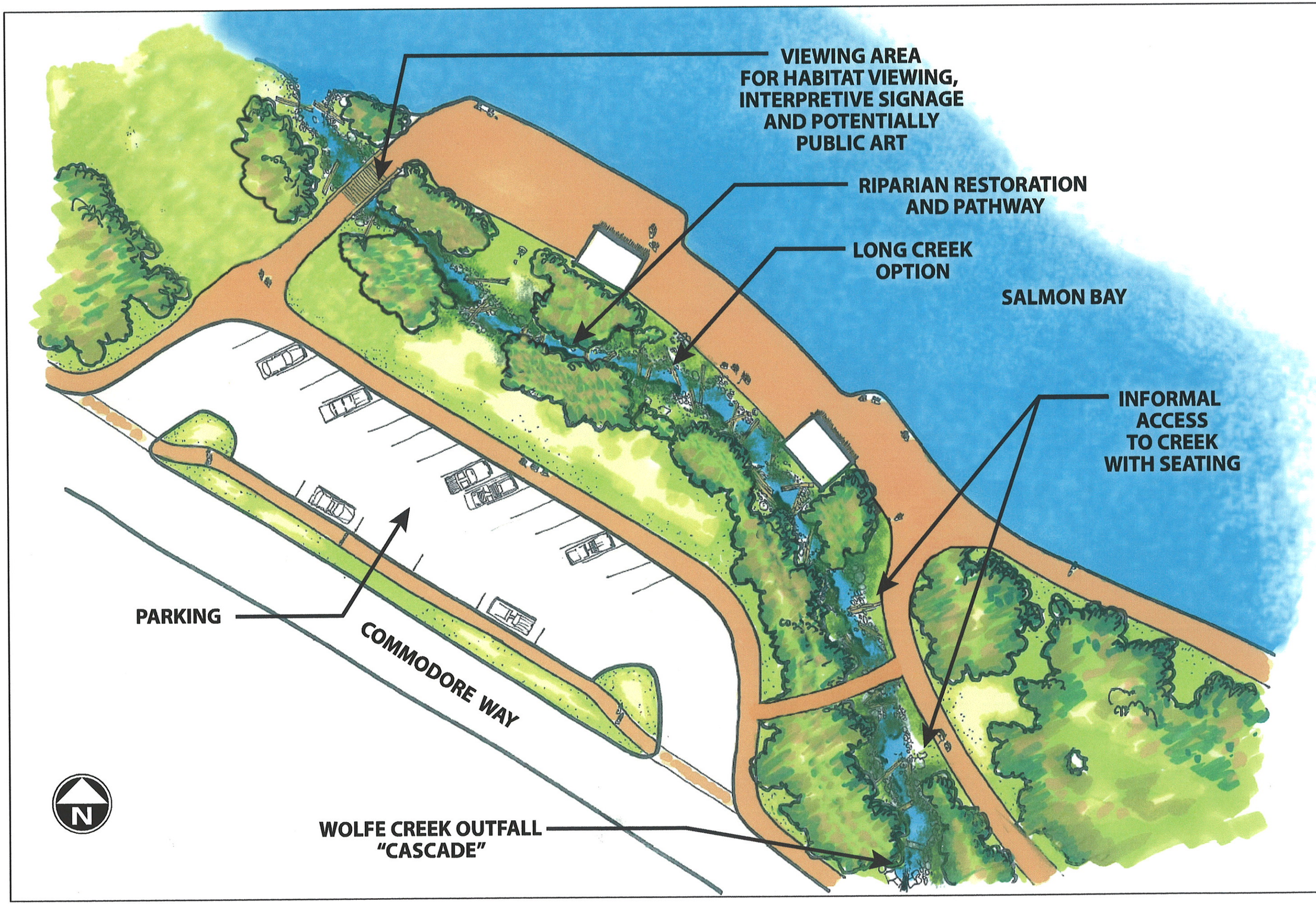
WOLFE CREEK DAYLIGHTING

FEASIBILITY STUDY

Prepared for Heron Habitat Helpers

SCALE:	1"=30'
DATE:	APRIL 2008
	ALT 2 (NORTH) LONG CHANNEL
	Fig. 7

Drawing: _Wolfe_ALL_REFS.dwg Date: 04/30/2008 Time: 10:01:41 AM Plotted by: TEVANS



WOLFE CREEK DAYLIGHTING

FEASIBILITY STUDY

Prepared for Heron Habitat Helpers

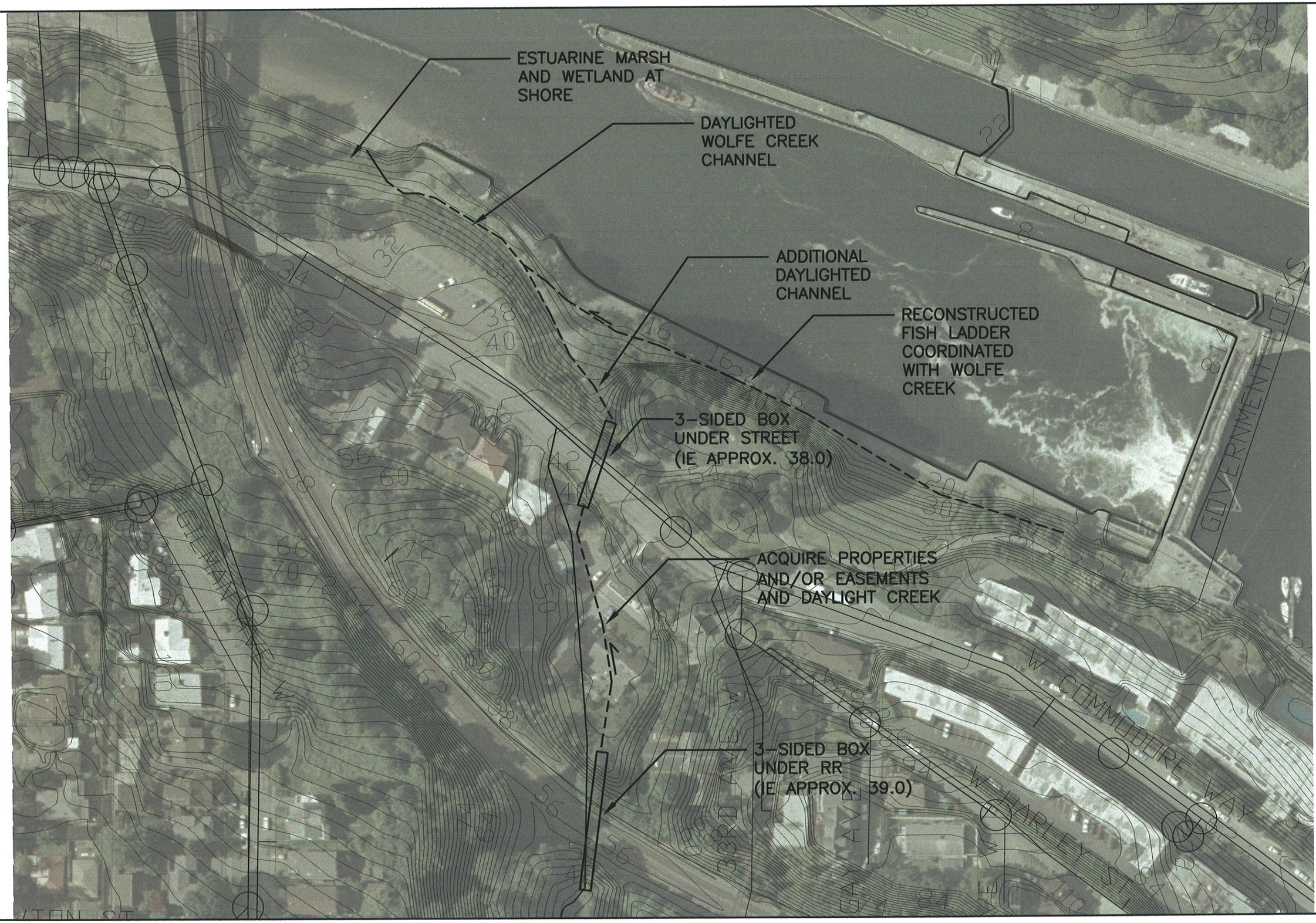
j.a. brennan

SCALE:

DATE:
APRIL 23, 2008

ALT 2
(NORTH)
LONG
CHANNEL

Fig. 8



WOLFE CREEK DAYLIGHTING

FEASIBILITY STUDY

Prepared for Heron Habitat Helpers

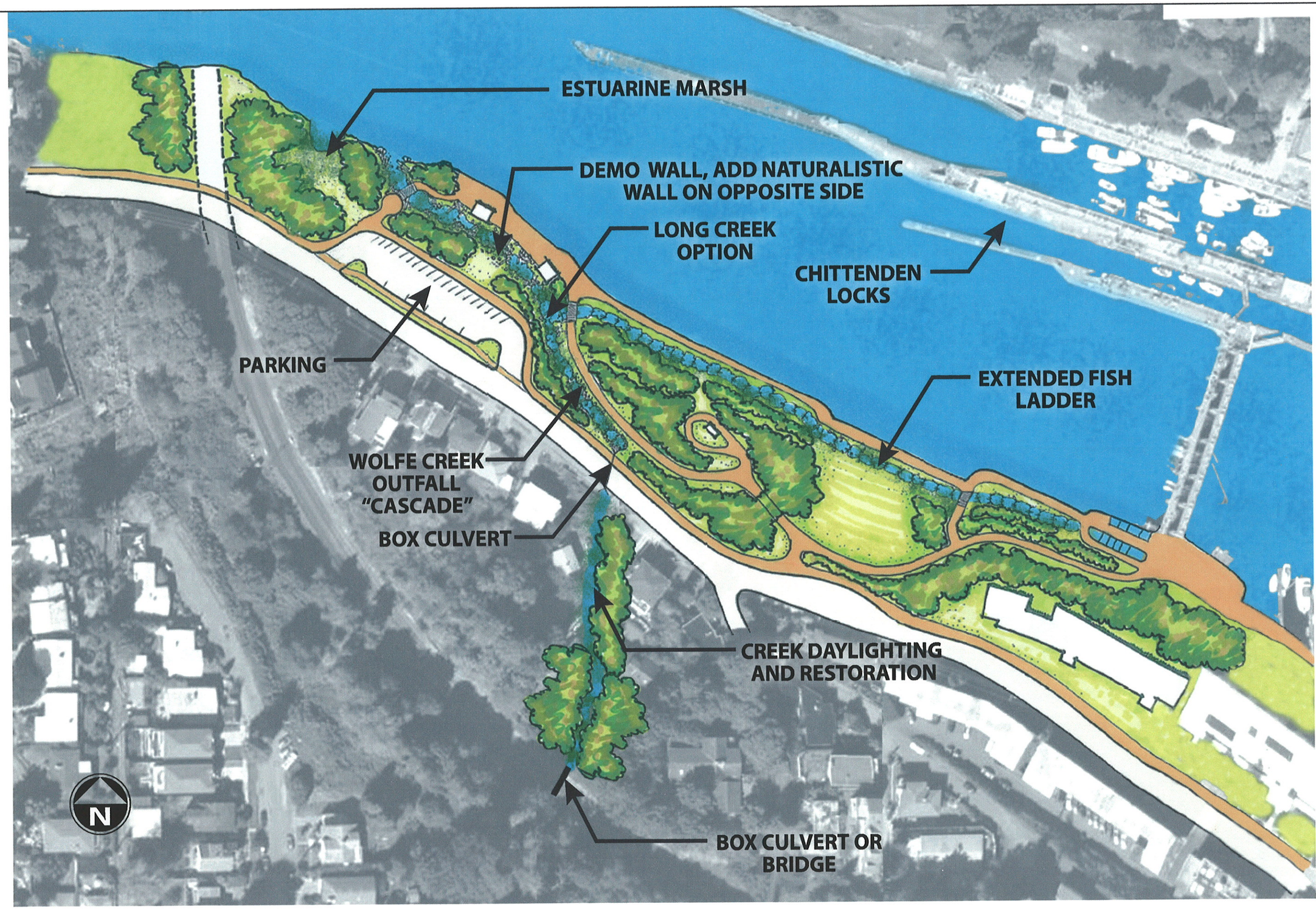
SCALE: 1"=100'

DATE: APRIL 2008

ALT 3 (N & S) FUTURE PLAN

Fig. 9

Drawing: _Wolfe_ALL_REFS.dwg Date: 04/30/2008 Time: 10:01:57 AM Plotted by: TEVANS



WOLFE CREEK DAYLIGHTING

FEASIBILITY STUDY

Prepared for Heron Habitat Helpers

j.a. brennan associates plc

SCALE:

DATE:
APRIL 23, 2008

FUTURE PHASES (N &S)

Fig. **10**

Appendix A

Ten Initial Alternatives Package
Wolfe Creek Daylighting

Prepared by:

Heron Habitat Helpers

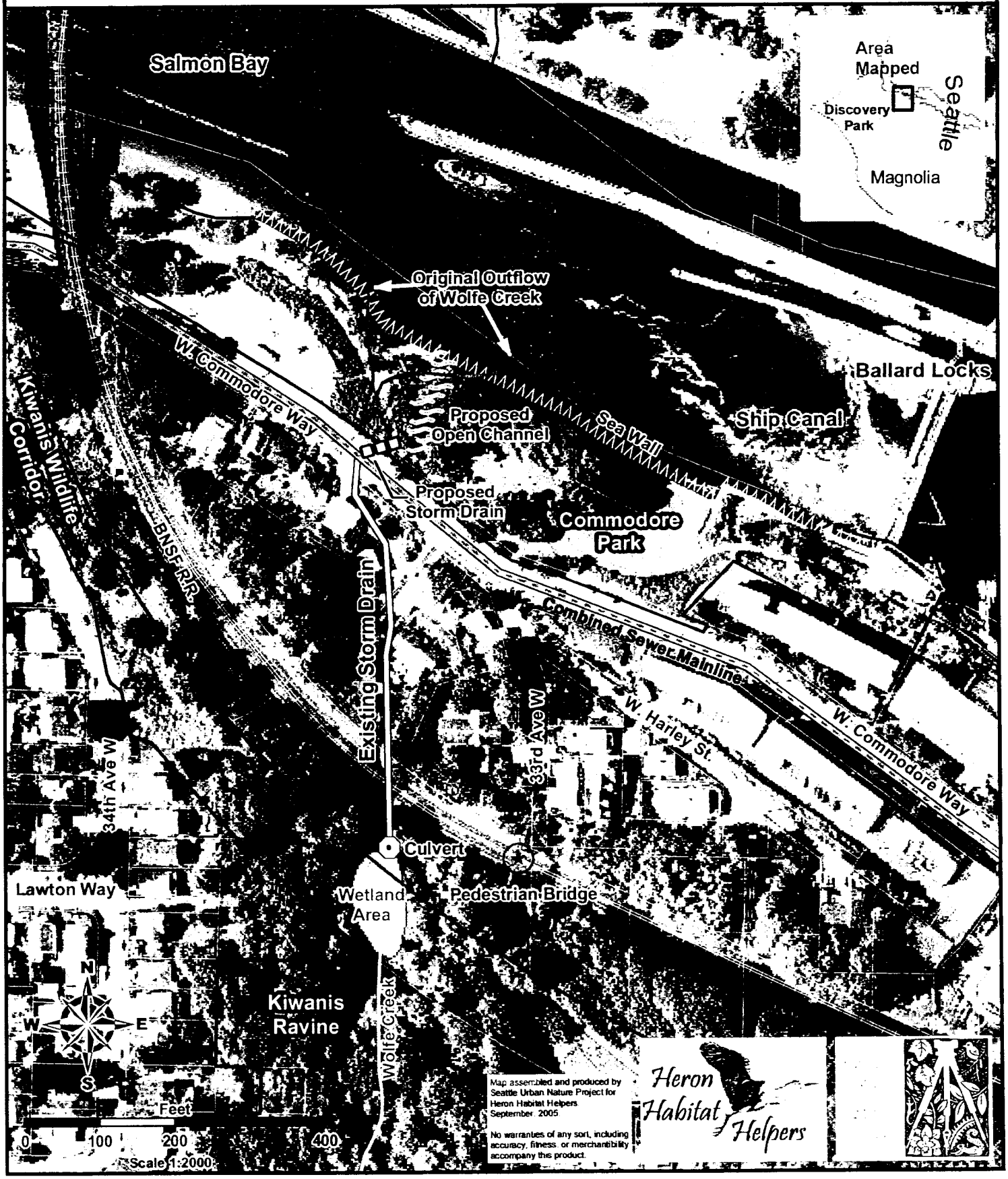
DRAFT Summary of Options
Wolfe Creek Daylighting Study
October 3, 2007

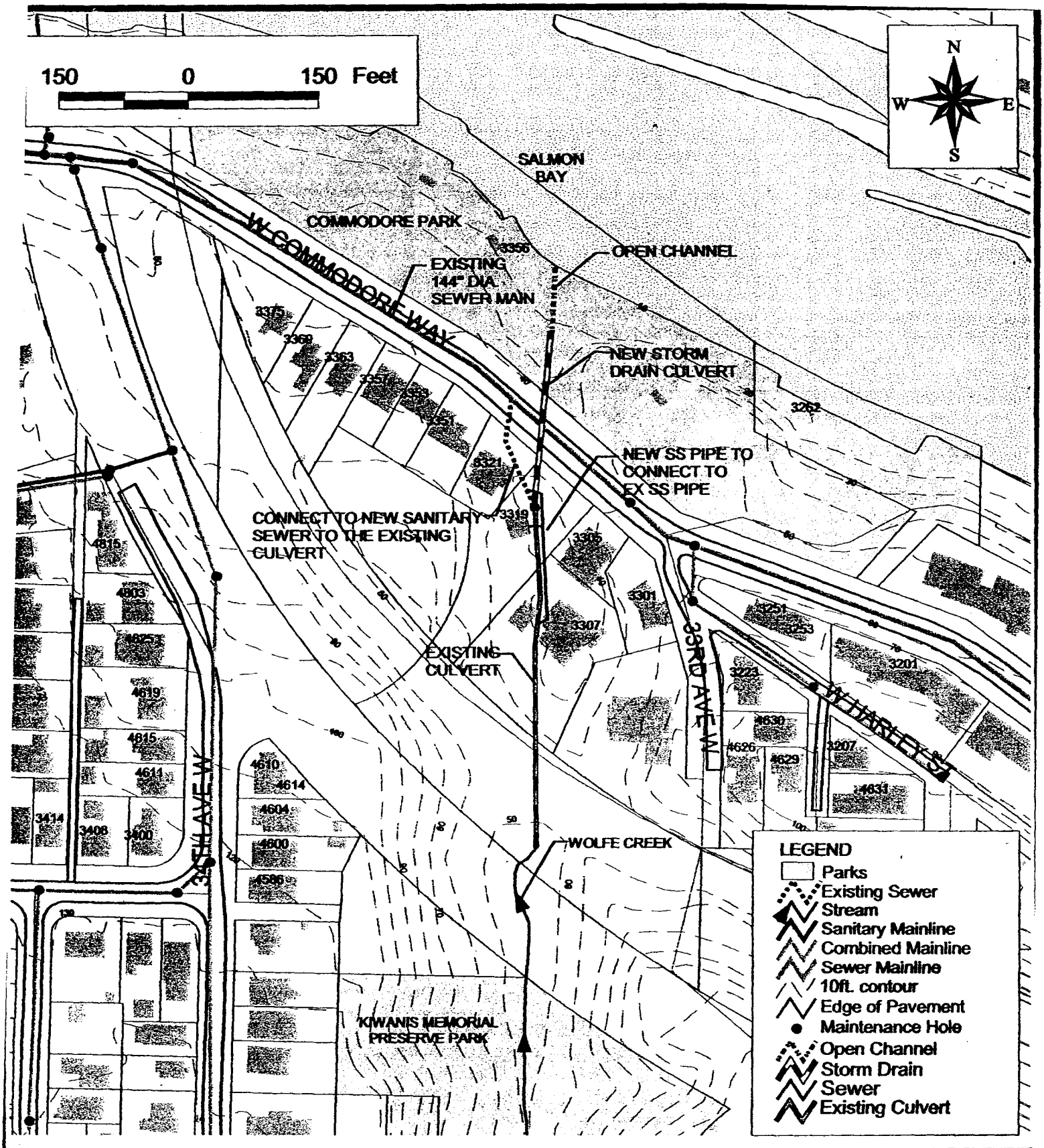
A number of studies and concept designs have been prepared for the proposed daylighting of Wolfe Creek. The intent is to promote the development of a viable plan for daylighting Wolfe Creek to provide a source of freshwater in the estuarine mixing zone for salmon migrating through the Ship Canal. These alternatives have various attributes with all generally meeting the intent of daylighting the Creek. It has been assumed that site constraints and associated costs preclude the construction of passage for fish.

Number	Option Name	Description	Cost
A	SvR Option A	New Outlet Culvert to Elev. 24; results in 80 ft of new channel	$535,000
B	SvR Option B	Long pipe, follows easements to Elev. 33; 140 feet of new channel	$1.7M
C	SvR Option C	Longer pipe, deep manholes, follows Right of Way to Elev. 33; 140 feet of new channel	$2.9M
D	Ken Nilson Mgmt. Plan 2003	Extend channel from north side of Commodore Way west to outlet near the RR Bridge	???
E	Brennan Alt. #1	Extend channel from north side of Commodore Way north to outlet in Salmon Bay; Marsh near RR Bridge	???
F	Brennan Alt. #2	Marsh near RR Bridge, clarify daylighting?	???
G	Brennan Alt. #3	Extend channel from north side of Commodore Way west to outlet near the RR Bridge; fish passage/estuary through park.	
H	Brennan Alt. #4	Extend channel from north side of Commodore Way west to outlet near the RR Bridge; fish passage/estuary through park; combine with Fish Ladder flow.	
I	Robin Clark Concept	Extend channel from north side of Commodore Way north to outlet in Salmon Bay at COE stairs into water.	
J	Clayton Beaudoin's MS Plan	Extend channel from north side of Commodore Way west with switchback to outlet near the RR Bridge; fish passage/wet meadow through park	

Wolfe Creek Daylighting Proposal

Salmon Bay Neighborhood





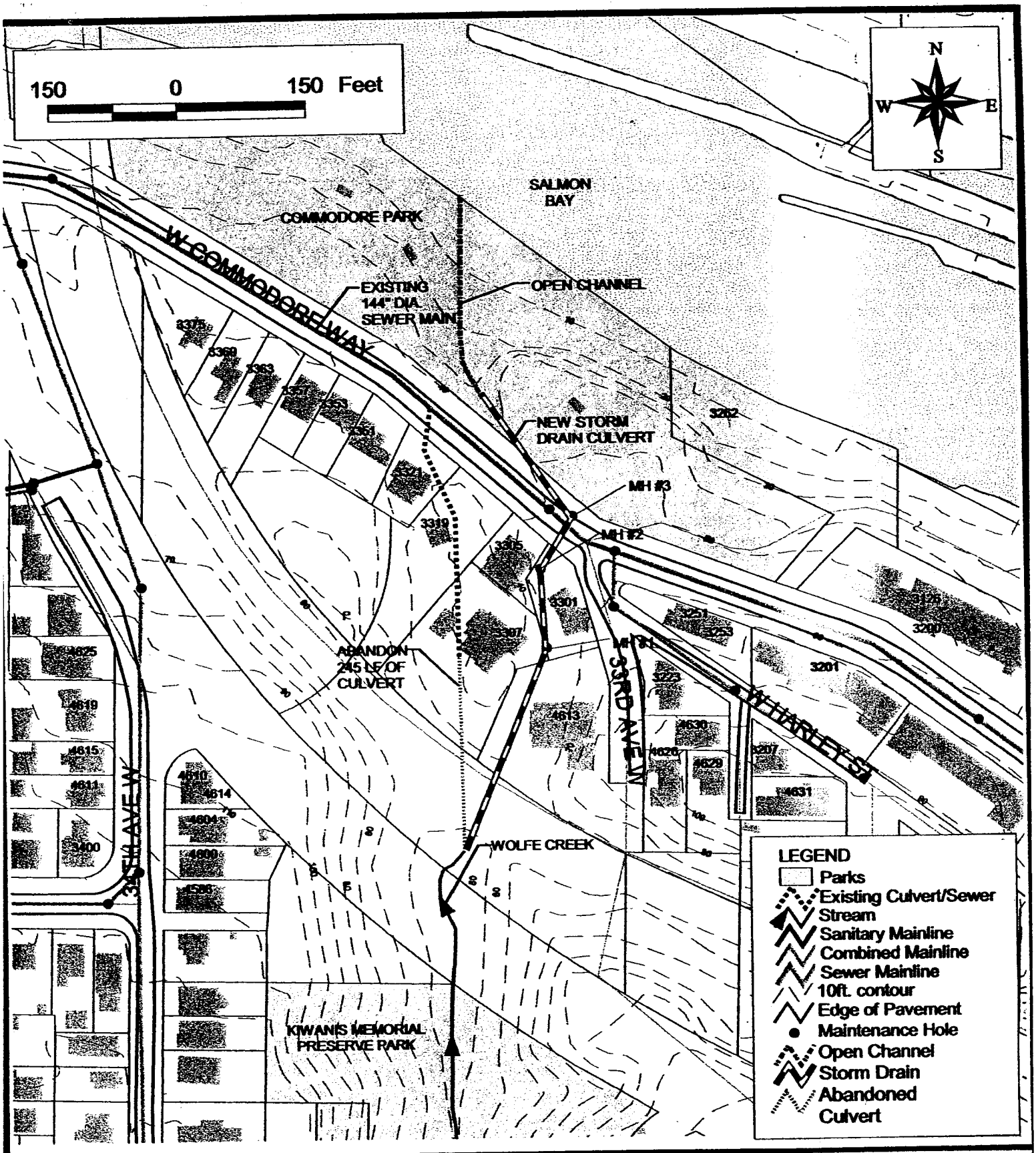
GIS Information Courtesy of City of Seattle / SPU

WOLFE CREEK
Diversion Feasibility Analysis
Seattle Public Utilities

Option A - Plan #600K

SvR DESIGN COMPANY

Figure 4A



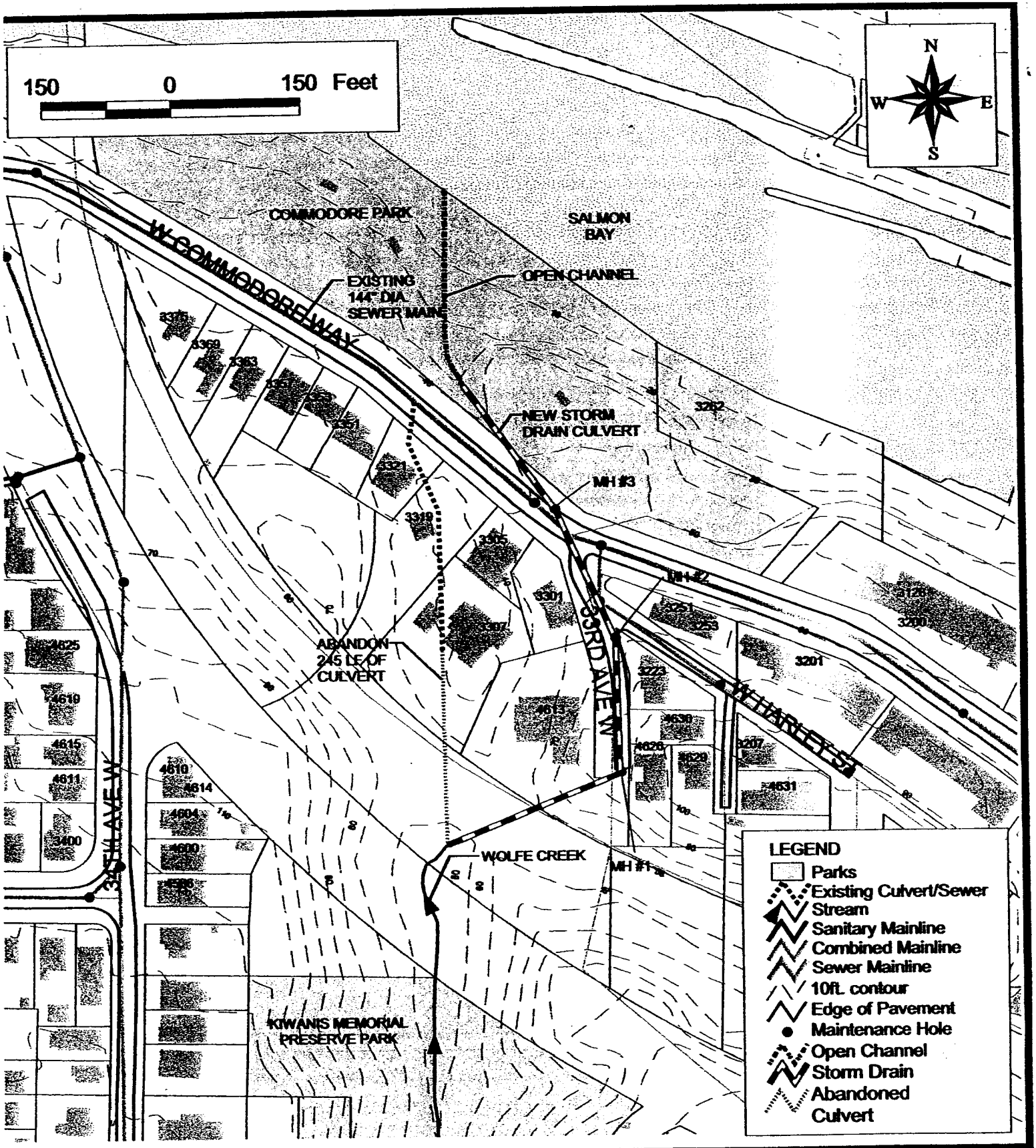
GIS Information Courtesy of City of Seattle / SPU

WOLFE CREEK
Diversion Feasibility Analysis
Seattle Public Utilities

Option B - Plan $1.7M

SVR DESIGN COMPANY

Figure 6 B



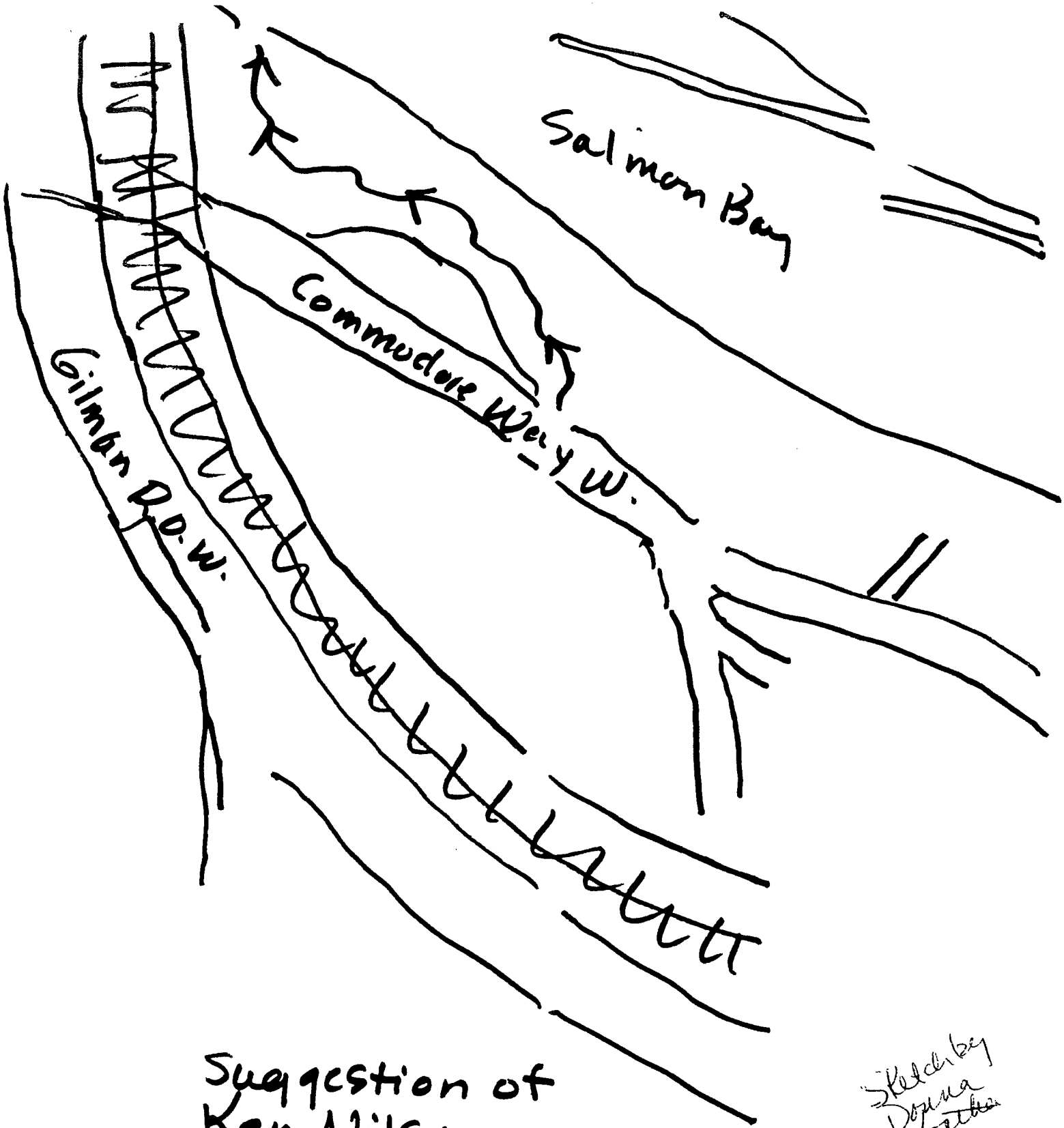
GIS Information Courtesy of City of Seattle / SPU

WOLFE CREEK
Diversion Feasibility Analysis
Seattle Public Utilities

Option C - Plan $2.9M

SvR DESIGN COMPANY

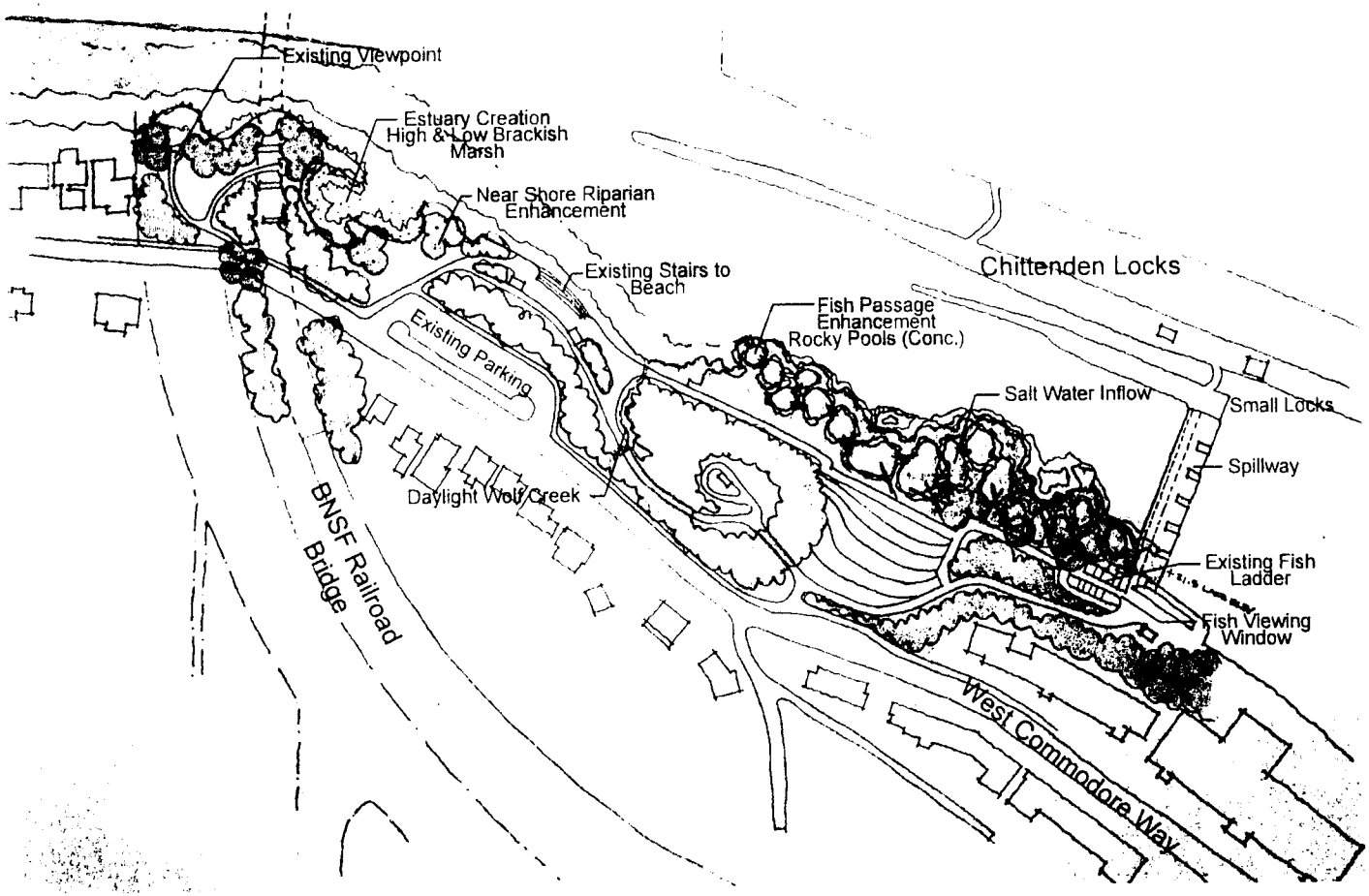
Figure 8 C



Suggestion of
Ken Nilson,
Penhallegen Assoc. in
"Kiwanis Ravine Mgmt. + Monitoring
Plan | Rept."
2003

Option D

Sketch by
Donna
Kostka



GROUNDSWELL NW

Concepts explored for fish passage are preliminary to begin discussion with biologists, engineers and other stakeholders. Feasibility of concepts should be determined at outset of design work.

Figure 9
Commodore Park Plan
Alternative #1

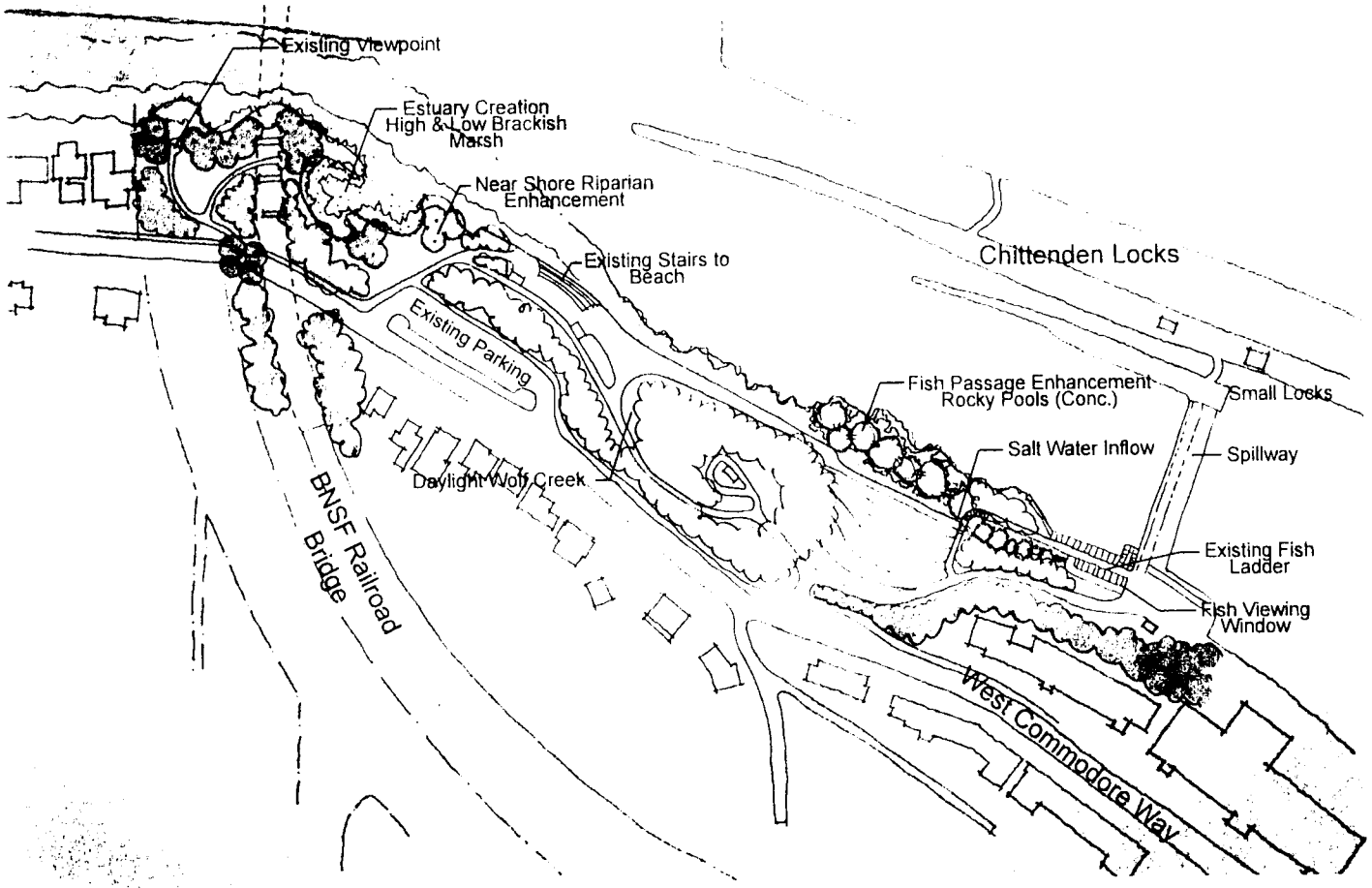
Greater Salmon Bay Concept Plan

Date: January 11, 2006

N

E

GROUNDSWELL NW



Concepts explored for fish passage are preliminary to begin discussion with biologists, engineers and other stakeholders. Feasibility of concepts should be determined at outset of design work.

Figure 10
Commodore Park Plan
Alternative #2

Greater Salmon Bay Concept Plan

Date: January 11, 2006

N

F

GROUNDSWELL NW

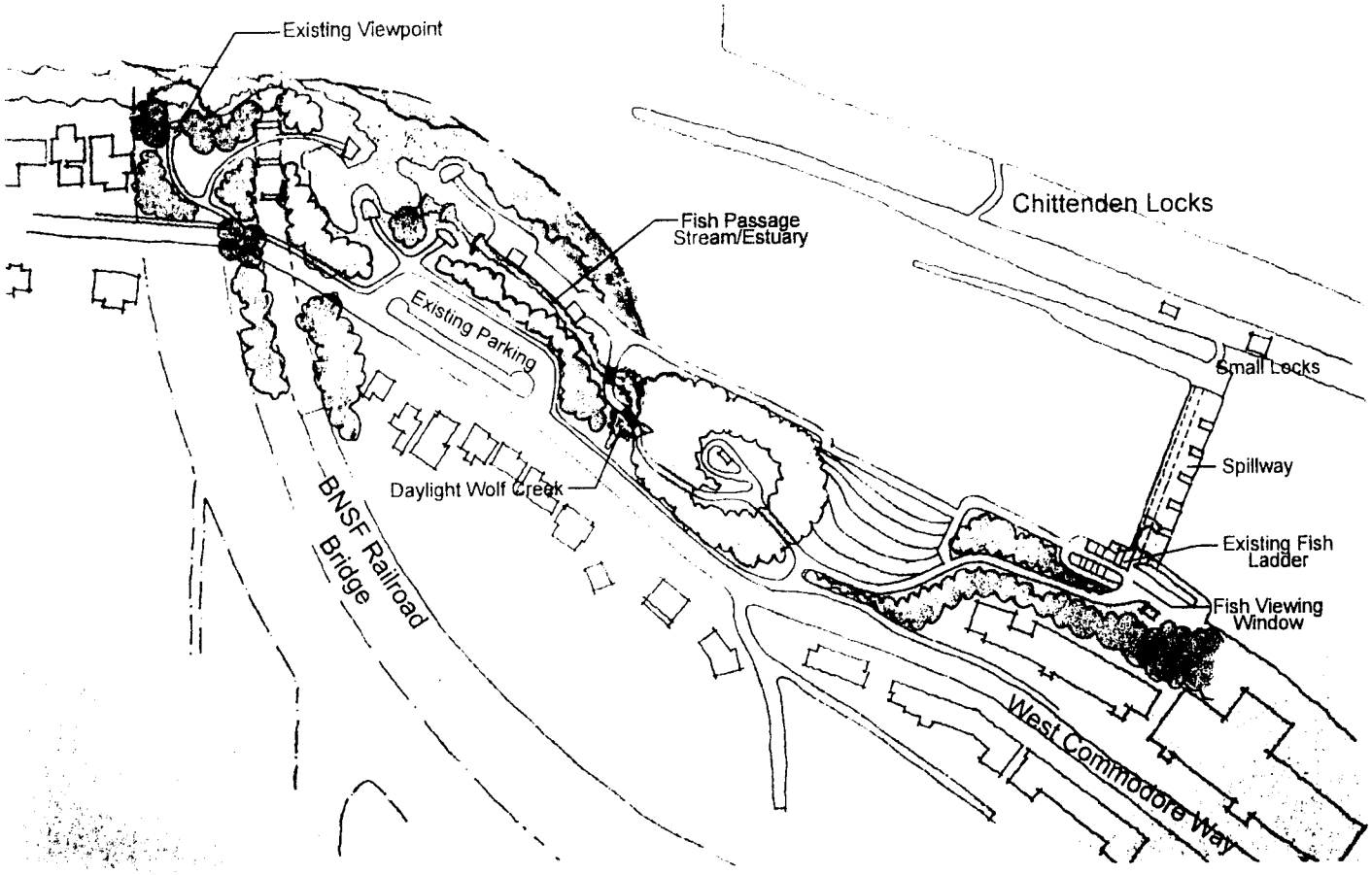
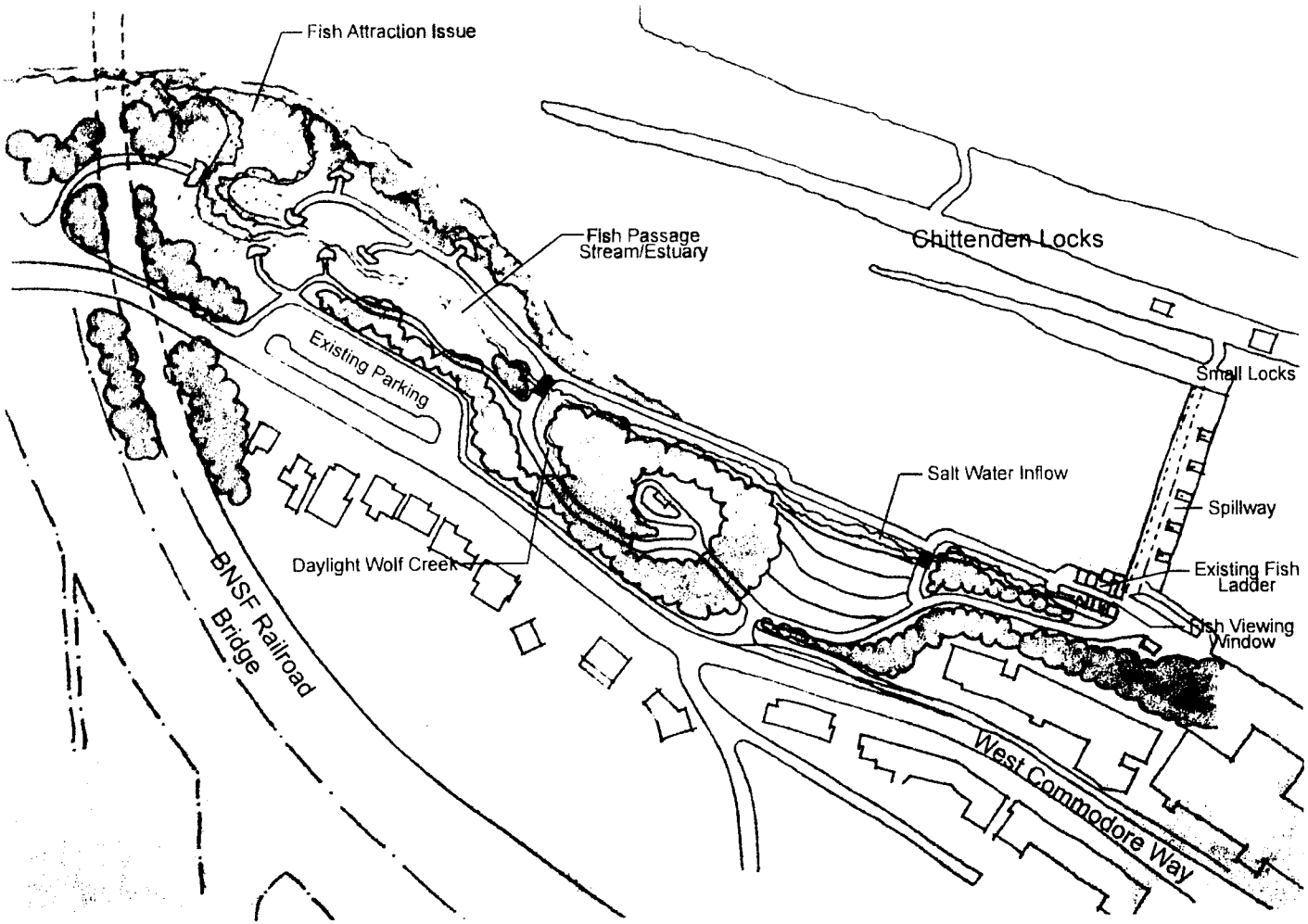


Figure 11
Commodore Park Plan
Alternative #3

Greater Salmon Bay Concept Plan

Date: January 11, 2006

N



GROUNDSWELL NW

Concepts explored for fish passage are preliminary to begin discussion with biologists, engineers and other stakeholders. Feasibility of concepts should be determined at outset of design work.

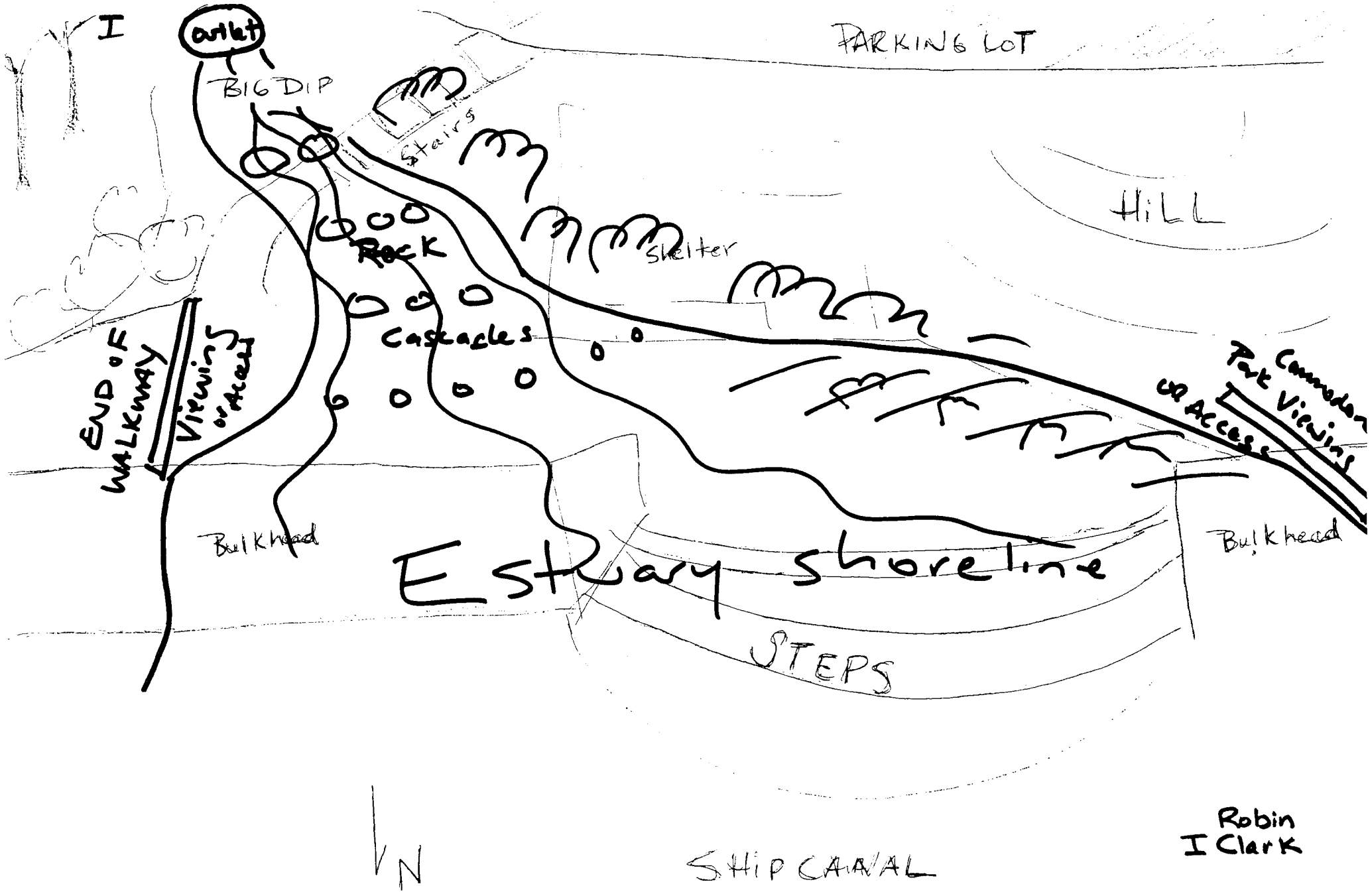
Figure 12
Commodore Park Plan
Alternative #4

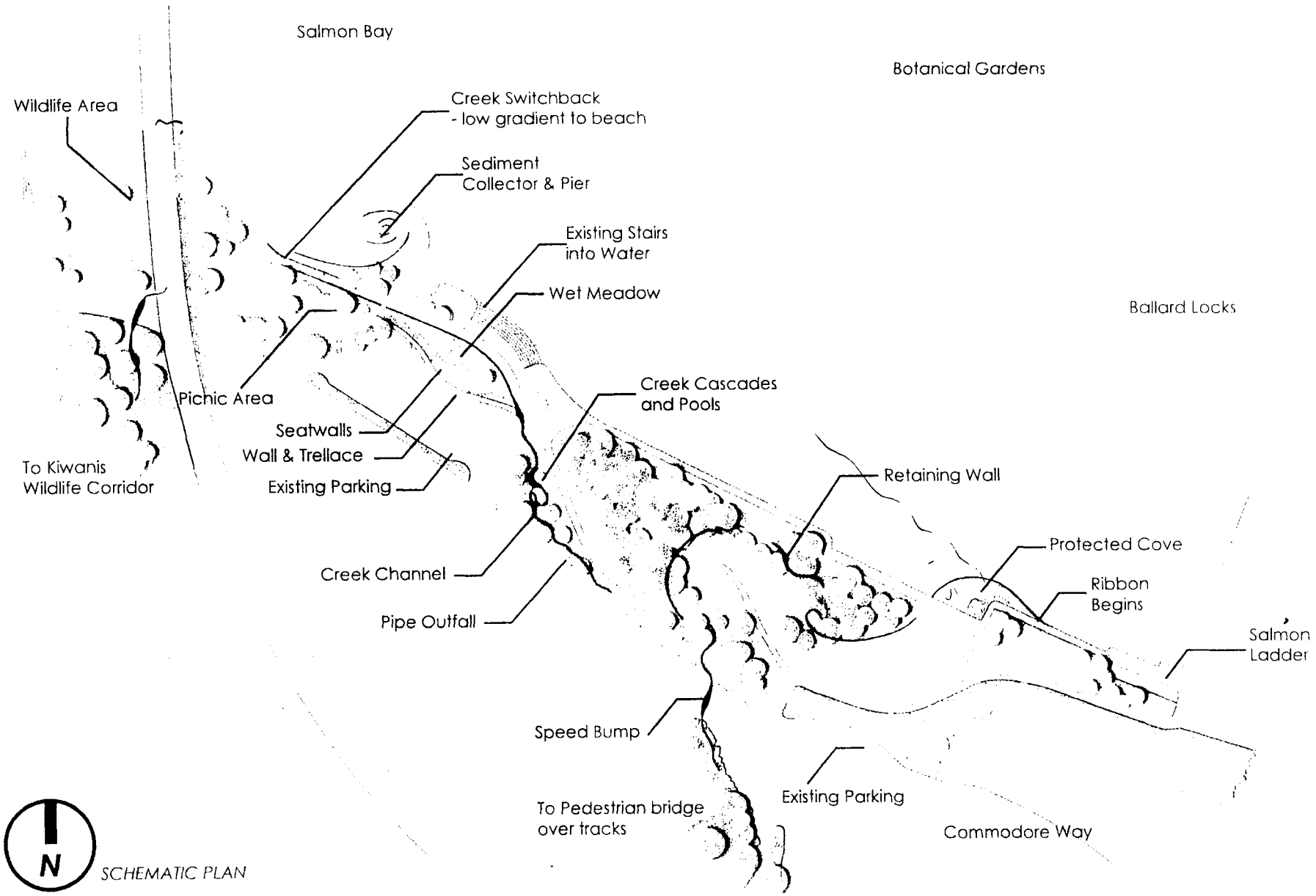
Greater Salmon Bay Concept Plan

Date: January 11, 2006

N

H


I
outlet
BIG DIP
PARKING LOT
Stairs
HILL
Rock
Shelter
Cascades
END OF WALKWAY
Viewing Island
Commodore Park Viewing
Access
Bulkhead
Bulkhead
Estuary shoreline
STEPS
N
SHIP CANAL
Robin I Clark



SCHEMATIC PLAN

Daylighting a Pipe Dream: Aesthetics and Ecoliteracy in the Restoration of Wolfe Creek

**Preserves existing park highlights - seawall, terraces, views and parking
**Provides a varied creek morphology, including fish friendly, low gradient channel
**Celebrates the cultural act of restoration while enhancing natural beauty and supporting ecological function

Clayton Beaudoin
Univeristy of Washington
student - Master of Landscape Architecture
claytonb@u.washington.edu

5

Appendix B

Stakeholder List and Input Summary
Wolfe Creek Daylighting

Prepared by:

WR Consulting, Inc.

WOLFE CREEK DAYLIGHTING STUDY

STAKEHOLDER INPUT LIST for Task 2 Technical Memorandum

- Burlington Northern Santa Fe Railway
  Anderson, Jennifer, (206) 625-6034, jennifer.anderson@bnsf.com
- Friends of Discovery Park
  Thompson, Paul, President, (206) 282-2872, pthompson2@farmersagent.com
- Groundswell Northwest
  Sam Star, (206) 789-3483, samstar500@yahoo.com
- Heron Habitat Helpers
  Shoudy, Kay, (206) 281-1635, shoudypk@comcast.net
  Wakeman, Brad, (206) 920-3638, brad@lakere.com
- King County Wastewater Treatment Division
  John Phillips (206) 263-6543 john.phillips@kingcounty.gov
- King County WRIA 8
  Jorgensen, Mary, (206) 296-8067, mary.jorgensen@kingcounty.gov
- Magnolia Community Club
  Rogers, Nancy, President, (206) 254-4417or 283-1188, nrogers@cairncross.com
- Magnolia Chamber of Commerce
  Alexandra Smith, (206) 284-5836 info@lerouxmagnolia.com or magnoliachamber.org
- Muckleshoot Tribe
  Mike Mahovlich, (253) 876-3113, mike.mahovlich@muckleshoot.nsn.us
- National Oceanic and Atmospheric Administration NWRO - NMFS
  Thomas Sibley (206)-526-4446 thomas.sibley@noaa.gov
- People for Puget Sound
  Robin Clark, (206) 382-7005, ext. 221, rclark@pugetsound.org
- Seattle City Council - Richard Conlin's staff
  Nelson, Sara (206) 684-5337, sara.nelson@seattle.gov
- City of Seattle - Office of Sustainability and Environment
  Nicholas, Steve, Director, (206) 615-0829, steve.nicholas@seattle.gov
- Seattle Public Utilities (SPU)
  Heiden, Deb, (206) 386-1802, deb.heiden@seattle.gov
  May, Christopher (Chris), (206) 386-4270, Chris.May@Seattle.Gov
  Minsch, Kathy, (206) 615-1441, kathy.minsch@seattle.gov
- Seattle Department of Parks
  Eastberg, Cheryl, (206) 386-4381, cheryl.eastberg@seattle.gov
  Patti Petesch, (206) 604-6462, patti.petesch@seattle.gov
- Sound Transit
  Townsend, Chris, (206) 398-5135, townsendc@soundtransit.org
- Suquamish Tribe
  Zischke, Jay, (360) 394-8444, jzischke@suquamish.nsn.us
- Washington Department of Fish and Wildlife (WDFW)
  Anderson, Chris, (425) 775-1311 X 111, andercda@dfw.wa.gov
- Washington State Department of Ecology (Lake Union Action Team)
  Maura O'Brien (425) 649-7249/7098, mobr461@ecy.wa.gov
- U.S. Army Corps of Engineers (COE)
  Ebel, Chuck, (206) 764-3626, charles.j.ebel@usace.army.mil

WOLFE CREEK DAYLIGHTING CONCEPT FEASIBILITY STUDY
Task 2 Technical Memorandum of Project Design Objectives

Prepared for Heron Habitat Helpers by the WR Consulting, Inc. Project Team under a grant from The Russell Family Foundation

This memorandum summarizes input about Wolfe Creek daylighting alternative options received from project stakeholders using a project questionnaire and follow-up emails and phone calls. The questionnaire was sent out to 1 or 2 people in 20 potentially interested stakeholder groups (listed in Attachment A). Nine surveys were completed and returned by stakeholders and two stakeholders responded that they would wait until a later stage of the project to provide input. The following summarizes the project design objectives (based on stakeholder questionnaire input supplemented by Wolfe Creek Daylighting quarterly meeting notes), preliminary input on preferred options, and additional input provided by stakeholders.

Summary of Project Design Objectives –

Stakeholder input was summarized into the following six main design objectives. Each design objective has several sub-headers that define it. These project design objectives will provide the basis for conducting a weighted evaluation of the ten daylighting alternatives (Attachment B). These results will be used to identify the three preferred alternatives.

Aesthetic-Recreational

- help move Seattle forward as a world class city that cherishes its natural beauty and healthy coexistence with Puget Sound and wildlife
- desire for a neighborhood amenity
- protect and enhance the resources and activities that are central to the Parks mission
- impacts to existing park infrastructure and impacts/disruption to existing park use at the locks

Habitat/Fisheries/Wildlife

- provide a healthy and sustainable environment, and protect salmon and habitat along the shorelines
- concerned about potential effects it may have on the nesting great blue heron colony found in Kiwanis Ravine
- this project is in the Action Start List (Volume I, Chapter 9) of the Final Lake Washington/Cedar/ Sammamish Watershed (WRIA 8) Chinook Salmon Conservation Plan, July 2005. This list is the highest priority of the actions that will work toward salmon recovery. The Wolfe Creek Restoration (project # 250) is combined with restoration at Commodore Park.
- improve/restore/enhance fish habitat on high priority park lands where it is feasible and compatible with other park uses

- providing quality nearshore/estuarine habitat for migrating salmon should be the top project goal
- Creating a small estuary area that would enable adult and juvenile salmon to adjust between salt and fresh water would increase their chances of survival
- Some of the designs appear to have the daylighted channel enter through the existing beach. This beach is actively used by Chinook salmon and modification of this area needs to be carefully reviewed by fishery biologists so that the work ends up as an enhancement rather than a loss.
- expand limited habitat for migrating Chinook in this area. In the Salmon Conservation Plan the objectives are to:
    - Remove the armored seawall and restore to a gentler vegetated slope.
    - Daylight Wolfe Creek to create a pocket estuary downstream of the Locks.
- do not conduct work within the breeding season for Kiwanis great blue herons, as established by the City of Seattle with assistance from WDFW, is Feb 1 - July 31.
- concerned about potential impacts to existing bull trout habitat
- question of how much fish use there would actually be in the creek if it was all day-lighted – we know that estuarine habitat (especially small creek type) is very much in need, so this would seem to be the primary goal at this stage
- relationship to seal predation on salmon

Water Quality/Watershed Protection

- providing additional freshwater into the lower ship canal in an effort to restore/improve a salinity transition for migrating juvenile salmonids is consistent with limiting factors affecting salmonids identified in that marine area. (WCC 1996 WRIA 8)
- Wolfe Creek provides the only potential fresh water input in the ship canal below the locks, other than the options of sending more fresh water from Lake Union to the area below the locks.
- there are limited studies on the benefit of the fresh water because it is such a small quantity within the salt water area
- help resuscitate Wolfe Creek, Salmon Bay and the upstream watershed - Improve quality of Wolfe Creek, restore natural systems, improve shoreline environment.

Engineering

- reduce stormwater piping issues
- remove the flow of the creek from the sewer line
- restore some hydrologic function for the creek
- desire as much of the stream daylighted as possible
- the more complex, and therefore expensive alternatives may be difficult to justify so simplify pipeline/infrastructure as much as possible to minimize costs
- this small amount of flow does not significantly impact the West Point Treatment plant during normal flow days or storm events. There is not a benefit to the King County sewer system from removing this flow

- establish technical feasibility
- geomorphology and soils – are alignments on fill or native soils?
- hydrologic and hydraulic analysis
- potential for turbulence downstream of fish ladder due to wave dynamics, boat traffic effects, westward currents, and tide and effect on softened shoreline (no seawall)

Education

- it would also improve the connection for people to the water, and to allow for a natural connection to the water that does not exist at Commodore Park
- continue to educate citizens about urban watersheds through projects such as this
- added benefit of the opportunities for public education throughout the site

Cost-Benefit

- maintain costs low and keep impacts to private property and park property to a minimum, while still creating a high-quality habitat project
- specific concerns include project cost and responsibility for long term maintenance
- of all the possible options for improving salmon survival through the locks, this is the most modest
- expensive (see recently constructed Madrona Creek daylighting). Careful consideration of the benefit for each cost needs to be considered
- find a balance between engineering benefits and environmental impacts

Preliminary Input on Preferred Options

Part of the stakeholder questionnaire requested preliminary input on preferred options and the reasons for or against preferences. The majority of stakeholders provided some input on their preferred options as summarized in the following table.

Option	Respondent	Basis
E&J or B&J	Heron Habitat Helpers-	None Stated
E-H and perhaps J if seawall removal too costly	King County WRIA8	Least preferred are B &C where the storm drain is moved and appears to add twice the length, which would be very high cost, yet the benefit is not given. D (not enough detail). A does not remove the seawall. Prefer E-H and perhaps J because they have a longer daylighted channel length, enhancement of the shoreline, and particularly enhancement at the stream mouth as it enters the estuary area. In addition, there is the added benefit of the opportunities for public education throughout the site. Extending the open channel may provide some additional resting areas for migrating salmon and is less costly than pipeline. Removing the seawall would be the optimum from our perspective – costly but higher benefit to salmon to have a natural shoreline at the mouth of the creek.

None Stated	King County Wastewater	King County has no formal comments on the benefits of one alternative over another.
A-C	People For Puget Sound	I think an alternative that include water from lake Washington should be considered, and the long stream channel through the park, along with the simpler straight connection with an estuary. These 10 generally "lump" into those 3 considerations.
None Stated	Seattle Public Utilities	Prefer an option that does not try to day-light the creek upstream of the main road crossing as an initial phase – separating the creek-flow into a separate pipe and bring that flow down to a location near Salmon Bay seems the most cost-effective – recreating an estuary with good freshwater-saltwater interface habitat would seem to be the most ecologically beneficial option at this point.
None Stated	Suquamish Tribe	An additional alternative would be to phase the restoration to package the preferred alternative with a phase II which would include a future daylighting under the BN ROW somewhere in the geologic future. This could be viewed as more of a master plan – phase one would be funding and completion of piping/daylighting in the vicinity of Commodore park – phase two would be design and construction of a trestle? To span the creek in the vicinity of the BN ROW. This may be unrealistic as I am admittedly unfamiliar with the topography in that vicinity? But I would imagine there are plans/discussions for the eventually retrofit of the BN span over the ship canal – that would be the opportune time to link on the phase two Wolf Creek daylighting?

Additional Input

Several stakeholders provided additional input as follows:

Input	Respondent
Removal of the flow of Wolfe Creek from the King County sewer system would require work within the King County owned pipes. Therefore King County must stay engaged and review all technical drawings relating to work in or around King County's pipes. If the Wolfe Creek flows are removed form King County's system, King County would want agreements in place that release the County from any liability of these flows in the future.	King County Wastewater
We don't need to limit the options to 3, but we do need to eliminate repetition in the concepts.	People For Puget Sound
Some of these alternatives show an estuary adjacent to the railroad bridge and a new fish ladder, both of which may need further evaluation.	Seattle Parks

Water Quality Analysis: First King County water quality sampling report for Wolfe Creek, sampling done September 6, 2007. The report contains a map of three sampling sites: the East Fork, West Fork, and Main Stem where the creek flows into the culvert. The report was generally typical of Seattle urban creeks. However, there was a high fecal coliform count on the East Fork, and borderline temperature overall. Flow was measured just at the outflow. Also noted that there was high turbidity and organic matter in the creek. Kathy Minsch will check on whether there are homes on septic systems that might still exist on the East Fork and possible water contamination from a chicken yard upslope on the north side of the creek from the East Fork sampling site. The water quality could be a design issue, but it is within expected ranges. Design could potentially address these issues, as overall there appears to be a strong need for freshwater estuaries to be added to the Ship Canal. King County plans two more samplings before the February 1 deadline not to go in the ravine for the heron nesting season.	King County Wastewater 10/10/07 Meeting Notes
The General Investigation process and the Juvenile Synthesis Report that was recently prepared as part of this process. The report gives the daylighting of Wolfe Creek as one of its recommendations.	Seattle Public Utilities - 7/11/06 Meeting Notes
If the Locks remain in future ACOE federal budget plans, then it is possible that daylighting Wolfe Creek could be included in that package. If so, ACOE would write an "Environmental Benefits Analysis" which must analyze all alternatives, although it's best to first narrows the benefits. Consultation with biologists is used to select the best alternative. Need to narrow down the 10 alternatives before this process starts.	ACOE - 10/11/06 Meeting Notes
Other sources of information might be MOHAI and the Ballard Historical Society. old T-sheets and old surveys of the coast line and original Locks construction drawings.	6/6/07 Meeting Notes
Seattle's "Restore Our Waters" Plan – Wolfe Creek Daylighting and Locks' bank softening are on list, but as yet unfunded. Determine if a softened shoreline could withstand turbulence of waves/tides	Seattle Public Utilities - 11/19/05 Meeting Notes
SPU is in the process of assessing and prioritizing opportunities to daylight creeks/pipes/culverts/ and streams that are publicly owned that would contribute towards salmon recovery. SPU and other city departments developed criteria. Matrix is still in draft form. SPU will soon develop a *Scientific Framework for Ecological Health*. SPU has already helped developed the *State of our Waters* report. support the *Restore Our Waters* report, and the WRIA work	Seattle Public Utilities - 2/27/07 Meeting Notes
Good model for daylighting Wolfe Creek is: Schmidt's Park or Madrona Creek daylighting is more comparable than Ravenna, because the creek flows into Lake Washington. Other creeks to look at: Fauntleroy, Ravenna, Longfellow & Thornton.	10/11/06 Meeting Notes

Appendix C

Preliminary Geomorphological Assessment
Wolfe Creek Daylighting

Prepared by:

Frank Pita
Jacobs Associates

JACOBS ASSOCIATES
Engineers/Consultants

8Mar08

To: John Rundall & Marian Wineman / WR Consulting, Inc.
From: Frank Pita, PE

RE: Preliminary Recommendations Regarding Geotechnical Parameters & Earthwork Considerations for 'Daylighting' a Creek along West Commodore Way, just East of BNSF RR Rail Crossing of Ship Canal near & next to the Southside Parking Area of the Ballard Locks, Seattle, WA

At your request, I visited the site at 1PM on the 14Feb08. I visited the entire project but the 'daylighting' earthwork will take place in the area from Commodore Way and along the existing parking lot. Therefore, JA's observations are in this area. The follow ing photos and captions are used as an means of explanation:

1

Photo #1 shows nearly the entire area where the 'daylighted' creek will flow on the surface. The parking lot is at the top of the hill on the right. The arrow points to where the creek will cross Commodore Way in a pipe and then release water on the currently vegetated hillside. The water will cascade down the slope and then be channel toward where the picture is taken generally following the contour of the land.

2

Photo #2 shows the vegetated slope discussed in photo #1. The creek channel would be generally flow along the pathway where the near person is walking. The water would cascade down the hillside about where the far person is walking.

811 1st Avenue, Suite 407, Seattle, Washington 98104 Phone: (206) 682.0081 Fax: (206) 682.0092

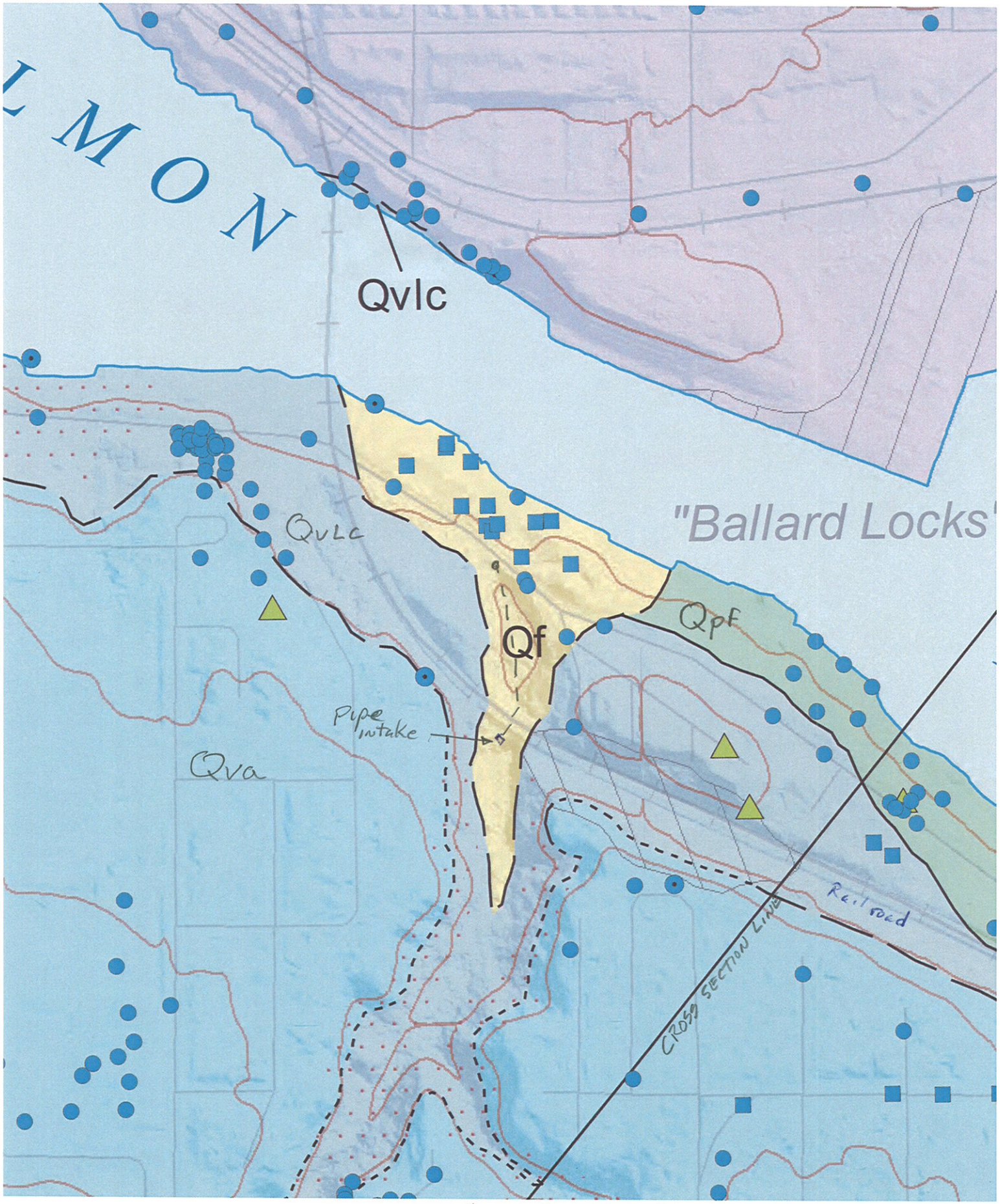
 3

Photo #3 shows the general area where the water would cascade down the hillside. Commodore Way is at the top of the slope. The new pipe would exit the ground about the middle of the slope.

Geotechnical Related Comments, Conclusions & Recommendations

- Based on the attached published geologic map of Seattle, it appears that the site is composed of old fluvial stream deposits from the original creek that overlying very dense glacially consolidated deposits.
- Based on the contouring of the land, it appears that much earthwork has taken place at the site, probably during the time of construction of the locks, Commodore Way and the parking lot/park.
- All slopes observed appear stable in their current condition.
- At this time, JA does not have any data on the type of material composing the slopes other then the information on the geologic map. Alluvial deposits tend to be granular (sandy) in nature so the 2H to 1V or flatter slopes could easily be constructed in this material.
- The underlying very dense fine grain glacial deposits are 'till' – like and would be considered a 'hardpan' type soil. This material can generally be cut to a stable 1H to 1V slope.
- The cascading portion of the creek can be constructed on the existing side slope below Commodore Way, by first;
    - Removing all the vegetation and topsoil,
    - Placing a 6 inch layer of WSDOT Shoulder Ballast rock that would both act as a drain rock and be stable on the hillside. This material needs minimal compaction.
    - Dig in large rockery stones and arrange the shoulder ballast between them.
    - Place fiber reinforced shotcrete over the ballast and around the rocks to act as a liner to prevent erosion and seepage loss.
- At the bottom, a slightly sloping creek channel can be construction long the route shown in photos #1 & 2. At this time, without soil data, I do not recommend cutting into the toe of the slope to form the channel. Instead, JA recommends having the channel be at the toe or away from it and the pathway being removed, made narrower and / or rearranged.

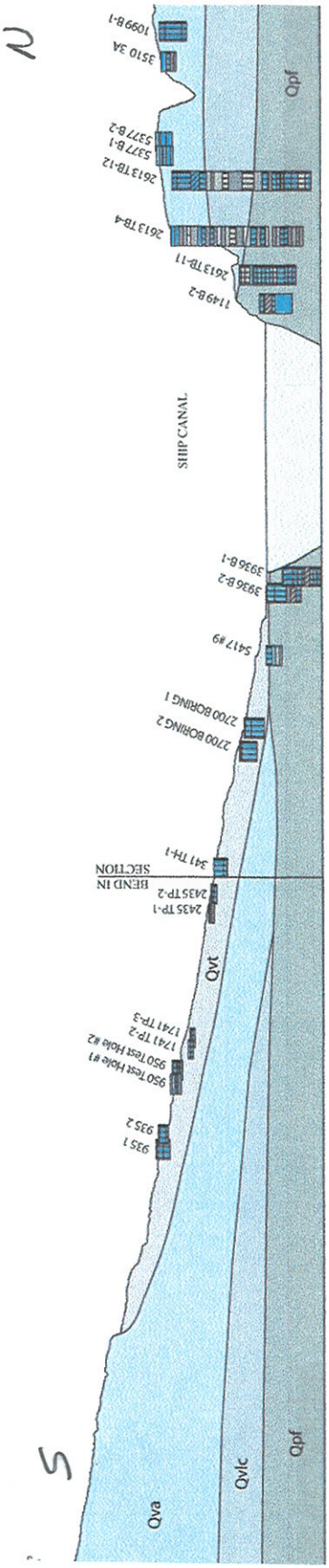
After reviewing this, if questions arise, please contact me.



Geologic Map of Ballard Locks Area

http://geomapnw.ess.washington.edu

JACOBS ASSOCIATES Engineers/Consultants	PROJECT HHH		SHEET
	SUBJECT		DATE 4Mar08
	BY Rita	CHECKED	PROJECT NO.



North / South Cross section near Ballard Locks

JACOBS ASSOCIATES Engineers/Consultants	PROJECT HHH	SHEET
	SUBJECT Geology MAP Key	DATE 4 Mar 08
	BY Pita	CHECKED / PROJECT NO.

Qf **Alluvial fan deposits (Holocene)**—Sand, silt, gravel, and cobbles; deposited in lobate form where streams emerge from confining valleys onto areas of reduced gradients. Mapped deposit grades upvalley into alluvium lacking fan morphology. Loose to dense

Qvt **Vashon till**—Compact diamict of silt, sand, and subrounded to well-rounded gravel; glacially transported and deposited under ice. Commonly is fractured and has intercalated sand lenses. Generally forms undulating, fluted surface; tends to drape topography and is found at both lowest and highest elevations in map area. Unit typically is 1 m (3 ft) thick but can be at least 30 m (100 ft) thick; thickest known deposit in map area is well exposed on northernmost point of hill at Magnolia. Uppermost meter generally is weathered and moderately dense; deeper levels characteristically are unweathered and very dense

Qva **Advance outwash deposits**—Well-sorted sand and gravel; deposited by streams issuing from advancing ice sheet. May grade upward into till. Silt lenses are common in lower part but are less abundant upward. Generally unoxidized to slightly oxidized. May include overlying areas of Vashon till too small to show at map scale. Locally over 60 m (200 ft) thick; dense to very dense. Includes the Esperance Sand Member of the Vashon Drift (Mullineaux and others, 1965). Grades downward into unit Qvlc with increasing silt content

Qvlc **Lawton Clay Member of the Vashon Drift**—Stiff to hard, laminated to massive silt, clayey silt, and silty clay; deposited in lowland or proglacial lakes. Dropstones locally present. Marks transition from nonglacial to earliest glacial time, although unequivocal evidence for glacial or nonglacial origin may be absent. Locally may include fine-grained sediment of unit Qob. Absent in places to over 30 m (100 ft) thick in map area

OLDER GLACIAL AND NONGLACIAL DEPOSITS

Qpf **Deposits of pre-Fraser glaciation age (Pleistocene)**—Interbedded sand, gravel, and silt; of indeterminate age and origin; lightly to heavily oxidized. Discriminated from texturally similar younger deposits, particularly unit Qva, on the basis of stratigraphic position, oxidation, and commonly heterogeneous grain size. On the basis of lithology, elevation, and proximity, some parts of unit probably are equivalent to dated deposits of unit Qob. Maximum elevation inferred to be about 40 m (130 ft); base of unit not exposed in map area. Dense to very dense

Appendix D

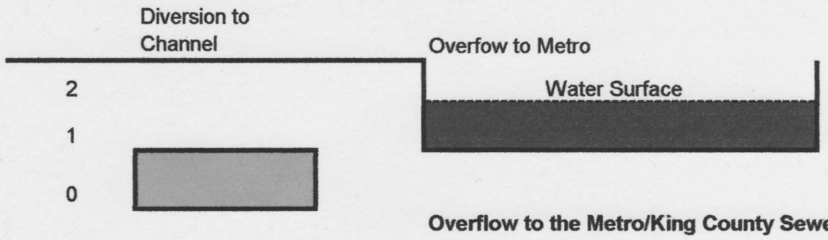
Hydrologic/Hydraulic Considerations Analysis
Wolfe Creek Daylighting

Prepared by:

WR Consulting, Inc.

Wolfe Creek Daylighting
April 11, 2008

Assume Sharp Crested Weir:
(per Brater and King, pg 5-24, when head is one to two times breadth, then sharp-crested weir)



Diversion to the Daylighted Creek:

With End Contractions:
Q = 3.33 * (L-.2H)* H^1.5

	Depth of Flow (ft)	Length (ft)	Flow to Daylighted Channel (cfs)
Low Flow	0.5	1	1.1
Mod. Flow	1.0	1	2.7
Orifice Flow in Diversion			
Mod. Flow	1.0		3.5
High Flow	1.5		5.0
100-yr Flow	2.0		6.1

Overflow to the Metro/King County Sewer

Without End Contractions:
Q = 3.33 * L* H^1.5

	Depth of Flow (ft)	Length (ft)	Flow to Metro (cfs)	Total Flow (cfs)
Low Flow	0.0	4.0	0.0	1.1
Mod. Flow	0.0	4.0	0.0	2.7
Orifice Flow in Diversion				
Mod. Flow	0.0	4.0	0.0	3.5
High Flow	0.5	4.0	4.7	9.7
100-yr Flow	1.0	4.0	13.3	19.4

Orifice Flow Calculation:
Q(cfs) = C* A * (2 * g* H) ^ 0.5

C = 0.62
A = 1
g = 32.2

	Depth of Flow	Head (ft)	Orifice Flow through opening (cfs)
Mod. Flow	1.0	0.5	3.5
High Flow	1.5	1.0	5.0
100-yr Flow	2.0	1.5	6.1

Summary of Flows to Diversion

	Creek Flow (cfs)	Flow to Daylighted Creek (cfs)	Flow to Metro (cfs)
Base Flow	0.4	0.4	0.0
2-year, 24-hour	4	4	0
10-year, 24-hour	9	5	4
100-year, 24-hour	18	6	12

Wolfe Creek Daylighting
April 11, 2008

Pipe Capacity Calculations:

Capacity of 18" Diameter Pipe at Commodore Way Crossing

Pipe Length (feet)	140	
Upper Elevation	25.00	
Lower Elevation	24.00	
Elevation Difference	1	Surcharge: 1 ft
Diameter (inches) =	18	18
Slope (S) =	0.0071	0.0143
S^.5 =	0.085	0.120
n =	0.013	0.013
Area (ft^2) =	1.767	1.767
WP (ft) =	4.712	4.712
R (Hyd. Rad.) = A/Wl	0.375	0.375
R ^ 2/3	0.520	0.520

Q = 1.49/n * A * R^2/3 * S^.5

Q (cfs) =	**8.9**	**12.6**

Capacity of 18" Diameter Pipe at Bulkhead

Pipe Length (feet)	20
Upper Elevation	15
Lower Elevation	12
Elevation Difference	3
Diameter (inches) =	18
Slope (S) =	0.1500
S^.5 =	0.387
n =	0.013
Area (ft^2) =	1.767
WP (ft) =	4.712
R (Hyd. Rad.) = A/Wl	0.375
R ^ 2/3	0.520

Q = 1.49/n * A * R^2/3 * S^.5

Q (cfs) =	**40.8**

Wolfe Creek Daylighting
April 11, 2008

Capacity of Directionally Drilled Pipe

Capacity of 8" Diameter Pipe

Pipe Length (feet)	430		
Upper Elevation	39.00		
Lower Elevation	30.00		
Elevation Difference (feet)	9	Surcharge:	
		4 ft	
Diameter (inches) =	8	8	
Slope (S) =	0.0209	0.0302	
S^.5 =	0.145	0.174	
n =	0.010	0.010	(smooth wall HDPE)
Area (ft^2) =	0.349	0.349	
WP (ft) =	2.094	2.094	
R (Hyd. Rad.) = A/WP	0.167	0.167	
R ^ 2/3	0.303	0.303	

Q = 1.49/n * A * R^2/3 * S^.5

Q (cfs) =	**2.3**	**2.7**

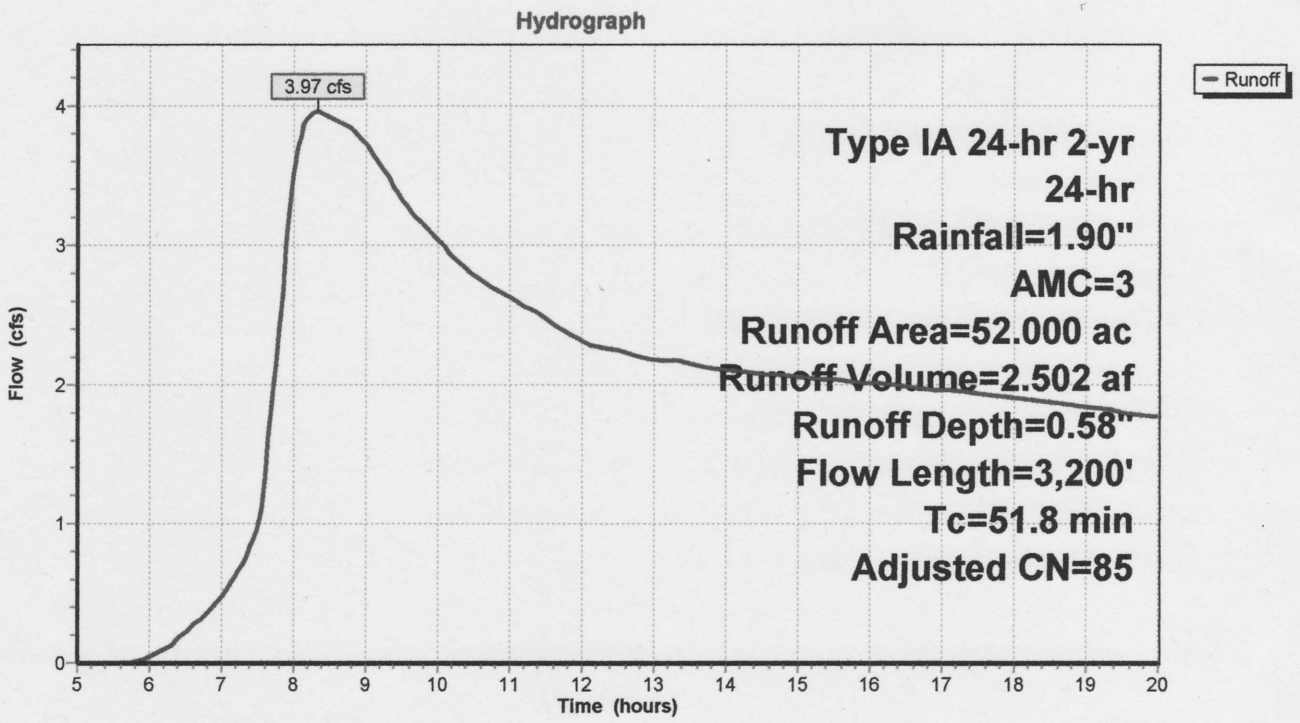
Capacity of 12" Diameter Pipe

Pipe Length (feet)	430		
Upper Elevation	39.00		
Lower Elevation	30.00		
Elevation Difference (feet)	9	Surcharge:	
		4 ft	
Diameter (inches) =	12	12	
Slope (S) =	0.0209	0.0302	
S^.5 =	0.145	0.174	
n =	0.010	0.010	(smooth wall HDPE)
Area (ft^2) =	0.785	0.785	
WP (ft) =	3.142	3.142	
R (Hyd. Rad.) = A/WP	0.250	0.250	
R ^ 2/3	0.397	0.397	

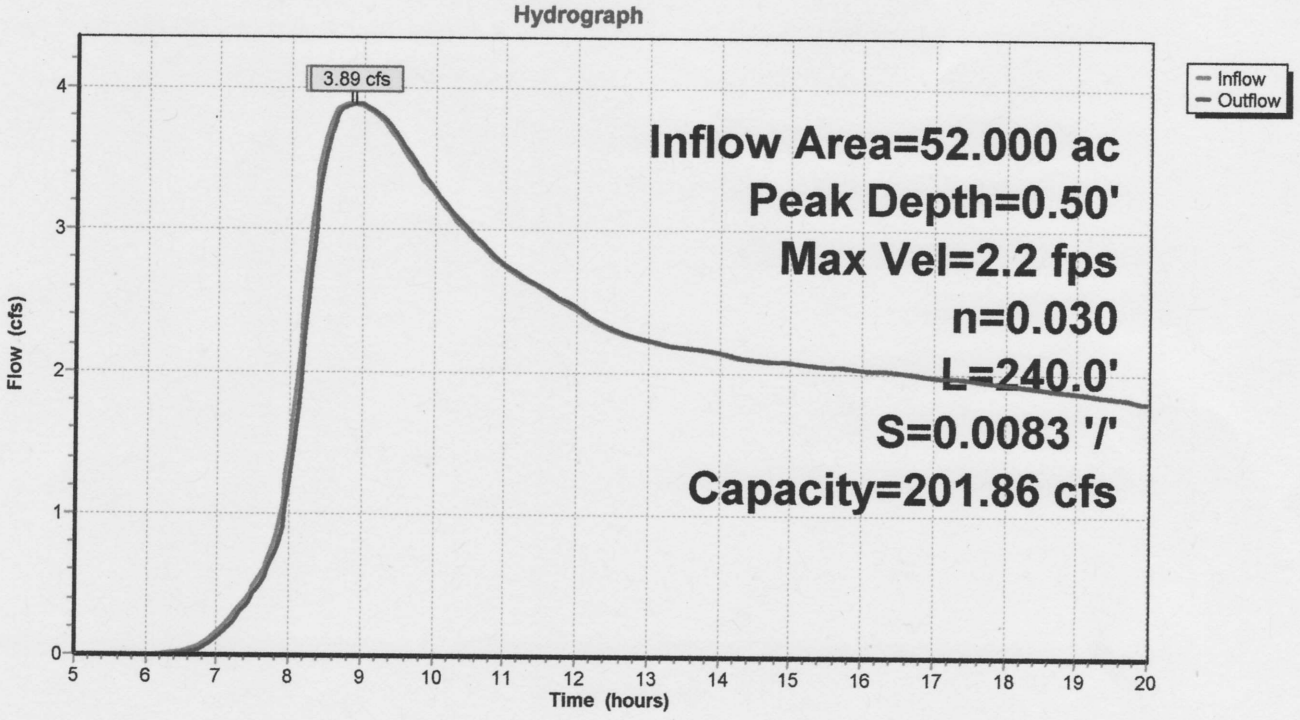
Q = 1.49/n * A * R^2/3 * S^.5

Q (cfs) =	**6.7**	**8.1**

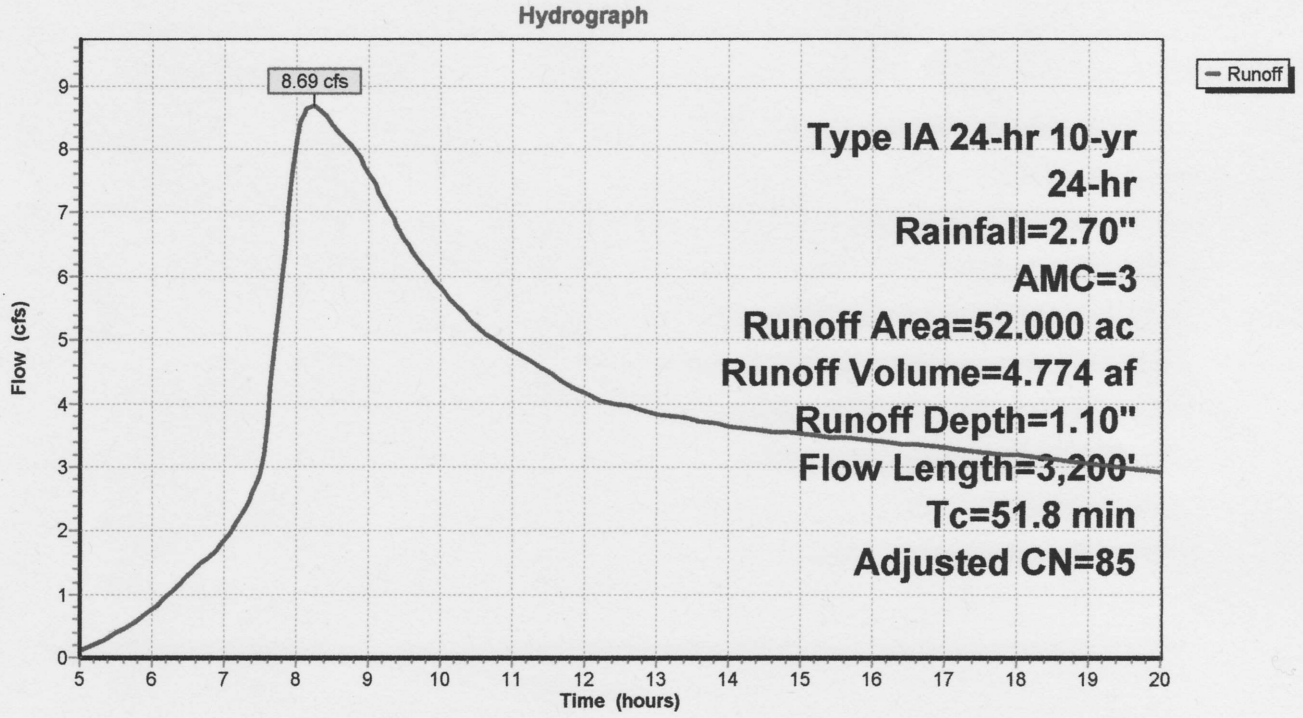
Subcatchment 1S: Wolfe Creek



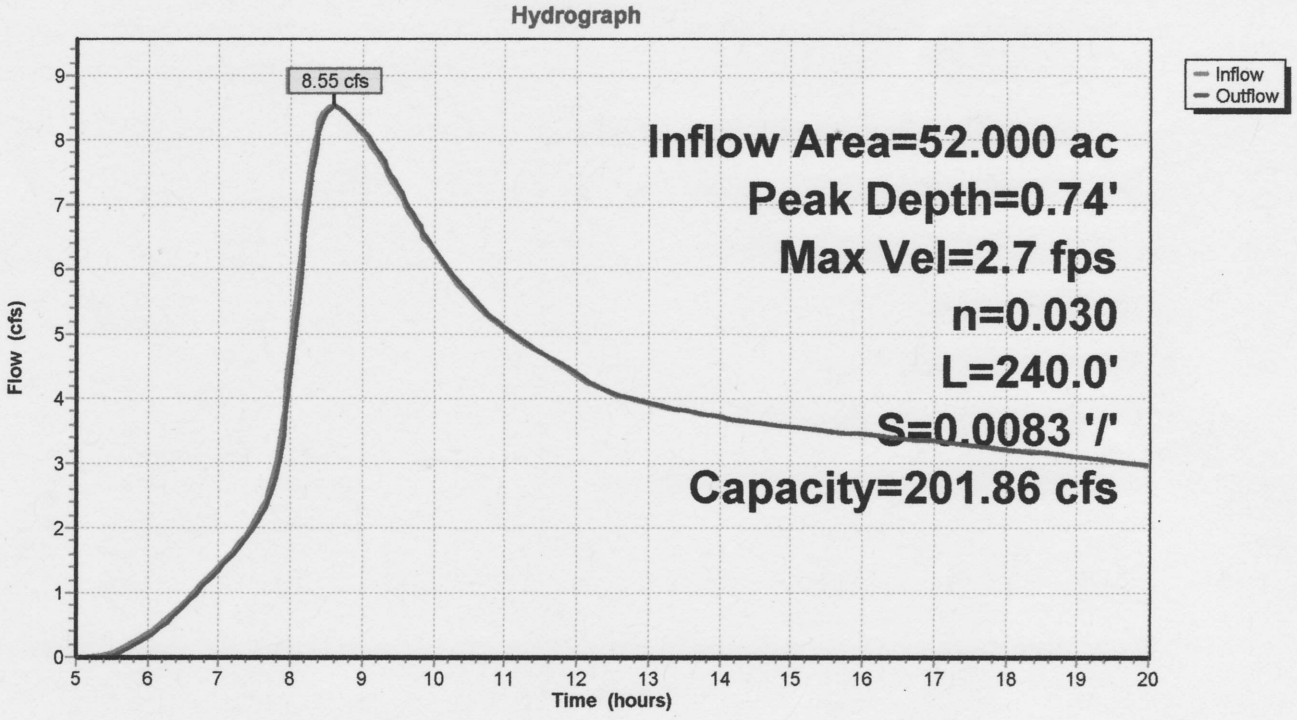
Reach 3R: Daylighted Channel



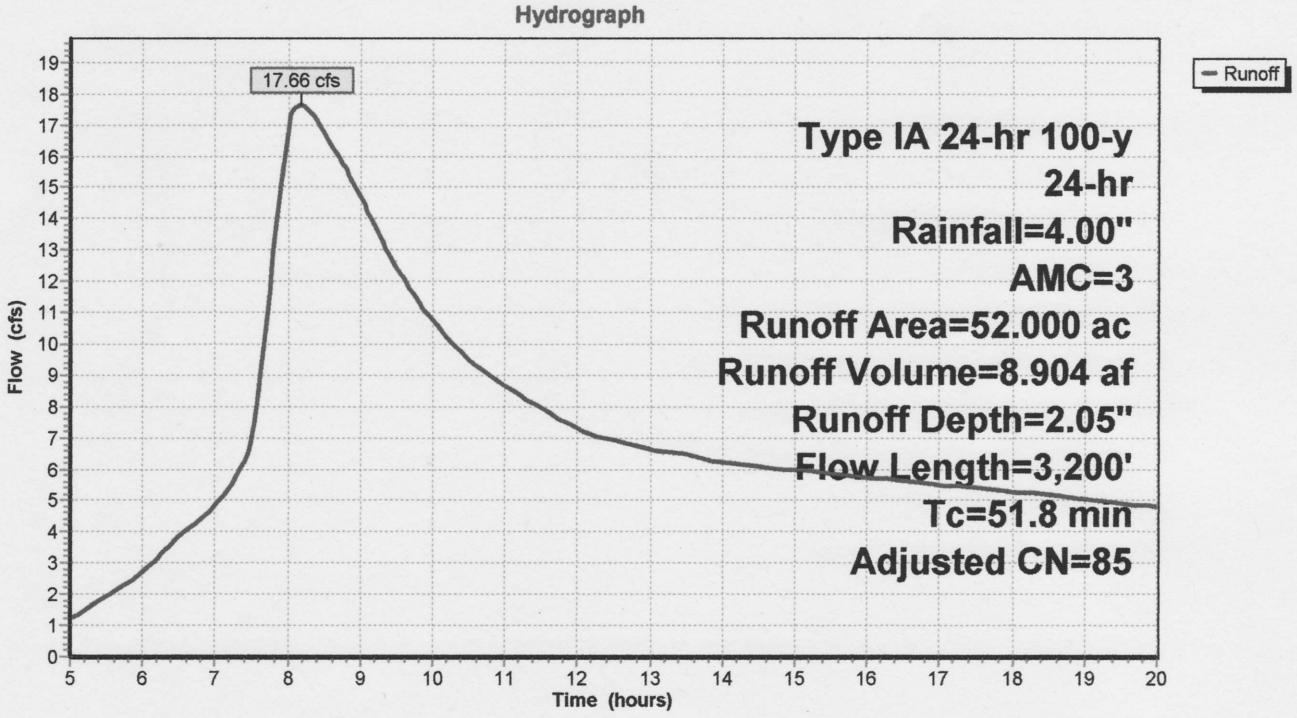
Subcatchment 1S: Wolfe Creek



Reach 3R: Daylighted Channel



Subcatchment 1S: Wolfe Creek



Appendix E

Preliminary Fish Biology Assessment
Wolfe Creek Daylighting

Prepared by:

Peter Heltzel
Taylor Associates, Inc.

Introduction

A number of studies and concept designs have been developed for the proposed daylighting of Wolfe Creek, located west of the Ballard Locks (Hiram M. Chittenden Locks). The ultimate fisheries benefits of daylighting Wolfe Creek would be to provide an influx of freshwater into the estuarine mixing zone for migrating and rearing salmonids through the Ship Canal. This section outlines the benefits of daylighting and how these apply to Wolfe Creek. It also addresses stakeholder concerns related to the fisheries aspects of this project and a brief discussion of the daylighting design alternatives.

Daylighting Benefits

"Daylighting" is a term that describes projects that deliberately expose some or all of the flow of a previously covered river, creek, or stormwater drainage. In this case, Wolfe Creek runs through a culvert and empties directly into a stormwater drainage system that is routed to the waste water treatment plant at West Point.

Daylighting projects can recreate habitat and improve fish passage as well as recreate valuable riparian habitat and corridors for wildlife movement (Pinkham 2000). The functional values of daylighted waterways are important benefits. Exposure to sunlight, air, and soil can allow growth of aquatic and riparian vegetation that can improve water quality by taking up organic and inorganic pollutants, and support development of an instream food web including invertebrate prey organisms for juvenile salmonids.

Daylighting can also remove storm water from the sewer systems effectively increasing wastewater system capacity. Other daylighting benefits include increased educational value of a waterway, increased property values, and reconnecting people to nature. The aesthetic and amenity value of water is quite high and daylighting projects can revitalize surrounding neighborhoods by providing these new amenities.

Wolfe Creek and Ship Canal Existing Conditions

Wolfe Creek runs through Kiwanis Ravine, just southwest of the Hiram M. Chittenden Locks. At the north end of the ravine, the water is trapped by a culvert and sent through an underground pipeline, ultimately terminating at the West Point Treatment Plant. There is currently no access for adult or juvenile salmonids to enter Wolfe Creek.

Adjacent to Wolfe Creek is the Lake Union/Lake Washington Ship Canal system and Salmon Bay Waterway. Currently, adult and juvenile salmonids utilize this area for migration, outmigration, and rearing. Salmonid species utilizing the ship canal system include coho (Oncorhynchus kisutch), sockeye (O. nerka), cutthroat trout (O. clarki clarki), ESA threatened bull trout (Salvelinus confluentus), steelhead (O. mykiss), chum (O. keta), and the ESA endangered Chinook salmon (O. tshawytscha) (Toft 2005). Additional evaluations and detailed information are needed on salmonid utilization of the Ballard Locks and habitats of Salmon Bay to fully understand any ecological benefits of

daylighting Wolfe Creek and reconnecting it the estuary (please see Data Gaps in main report).

Native char (Bull trout), are known to be highly migratory and opportunistic feeders. There is currently very little information on the utilization of the Ballard Locks and habitats within Salmon Bay by native char. The 1994 master plan for the Ballard Locks mentions the presence of native char, suggesting that they pass through the locks from Puget Sound to Lake Washington. However, there are no data on the number of char passing through this facility from and to Lake Washington. Eric Warner with the Muckleshoot Indian Tribe observed native char in the viewing chamber of the locks on June 21, 1996. Bill Mavros (King County DNR) and Brian Footen (Muckleshoot Indian Tribe) caught and released a native char on May 3, 2000 during a beach seine in Shilshole Bay near the outlet of the Ballard Locks. Native char have been known to congregate in Shilshole Bay and in other estuarine areas to feed on smolts during the spring outmigration period (KCDNR 2000). A healthy population of native char currently uses the natural beach area at the former outlet of Wolfe Creek (Chuck Ebel, Pers. Comm., 2006).

Many other important marine species utilize the habitats below the locks. These include sand lance (Ammodytes americanus), Pacific herring (Clupea pallasi), Dungeness crab (Cancer magister), shiner perch (Cymatogaster aggregate), three-spine stickleback (Gasterostreus aculeatus), sculpin species, and many others (Toft 2005). There is also a diverse array of marine invertebrates.

Benefits of Daylighting Wolfe Creek and Downstream Nearshore Area

Daylighting Wolfe Creek would ultimately create new upland riparian and instream habitat, reconnect the creek to the salt water in the ship canal, and create a localized delta environment at the mouth of the creek. Although fish passage into the creek would be limited, due to the inherent small size of the creek, benefits to juvenile and adult salmon would still be created in the nearshore marine environment.

Simenstad et al. (in review) found that juvenile salmonid diets within Salmon Bay were not typical prey items for juvenile salmonids in estuaries and nearshore waters of Puget Sound. Diets consisted more of freshwater prey items and lacked the typical estuarine benthic/epibenthic and terrestrial riparian prey items. Juvenile salmonid habitat can be enhanced by increasing both the production and availability of estuarine prey resources (Toft 2005), specifically in regard to prey resources for juvenile salmonids.

Daylighting Wolfe Creek and creating an upland riparian habitat would increase the availability of terrestrial food sources by flushing entrained insects into the ship canal nearshore habitat. Created riffle sections in daylighted areas would also provide in-channel aquatic macroinvertebrates that would provide another source of prey items not currently available in the ship canal habitats below the locks. Daylighting Wolfe Creek would help increase drift production to the nearshore environment, and in turn increase and diversify prey availability for out-migrating juvenile salmonids.

Reconnecting Wolfe Creek to the salt water habitat of the ship canal would create a localized brackish environment and intertidal delta. These shallow littoral habitats are absent below the locks and provide both foraging opportunities and protection from predators for juvenile salmonids.

Some of the designs for daylighting Wolfe Creek show the daylighted channel entering through the existing beach. These options would impact a relatively small portion of the existing beach. Although juvenile salmonids likely utilize this area of beach for foraging, the resulting benefits of channel refuge, increased food availability, decreased temperatures, and salinity gradients would likely outweigh any existing benefits the beach currently provides. Additional considerations include disruption of the biological function of the existing small beach area (including the healthy population of bull trout, an ESA listed species, currently using it (Chuck Ebel, Pers. Comm., 2006) and the potential impacts to a small portion of the last remnant of the natural shoreline in the area. These possible benefits and additional evaluations need to be further addressed in a Biological Assessment (please see Data Gaps in the main report).

Current conditions at the locks have created a thermal and salinity barrier causing adult and juvenile salmonids to have to quickly adapt between salt and freshwater, which can cause extreme stress and decrease survivability. A shallow littoral habitat at the mouth of Wolfe Creek could help adult and juvenile salmonids adjust between salt and freshwater effectively increasing their chance for survival.

Other benefits of daylighting Wolfe Creek include increased fine sediment transport, increased variety of algae, creating heterogeneity of the beach, and recruitment of wood and detritus. These beneficial attributes would help diversify the estuarine habitat below the locks and help create estuarine processes not currently available to out-migrating, migrating, and foraging salmonids.

Discussion of Alternatives

Ten alternatives have been submitted for review. Alternatives showing the longest stretches of daylighted channel would give the most benefit to upland riparian production and input to the marine environment. Longer channels with predominately riffle sections would also contribute towards improving water quality and increased macroinvertebrate production. Alternatives showing creation of brackish marshes, near shore riparian enhancement, and fish passage enhancement would help contribute other ecological benefits in conjunction with reconnecting Wolfe Creek.

Conclusion

Recently, salmon ecology researchers have found that small “pocket estuaries” are important marine habitats for juvenile salmon, and that many of the Puget Sound “pocket estuaries” have disappeared or are severely degraded through human activities. Although reconnecting Wolfe Creek to Salmon Bay and creating a “pocket estuary” would add a

relatively minimal amount of freshwater input, this project is the first phase of many future restoration/enhancement projects for the Ballard Locks and Salmon Bay estuary. This project in conjunction with others (i.e. freshwater addition to the fish ladder from Lake Union and future nearshore restoration at Wolfe Creek), can positively add to the larger cumulative effect on the life history of salmonids.
Daylighting Wolfe Creek and reconnecting it to the marine environment below the locks would ultimately create a productive upland riparian habitat, reconnect the creek to the salt water environment in the ship canal, and create a localized shallow littoral zone at the mouth of the creek. These new habitats would help increase/diversify prey sources and create a localized brackish transition zone for all species of adult and juvenile salmonids, particularly for endangered Chinook salmon. Creating a diversified habitat and a more natural estuary environment directly below the locks would not only help the survivability of salmonids, but also benefit many other marine species that utilize estuary environments.

References

Chuck Ebel, U.S. Army Corps of Engineers. Personal Communication in July 11, 2006 Wolfe Creek Daylighting Stakeholder's Meeting Notes.

King County Department of Natural Resources. Literature Review and Recommended Sampling Protocol for Bull Trout in King County. Seattle, WA. June, 2000.

Pinkham, R. 2000. Daylighting: New Life for Buried Streams. Rocky Mountain Institute, Snowmass, Colorado. September 2000. 73 pp.

Simenstad, C., J. Toft, M. Hass, M. Koeler, J. Cordell, and K. Fresh. In Review. Investigations of juvenile salmon passage and habitat utilization. Technical Report, School of Aquatic and Fisheries Sciences, University of Washington, Seattle, Washington. Prepared for USACE Seattle District. 45 pp.

Toft, J., J. Cordell, B. Starkhouse. 2005. Salmon Bay Natural Area Pre-Restoration Monitoring 2004. School of Aquatic and Fisheries Sciences, University of Washington, Seattle, Washington. March 2005. SAFS-UW-0503. 28 pp.

Appendix F

Wolfe Creek Water Quality Data
Wolfe Creek Daylighting

Prepared by:

King County Wastewater

King County Environmental Lab Analytical Report

PROJECT: 423586-001-1

Locator:	WC001	WC002	WC003
Descrip:	WOLF CREEK W KIWAN	EAST FORK	WEST FORK
Client Loc:			
Sampled:	09/06/07 10:22:00 AM	09/06/07 10:54:00 AM	09/06/07 11:15:00 AM
TimeSpan:			
Lab ID:	L43794-1	L43794-2	L43794-3
Matrix:	FRESH WTR	FRESH WTR	FRESH WTR
% Solids:			

Parameters	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units
			-Wet Weight Basis					-Wet Weight Basis					-Wet Weight Basis		
COMBINED LABS															
M=CV SM4500-NH3-G (03-03-012-004)															
Ammonia Nitrogen	0.019	<RDL	0.01	0.02	mg/L	0.0337		0.01	0.02	mg/L	0.068		0.01	0.02	mg/L
M=CV SM4500-NO3-F (03-03-012-004)															
Nitrite + Nitrate Nitrogen	1.55		0.04	0.08	mg/L	1.56		0.02	0.04	mg/L	1.55		0.02	0.04	mg/L
M=ES Hydrolab (02-01-005-002)															
Dissolved Oxygen, Field	9.5		0.5	1	mg/L	9.1		0.5	1	mg/L	9.2		0.5	1	mg/L
pH, Field	7.93				pH	7.83				pH	7.78				pH
Sample Temperature, Field	14.38				deg C	14.72				deg C	14.18				deg C
M=ES NONE															
Discharge Rate of Stream	0.23		0.05	0.1	cfs										
Field Personnel	JDD				none	JDD				none	JDD				none
Sample Information	very turbid-lots of organics debris				none	low water-difficult to sample; turbid				none	significantly more water than east fork				none
M=MC METRO MC SOP 6.5.1															
Escherichia coli	2100				CFU/100ml	8900				CFU/100ml	700				CFU/100ml
M=MC SM-9222 D ed.17															
Fecal Coliform	950				CFU/100ml	9800				CFU/100ml	920				CFU/100ml

King County Environmental Lab Analytical Report

PROJECT: 423586-001-1

Locator:	WC001	WC002	WC003
Descrip:	WOLF CREEK W KIWAN	EAST FORK	WEST FORK
Client Loc:			
Sampled:	11/13/07 9:55:00 AM	11/13/07 10:20:00 AM	11/13/07 10:39:00 AM
TimeSpan:			
Lab ID:	L44462-1	L44462-2	L44462-3
Matrix:	FRESH WTR	FRESH WTR	FRESH WTR
% Solids:			

Parameters	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units
	-Wet Weight Basis					-Wet Weight Basis					-Wet Weight Basis				
COMBINED LABS															
M=CV SM4500-NH3-G (03-03-012-004)															
Ammonia Nitrogen	0.0204		0.01	0.02	mg/L	0.0561		0.01	0.02	mg/L	0.0559		0.01	0.02	mg/L
M=CV SM4500-NO3-F (03-03-012-004)															
Nitrite + Nitrate Nitrogen	1.26		0.02	0.04	mg/L	1.48		0.1	0.2	mg/L	1.25		0.02	0.04	mg/L
M=ES Hydrolab (02-01-005-002)															
Dissolved Oxygen, Field	11.1		0.5	1	mg/L	10		0.5	1	mg/L	10.2		0.5	1	mg/L
pH, Field	7.65				pH	7.53				pH	7.64				pH
Sample Temperature, Field	8.2				deg C	8.25				deg C	9.36				deg C
M=ES NONE															
Discharge Rate of Stream	0.19		0.05	0.1	cfs										
Field Personnel	JDD				none	JDD				none	JDD				none
Sample Information						Very low flow				none					
M=MC METRO MC SOP 6.5.1															
Escherichia coli	510				CFU/100ml	1600				CFU/100ml	510				CFU/100ml
M=MC SM-9222 D ed.17															
Fecal Coliform	450				CFU/100ml	460				CFU/100ml	180				CFU/100ml

King County Environmental Lab Analytical Report

PROJECT: 423586-001-1

	Locator:	WC001	Locator:	WC002	Locator:	WC003
	Descrip:	WOLF CREEK W KIWAN	Descrip:	EAST FORK	Descrip:	WEST FORK
	Client Loc:		Client Loc:		Client Loc:	
	Sampled:	01/23/08 10:50:00 AM	Sampled:	01/23/08 11:23:00 AM	Sampled:	01/23/08 11:38:00 AM
	TimeSpan:		TimeSpan:		TimeSpan:	
	Lab ID:	L44993-1	Lab ID:	L44993-2	Lab ID:	L44993-3
	Matrix:	FRESH WTR	Matrix:	FRESH WTR	Matrix:	FRESH WTR
	% Solids:		% Solids:		% Solids:	

Parameters	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units
			-Wet Weight Basis					-Wet Weight Basis					-Wet Weight Basis		
COMBINED LABS															
M=CV SM4500-NH3-G (03-03-012-004)															
Ammonia Nitrogen	0.0803		0.01	0.02	mg/L	0.051	<RDL	0.05	0.1	mg/L	0.117		0.01	0.02	mg/L
M=CV SM4500-NO3-F (03-03-012-004)															
Nitrite + Nitrate Nitrogen	1.98		0.1	0.2	mg/L	1.09		0.1	0.2	mg/L	1.86		0.1	0.2	mg/L
M=ES Hydrolab (02-01-005-002)															
Dissolved Oxygen, Field	12.4		0.5	1	mg/L	12		0.5	1	mg/L	11.4		0.5	1	mg/L
pH, Field	7.58				pH	7.61				pH	7.62				pH
Sample Temperature, Field	3.03				deg C	3.05				deg C	4.79				deg C
M=ES NONE															
Discharge Rate of Stream	0.22		0.05	0.1	cfs										
Field Personnel	JDD				none	JDD				none	JDD				none
Sample Information						Low Flow				none					
M=MC METRO MC SOP 6.5.1															
Escherichia coli	52				CFU/100ml	100				CFU/100ml	15				CFU/100ml
M=MC SM-9222 D ed.17															
Fecal Coliform	22				CFU/100ml	12				CFU/100ml	10				CFU/100ml


WC001- Wolfe Creek-Main Stem
WC002- Wolfe Creek East Fork
WC003- Wolfe Creek West Fork
W LAWTON ST
W HARLEY ST
W COMMODORE WAY
W 33RD PED AVE
34TH AVE W
35TH AVE W
33RD AVE W
GAY AVE W
32ND AVE W
W FORT ST
W FORT ST
W GOVERNMENT WAY
31ST AVE W
30TH AVE W
29TH AVE W
BRYGGER DR W
36TH AVE W
W JAMESON ST
32ND AVE W
31ST AVE W

DESCRIPTION OF COMPREHENSIVE REPORT CONTENTS

Locator

Each sampling site is assigned a unique locator code which defines a unique geographic reference for that sampling point. Locators are also used to identify non-geographic samples in LIMS.

Sample Date

The sample date is labeled Sampled. It is the record in LIMs, of the month, day, and year the sample was collected.

Lab ID

Each sample receives a unique Lab sample number, so that all samples can be referenced by their sample numbers.

Matrix.

Matrix is the Lab's designation of the physical nature of the sample and source. There are four groups of matrices: liquids, solids, tissues, and air. The matrices and their codes are as follows.

LIQUID		
	OTHER WTR	LA
	INFLUENT	LB
	EFFLUENT	LC
	DIG SLUDGE	LD
	IW WATER	LE
	SEWER WTR	LF
	STORM WTR	LG
	DRINK WTR	LH
	GRND WTR	LJ
	FRESH WTR	LK
	SALT WTR	LL
	FILTER WTR	LM
	BLANK WTR	LN
	SEPTAGE	LP
	TCLP LEACH	LQ
	RECON WTR	LR
	SEM EXTRACT	LS
	NON-WATER	LT
	CONSTRUCTION DEWATERING WATER	LU
SOLIDS		
	OTHR SOLID	SA
	SOIL	SB
	COMPOST	SC
	SLUDGE	SD
	FRSHWTRSED	SE
	SALTWTRSED	SF
	IW SLUDGE	SG
	IN-LINE SED	SH
	SOLIDBLANK	SJ
TISSUES		
	OTHR TISS	TA
	ALGAE	TB
	PLANT	TC
	SHELLFISH	TD
	FISH	TE
	CRAYFISH W	TF
	CRAYFISH E	TG
	ORGANS	TH
	FISH PLASMA	TP
AIR		
	AIR BLANK	AA
	AMBIENT AIR	AB
	LANDFILL GAS	AC
	SEWER GAS	AD

%Solids

The percent of the non-liquid (by weight) portion of the solid sample. All data are calculated and stored on a wet weight basis. The % Solid value is used, if requested, to normalize and report data on a dry weight basis. Each sample will be flagged either **Wet Weight Basis** or **Dry Weight Basis** in the report. Note that the conversion to a dry weight basis is not applicable to all parameters, such as pH and Particle Size Distribution. Parameters not converted to dry weight basis may be included in the same column with dry weight results but will be noted with an *.

Parameters

Parameters (analytes tested for) are reported in sub-groups corresponding to the laboratory that tested for them. The sub-groups are: **organics, metals, conventionals, microbiology, field analysis, and toxicology**.

Value and Units

The value is the measurement of the parameter expressed in the appropriate units of measure. The units of measure are stated directly beneath the label ***Units***.

Qual (qualifiers)

See attached table on the reverse side.

MDL and RDL

The Method Detection Limit (MDL) is the minimum concentration of an analyte that can be measured and reported with 99% confidence that the true analyte concentration is greater than zero. The MDL value reported may be adjusted upward to eliminate false positives or meet qualitative requirements of the method.
The Reporting Detection Limit (RDL) is the minimum measured concentration of an analyte that can be reliably quantitated. The RDL is usually a multiple of the reported MDL.

Additional Information:

1. Significant Figures for reported values: As standard practice the Lab reports values above the RDL to 3 figures. Values below the RDL are reported to 2 figures. There are exceptions to the standard convention for microbiological, aquatic toxicology, field and some conventional data.
2. Precautions concerning data: It is possible to inadvertently commit errors in combining data points. **Matrix, Units and Analytical Method** should be consistent when combining or comparing data. Parameter name changes, analytical methods and detection limits have changed over time. Data storage practices have also changed. In the 1970's and 80's measured values that were below the detection limit were not always reported with a <MDL qualifier. The value reported may be the detection limit rather than a quantifiable response. If, in older data (i.e. 1970's) the lowest value in the series is repeated several times, the Lab should be contacted for clarification.

If you have questions, call the Info Systems and Data Analysis Unit: Kerry Tappel (684-2366).

Revised: April 11, 2007

see reverse side

DESCRIPTION OF COMPREHENSIVE REPORT CONTENTS

General Purpose Qualifiers		Chemistry and Biology Qualifers		Sediment (QA1) Qualifiers	
Qualifier	**Definition**	**Qualifier**	**Definition**	**Qualifier**	**Definition**
B	Blank contamination observed	P	Target parameter detected above the MDL (HCID only)	X	Very low (10%) matrix spike or surrogate recovery
E	Estimated value	J#	Tentatively identified compound (GCMS only). The value entered for # indicates the confidence level of the identification.	G	Matrix spike, SRM or surrogate recovery was below the acceptance limit
H	a sample handling criteria has been exceeded	>MR	Result exceeds measurable range of either instrument or method * (chemistry only)	L	Matrix spike, SRM or surrogate recovery was above the acceptance limit
R	Rejected, unusable for all purposes	C	Value is an estimate, based on presence of confluent growth (microbiology only)	E	Duplicate RPD or triplicate RSD result was above the acceptance limit
RDL	equal to the reporting detection limit	E	Result is based on an estimation technique (microbiology only)	B	Contamination reported in blank
< RDL	less than the reporting detection limit	> ####	Result exceeds measurable range of the procedure** (biology only) where ### = measurable range		
< MDL	less than the method detection limit	NF	Target organism not recovered or identified (microbiology only)		
TA	text information available	P	Target organism identified (biology methods)		
		D	Indicates the species was predominant in the population (biology only)		
		S	Indicates the species was second to predominant in the sample (biology only)		
		AD	Adult form of organism identified in sample (biology only)		
		LV	Larval form of organism identified (biology only)		
		PU	Pupa form of organism identified (biology only)		
		PASS	Qualitative QC response was acceptable		
		FAIL	Qualitative QC response was unacceptable		

* >MR indicates the measured response was above the measurable range of the method. The numeric value in the value field is an estimate of the minimum value of the true concentration. This qualifier is used only for chemistry parameters.

** > ### is used for biological tests where the result of the analysis is above the measureable range of the method. The value entered for ### is the upper range of the method. No value is entered in the value field.

Appendix G

Preferred Alternatives Concept-Level Construction Cost Estimates

Wolfe Creek Daylighting

Prepared by:

WR Consulting, Inc.

Wolfe Creek Daylighting - Cost Estimate
April 30, 2008

Option 1 (South) - Pipe Diversion

Item	Description	Qty.	Unit	$/Unit	Total
Site Preparation / Demolition					
	Mobilization	1	10%	$30,520	$31,000
	Temp. Erosion and Sediment Control	1	LS	$10,000	$10,000
	Temp. Creek Diversion	1	LS	$10,000	$10,000
	Traffic Control	1	LS	$20,000	$20,000
	Clearing and Grubbing	1	LS	$1,000	$1,000
Storm Drains (Stream Diversion)					
	Diversion Structure (60" Diam. MH)	1	LS	$25,000	$25,000
	Diversion Wier in Structure	1	LS	$3,000	$3,000
	Jack 24" Casing under Commodore Way	130	LF	$1,000	$130,000
	18" Diam. Culvert in Casing	130	LF	$150	$19,500
	Connection to Existing Pipe/Structure	2	LS	$2,000	$4,000
Sanitary Sewer					
	SSMH	1	EA	$5,000	$5,000
	8" SSS	70	LF	$120	$8,400
	6" SSS	130	LF	$110	$14,300
	6" SSS C.O.	3	EA	$1,000	$3,000
	Connect to Existing Houses	2	EA	$1,000	$2,000
Restoration and Site Improvements					
	Restoration at Diversion Structure	1	LS	$15,000	$15,000
	Restoration at Sanitary Sewer	1	LS	$20,000	$20,000
	Misc. Restoration	1	LS	$15,000	$15,000
				SUBTOTAL:	**$336,200**

Contingency (30%)	**$100,860**
TOTAL:	**$437,060**

Wolfe Creek Daylighting - Cost Estimate
April 30, 2008

Option 2 (South) - Directional Drilling

Item	Description	Qty.	Unit	$/Unit	Total
Site Preparation / Demolition					
	Mobilization	1	10%	$31,860	$32,000
	Temp. Erosion and Sediment Control	1	LS	$10,000	$10,000
	Temp. Creek Diversion	1	LS	$10,000	$10,000
	Traffic Control	1	LS	$10,000	$10,000
	Clearing and Grubbing	1	LS	$1,000	$1,000
Storm Drains (Stream Diversion)					
	Diversion Structure (60" Diam. MH)	1	LS	$20,000	$20,000
	Diversion Wier in Structure	1	LS	$3,000	$3,000
	Mobilize Directional Drilling	1	LS	$50,000	$50,000
	Directional Drilling	430	LF	$300	$129,000
	12" HDPE Pipe	430	LF	$120	$51,600
	Connection to Existing Pipe/Structure	2	LS	$2,000	$4,000
Sanitary Sewer					
	SSMH	0	EA	$3,000	$0
	8" SSS	0	LF	$25	$0
	6" SSS C.O.	0	EA	$500	$0
	Connect to Existing	0	EA	$1,000	$0
Restoration and Site Improvements					
	Restoration at Diversion Structure	1	LS	$10,000	$10,000
	Restoration at Access Pit	1	LS	$10,000	$10,000
	Misc. Restoration	1	LS	$10,000	$10,000
				SUBTOTAL:	**$350,600**

Contingency (30%)	**$105,180**
TOTAL:	**$455,780**

Wolfe Creek Daylighting - Cost Estimate
April 30, 2008

Option 1 (North) - Short Channel

Item Description		Qty.	Unit	$/Unit	Total
Site Preparation / Demolition					
	Mobilization	1	10%	$18,630	$19,000
	Temp. Erosion and Sediment Control	1	LS	$5,000	$5,000
	Traffic Control	1	LS	$2,500	$2,500
	Clearing and Grubbing	1	LS	$5,000	$5,000
Earthwork					
	Excavation and Haul for Channel	1	LS	$5,000	$5,000
	Finish Grading at Channel	1	LS	$2,500	$2,500
Storm Drains (Stream Diversion)					
	18" Diam. Culvert at Bulkhead	20	LF	$150	$20,000
	18" Diam. Culvert through Bulkhead	1	LS	$2,000	$2,000
	3-Sided Box Culvert at Driveway	1	LS	$10,000	$10,000
	Channel Lining (HDPE Membrane)	85	LF	$50	$4,250
	Channel Soil and Streambed Gravel	85	LF	$150	$12,750
	Logs and Woody Debris in Channel	10	EA	$2,000	$20,000
	Rock Wiers in Channel	5	EA	$5,000	$25,000
Restoration and Site Improvements					
	AC Restoration	1	LS	$4,000	$4,000
	Hand Rails at Box Culvert Crossing	1	LS	$4,000	$4,000
	Planting Soil and Mulch	3,400	SF	$2	$6,800
	Landscape Restoration - Channel (10 ft wide)	850	SF	$10	$8,500
	Landscape Restoration - Riparian (2 x 20 ft wide)	3,400	SF	$10	$34,000
	Irrigation/Plant Establishment	1	LS	$5,000	$5,000
	Misc. Restoration	1	LS	$10,000	$10,000
				SUBTOTAL:	**$205,300**

Contingency (30%)	**$61,590**
TOTAL:	**$266,890**

Wolfe Creek Daylighting - Cost Estimate
April 30, 2008

Option 2 (North) - Long Channel

Item Description		Qty.	Unit	$/Unit	Total
Site Preparation / Demolition					
	Mobilization	1	10%	$55,250	$55,000
	Temp. Erosion and Sediment Control	1	LS	$10,000	$10,000
	Traffic Control	1	LS	$5,000	$5,000
	Clearing and Grubbing	1	LS	$5,000	$5,000
	Remove Existing Sidewalk	1	LS	$3,000	$3,000
	Remove Existing Storm Drains	1	LS	$2,000	$5,000
	Relocate Existing Electrical	1	LS	$2,000	$2,000
Earthwork					
	Excavation and Haul for Channel	1	LS	$20,000	$20,000
	Finish Grading at Channel	1	LS	$10,000	$10,000
Storm Drains (Stream Diversion)					
	3-Sided Box Culvert at Stairs	1	LS	$5,000	$5,000
	Channel Lining (HDPE Membrane)	350	LF	$50	$17,500
	Channel Soil and Streambed Gravel	350	LF	$150	$52,500
	Logs and Woody Debris in Channel	40	EA	$2,000	$80,000
	Rock Wiers in Channel	10	EA	$5,000	$50,000
	Energy Dissipation at Outfall	1	LS	$5,000	$5,000
Restoration and Site Improvements					
	Stair Reconstruction at Box Culvert	1	LS	$5,000	$5,000
	Path Construction	300	LF	$15	$4,500
	Planting Soil and Mulch	14,000	SF	$2	$28,000
	Landscape Restoration - Channel (10 ft wide)	3,500	SF	$10	$35,000
	Landscape Restoration - Riparian (2 x 20 ft wide)	14,000	SF	$10	$140,000
	Irrigation/Plant Establishment	1	LS	$15,000	$15,000
	Gabions/Retaining Structure at Ped. Bridge	1	LS	$10,000	$10,000
	Pedestrian Bridge at West Path	1	LS	$20,000	$20,000
	Misc. Restoration	1	LS	$25,000	$25,000
				SUBTOTAL:	**$607,500**

Contingency (30%)	**$182,250**
TOTAL:	**$789,750**

Appendix H

Project Team Information
Wolfe Creek Daylighting

The Wolfe Creek Daylighting Concept Feasibility Study was managed by Heron Habitat Helpers (HHH) under a grant from The Russell Family Foundation. The Project Manager for HHH was Kay Shoudy and the HHH review team included Kay Shoudy, Donna Kostka, Mark Ewbanks and Brad Wakeman.

The Wolfe Creek Daylighting Concept Feasibility Study was conducted by the WR Consulting, Inc. Team. The team members and their roles on the project are as follows:

- WR Consulting, Inc. – Project Lead and Civil Engineering by John Rundall, P.E. and Marian Wineman, M.S.E.
- Resolvent LLC – Civil Engineering by Maureen Kwolek, P.E.
- J.A. Brennan and Associates – Landscape Design by Jim Brennan, Landscape Architect and Planner
- Taylor Associates – Fisheries Biology by Bill Taylor, M.S., Environmental Science and Engineering and Peter Hetzel, M.S. , Environmental and Marine Sciences
- Jacobs Associates – Geotechnical Analysis by Frank Pita, P.E., LHG

Contributions were also made by Clayton Beaudoin of Site Workshop LLC and many stakeholders listed in Appendix B.