Vancouver Energy
NPDES Engineering Report

EFSEC Application for Site Certification No. 2013-01
Docket No. EF131590

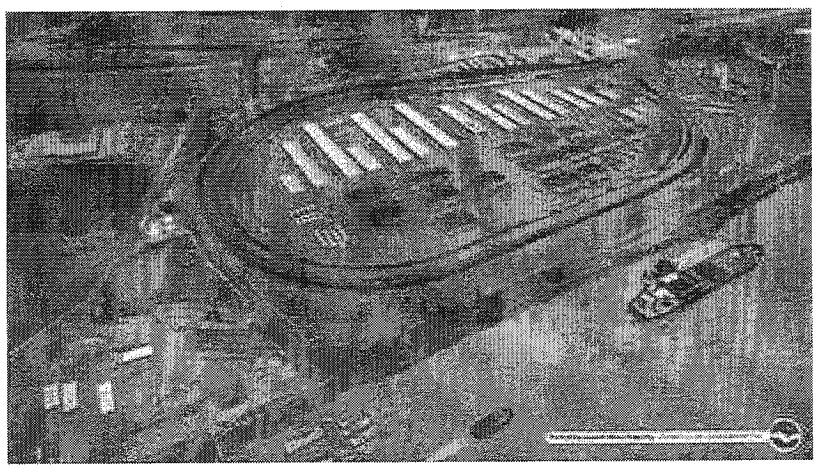
Appendix D
Existing Drainage Reports

West Vancouver Freight Access

Terminal 5 Expansion (4000A and SPL)

Final Hydrologic and Hydraulic Analysis Report

Case Number ENG2012-00016
Project PRJ2012-00414



Revision 1: May 3rd, 2012

PORT OF VANCOUVER U.S.A.

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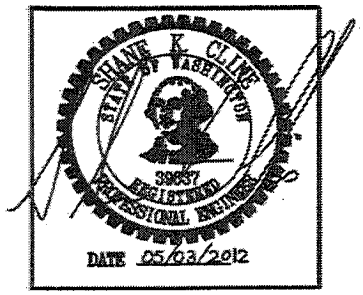


EXECUTIVE SUMMARY

This report provides the stormwater system design and hydrologic and hydraulic analysis information for the Terminal 5 (T5) Expansion, part of the West Vancouver Freight Access (WVFA) Project (Project) located at the Port of Vancouver (Port), Washington.

The Project will expand the capacity of the rail system in order to reduce track congestion. Currently, stormwater runoff either infiltrates directly into the ground or is collected by an existing stormwater system and treated at the T5 lagoons. Quantity treatment or detention of stormwater will not be required on the Project because all stormwater at the Port is discharged to the Columbia River, which is an exempt water body with respect to quantity treatment.

The T5 Expansion will relocate existing tracks and construct a new perimeter access road around the outside of the track loop. Several crossings will be constructed to allow vehicular access to the inside of the track loop. New lighting and electrical conduit will be installed and multiple casings will be placed under the shifted tracks. A new tenant, Broken Hill Proprietary Billiton (BHPB), will be performing extensive site improvements at T5 beginning in the summer of 2012. These site improvements will include construction of a potash storage and transfer facility, rail dumper pit, and a ship loading facility. The stormwater design for T5 is intended to prepare the terminal for the construction associated with these site improvements.

The T5 Expansion will be constructed in phases to facilitate coordination with other projects on the site and reduce the impact of construction issues associated with groundwater. The 4000A project is the first phase of the T5 Expansion during which a portion of the complete stormwater system will be completed. The remainder of the stormwater system will be constructed during the next phase called the SPL Project. The second phase includes addition of a pump station and wet well, which will pump the water quality flow rate to the T5 lagoons. The stormwater system will not be operational during the end of the 4000A project (when the existing system is decommissioned) and during the beginning of the SPL Project (when the new stormwater system is completed).

HDR's stormwater design for the Project includes re-routing of the existing stormwater system so that the pipes do not cross the new tenant's lease area, additional stormwater infrastructure associated with roadway improvements, and a connection from BHPB's lease area to discharge treated stormwater to the existing outfall. The existing outfall will be used to discharge overflows from other portions of T5, as well as the BHPB's treated runoff, to the Columbia River. The SPL Project includes a rehabilitation of this existing outfall using a cured-in-place pipe lining method.

1.0 PROJECT OVERVIEW

1.1 Site Description

The Port's WVFA project will construct approximately 3.2 miles of new rail line to expand its rail capacity within the existing facility and relieve track congestion. Overall, the goals of the WVFA project are:

- Expand the Port rail capacity and operations within the existing Port facility;
- Relieve congestion and ensure continued safe operations as rail traffic expands in the Port and along the existing north-south and west-east main lines; and
- Minimize disruption to existing Port tenants and businesses while enhancing the rail system for future growth.

The Project site starts approximately 1,200 feet east of the Columbia River Rail Bridge, extends approximately 3.2 miles west, and ends just before the intersection of N.W. Old Lower River Road. Figures 1 and 2 provide the project location. The Port has filled the floodplain with dredge spoils which are the top layer of soils for much of the project area.

This report evaluates impacts to stormwater drainage resulting from the 4000A and SPL Projects of the T5 Expansion, associated with the full build-out of T5.

1.2 Existing Conditions

T5 currently consists of a track loop which was recently cleared to provide a graded surface for windmill turbine parts storage. The graded area is mostly compacted gravel with minimal paved roadways, several environmental caps, and a stormwater catchment and conveyance system composed of both recently constructed and older components. A trunkline collecting all of the flow conveys runoff to an existing pump station which operates as a temporary solution at this time. No power is currently routed to the existing pumps, so a generator is parked adjacent to the pump station. This generator must be manually activated to power the pumps so that water can be routed to the T5 lagoons west of the track loop.

Overflows are routed to a diversion box that spills into the outfall to the Columbia River. This system as a whole, including the T5 lagoons, was designed to drain and treat the terminal in its past condition, which included significantly more impervious pavement and roofing. Since most of the Terminal is now surfaced with gravel, the pumps are rarely activated. Figure 6 shows the layout of the existing system.

The T5 Lagoons were designed to treat industrial process water and stormwater for Terminal 5. The total area draining to the lagoons was over 130 acres when the site was used for aluminum industry related purposes.

1.3 Proposed Design

The Project includes relocation of existing tracks, construction of a new perimeter access road around the outside of the track loop and several crossings for vehicular access to the inside of the track loop, and installation of several utilities. The Port's new tenant, BHPB, will be performing extensive site improvements including construction of a

potash storage and transfer facility, rail dumper pit, and a ship loading facility. The stormwater design for T5 is intended to provide drainage for the future build-out of T5.

The proposed stormwater system needs to satisfy the City of Vancouver's stormwater management requirements, which are based on the Department of Ecology's 2005 Stormwater Management Manual for Western Washington (SMMWW) for design of water quality treatment facilities. These requirements include the need to treat runoff from new pollutant generating impervious surfaces (PGIS) to a "basic treatment" level. Detention is generally also a consideration, but due to the Project's proximity to the Columbia River, detention is not required. Since detention is not necessary, the Soil Conservation Service Unit Hydrograph Method was used for hydrology calculations. Standards, codes, and guidelines for conveyance are as per The City of Vancouver Engineering Services General Requirements and Details 2009 (GRD) and the American Railway Engineer and Maintenance-of-Way Association Manual for Railway Engineering 2007 (AREMA).

1.3.1 Full Build-Out

The proposed fully built-out system replaces any stormwater infrastructure that lies within the future BHPB lease and routes the trunkline around this property. Additional stormwater inlets are placed along a new perimeter access road that encircles much of the track loop. The trunkline structures are mostly WSDOT Manhole Type III with a few WDSOT Catch Basin Type II structures. WSDOT Catch Basin Type I structures are used for the lateral inlets. The pipe network consists of mostly corrugated polyethylene stormwater sewer pipes (CPSSP) with ductile iron sewer pipes and reinforced concrete pipes at a few locations. The stormwater system drains to a new wet well and pump station location outside of the track loop at the southwest portion of the Terminal. A 30-inch force main will connect the proposed pump station to the T5 lagoons.

1.3.2 Phases of the T5 Expansion: 4000A and SPL

The construction of the stormwater system needs to be completed in phases due to constructability constraints. Stone columns will be installed as part of another project at T5. This stone column work is expected to cause settlement which could damage any infrastructure nearby. Hence, these stone columns must be in place before subsurface infrastructure can be placed in their vicinity. In addition, high groundwater and the degree of contamination of the groundwater will increase the cost and duration of any construction that requires excavation. In consideration of these constraints, the stormwater conveyance system for the Project will be constructed in two phases: the 4000A Project and the SPL Project.

The proposed stormwater system has been divided into seven alignments (Alignments A through G). The 4000A Project will include construction of Alignments A, B, C, and D (See Figure 7). Alignment A drains the T5 perimeter access driveway from the intersection with Old Lower River Road to the proposed pump station. Alignment B drains a portion of the T5 perimeter access driveway to the east and a portion of T5 inside the track loop. Alignment D provides the connection to the BHPB stormwater system (which has its own, separate, water quality treatment facility) and allows it to drain directly to the existing outfall. Alignment C is a single pipe connecting the inside of the track loop to Alignment A. The components constructed in the 4000A project are discontinuous and will not be operational until the remainder of the stormwater system is completed in the next phase. The existing stormwater system will remain operational as long as is reasonably possible considering construction logistics. In addition, the Port is

prepared to pump and treat water from the non-operational system as needed while there is no connection to the T5 lagoons or the existing outfall.

The SPL Project is the second phase which will include construction of the remaining portions of the stormwater conveyance system including Alignments E, F, and G and the proposed wet well and pump station connecting the system to the T5 lagoons (see Figure 7). Alignments E and F drain portions of the T5 perimeter access driveway. Alignment G, which forms a connection between Alignments B and C, drains a portion of T5 inside the track loop. The SPL contractor will be responsible for pumping and treating water in the non-operational system as soon as they are mobilized. This contractor will also be required to complete construction of the operational stormwater system by September 30th, 2012.

The existing outfall will remain in service with the new upstream connection as part of the 4000A and SPL Projects. The outfall will be rehabilitated as part of the SPL Project. This work will include removal of a portion of the outfall pipe that extends into the Columbia River, and a new liner in the outfall pipe that will improve structural integrity while maintaining adequate conveyance capacity.

1.4 Conveyance System Analysis and Design

The Port's new tenant, BHPB, will treat their own stormwater and discharge the flows to the existing outfall through a connection to the proposed stormwater system. This accounts for approximately 40 acres of drainage area. While some additional area on the perimeter of T5 will drain to the T5 lagoons through the proposed pump station, the total contributing drainage area from T5 to the lagoons will be reduced from over 130 acres in the existing scenario to approximately 91 acres. BHPB has estimated the peak flow rate for their property to be 24 cubic feet per second (cfs) for the 25-year storm event and 30 cfs for the 100-year storm event; the downstream stormwater system has been designed with consideration of this input.

This pump station is designed to pump the water quality flow rate to the T5 lagoons. The water quality flow rate has been calculated to be 9 cfs based on the drainage area of 91 acres using MGS Flood and assumes fully impervious, fully built-out conditions (see Appendix B). The complete T5 Expansion proposed stormwater system is shown in Figure 6.

Due to the long runs of pipe and the desire to keep portions of the system elevated as high as possible (such as the pump station wet well), the system has been designed *without* the usual 0.2-foot drop per structure. Backflow prevention valves are proposed in structures just downstream of the overflow structure and where the connection is made to the BHPB storm line. These valves will be elastomer duckbill-type valves that will help reduce flooding inside the track loop during extremely high flows in the Columbia River. Due to the possibility of high groundwater and a relatively empty stormwater system because of the backflow prevention valves, all manholes and catch basin type II structures have been designed with counter buoyancy bases.

All the alignments except Alignment D (connection between the BHPB drainage system and the existing outfall) will drain to the proposed pump station which is designed to pump out the water quality flow. The pipes between the existing outfall pipe and the proposed pump station are designed to flow full before the outfall is utilized. In the event that the inflow rate of stormwater runoff into the system exceeds the pump station

pumping rate, flow in the pipeline between the pump station and the outfall will back up and discharge to the outfall while the pump station continues to pump the water quality flow rate. This allows the use of a portion of the pipe system as additional storage beyond the wet well. This reduces the number of required pump operation cycles and precludes the need for an additional storm line from the proposed pump station to the existing outfall.

1.5 Drainage to and from Adjacent Properties

The Port's facility and adjacent properties are mostly built-out and already have stormwater infrastructure installed. Offsite drainage improvements have been developed by tenants as separate projects; therefore, no offsite contributions of surface runoff are anticipated for the projects discussed here.

1.6 Downstream Boundary Condition

The two downstream boundary elements of the T5 stormwater conveyance system are the existing 36-inch outfall pipe discharging into the Columbia River and the proposed 30-inch force main between the new pump station and the T5 lagoons. The hydraulic capacity of the existing outfall pipe has been conservatively estimated to be at least 120 cfs which exceeds the maximum anticipated flow rate. The proposed pump station has been designed to pump the water quality flow rate through the 30-inch force main to the T5 lagoons.

2.0 CONVEYANCE SYSTEM MODELING

2.1 Model Development

A hydrologic and hydraulic model was developed using Bentley CivilStorm V8i to determine peak flow rates and size the conveyance system for the full build-out of the T5 Expansion. This model considers existing infrastructure that will remain in place and future infrastructure that is anticipated as part of the complete T5 Expansion project, as well as other future infrastructure that is not part of the T5 Expansion but will contribute to total runoff from the system. The model also assumes that all areas except track alignments are paved with impervious asphalt.

Civilstorm successively runs the hydrologic and hydraulic analysis. Rainfall depths for the 25-year, 24-hour and 100-year, 24-hour storm events were obtained from isopluvials for the state of Washington from the National Oceanic and Atmospheric Administration (NOAA) Atlas 2 (See Figure 2). The SCS Type-1 rainfall distribution was used for the project location. The Soil Conservation Service (SCS) Unit Hydrograph was used for the hydrology calculations. Curve numbers for the catchments were estimated using the data provided in Table 2.2 of the 2005 SMMWW Volume III; all curve numbers are 98 assuming full build out and paving for the entire terminal except on areas occupied by railroad tracks. Appendix B provides the curve number information and hydrologic modeling results for the T5 Expansion stormwater system. All times of concentration were assumed to be five minutes with the exception of two basins that have longer than typical flowpath lengths and the basin which will be occupied by the mining company. The time of concentration for this basin is adjusted such that the modeled peak flow rate matches the peak flow rate estimated by others and provided to HDR. Table B1 only

shows basin results for basins that drain to new structures and pipes constructed as part of the Terminal 5 Expansion project. Other basins shown in Figure 9 drain to existing or proposed structures and pipes.

2.2 Pipe Capacity

The 25-year storm event was used to determine if each pipe has sufficient capacity and the 100-year storm event was used to check for surcharging of structures. The modeling results presented in this report represent fully built-out conditions of the proposed stormwater conveyance system in T5 (See Appendix C).

Velocities in some of the pipes in the system may not meet flushing velocity requirements per the City of Vancouver's requirements, but the Port has been made aware of this and is prepared to increase maintenance activities as required. Due to modeling limitations in CivilStorm, the pump station has not been included in the model. This approach is conservative, as the pump station would in reality be pumping a constant 9 cfs out of the stormwater system before the flows back up in the pipe system and discharge to the existing outfall. In some cases, modeling results show that the existing pipes do not have sufficient capacity. This could be attributed to conservatism in the model or, in other cases, limitations of the model in representing the pipe systems accurately. In particular, some of the existing pipes are perforated pipes installed at a very shallow slope, and are designed to flow full. Since the model does not accommodate perforated pipes, they have been modeled as solid pipes with an inlet upstream. The lack of capacity shown in the model results is not due to insufficient downstream conveyance capacity. These pipes are designed by others and already exist at Terminal 5.

Figure C1 shows the hydrograph for the 100 year event through the outfall pipe to the Columbia River. The peak flow rate is 94 cfs. Note that this is assuming that the pump station is not in operation since the model does not account for the water quality flow rate being pumped to the T5 Lagoons. The final outfall pipe maximum capacity depends on the methods used to reline the pipe in the future. The current capacity of the pipe is estimated to be approximately 114 cfs. The pipe will be relined in the SPL Project. With a smoother interior but reduced diameter, the future maximum capacity of the pipe is estimated to be 120 cfs.

In conclusion, the modeling results indicate that the stormwater system design functions as intended to accommodate the 25- and 100-year storm events using conservative modeling techniques.

APPENDIX A

Project Figures

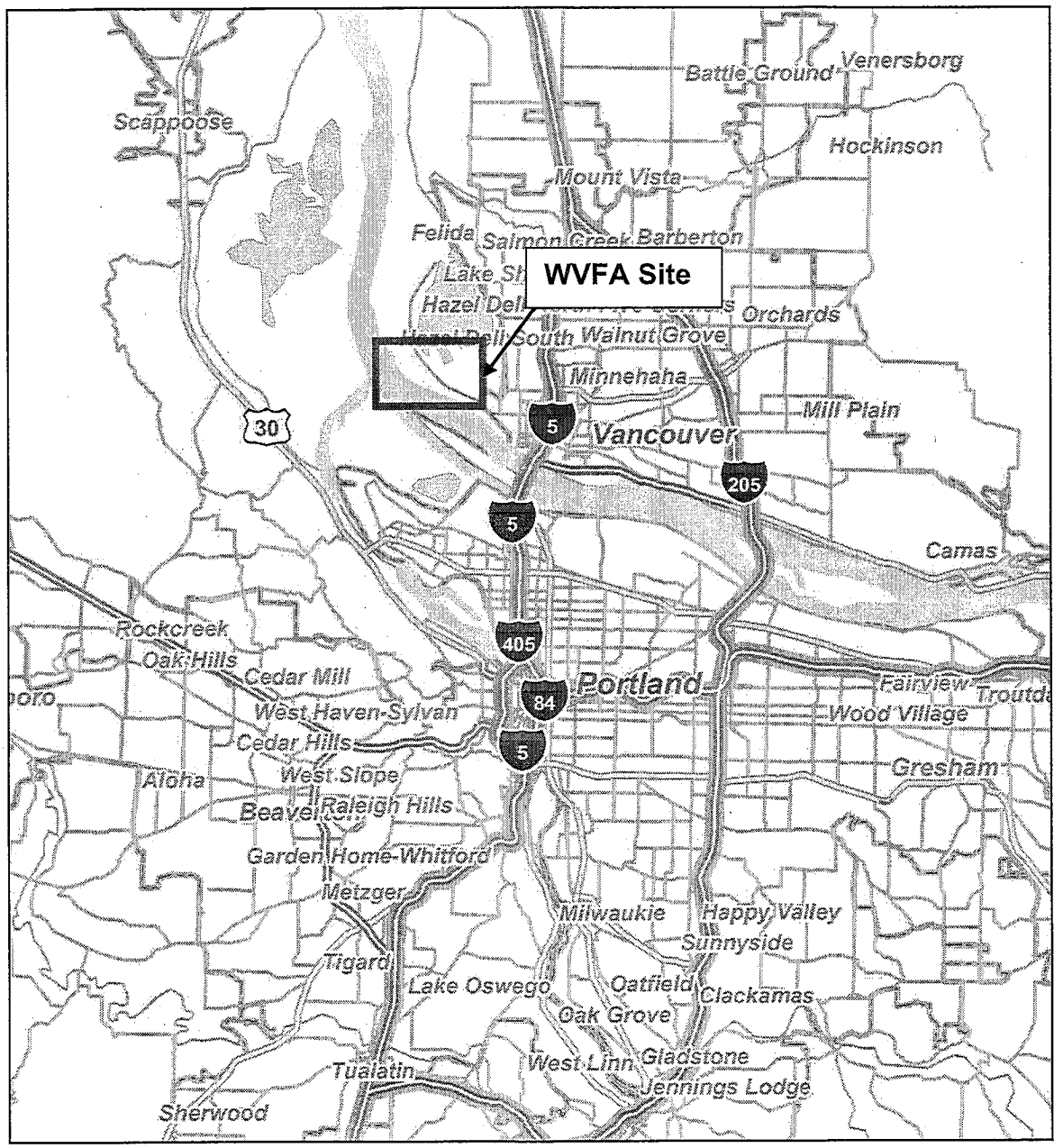
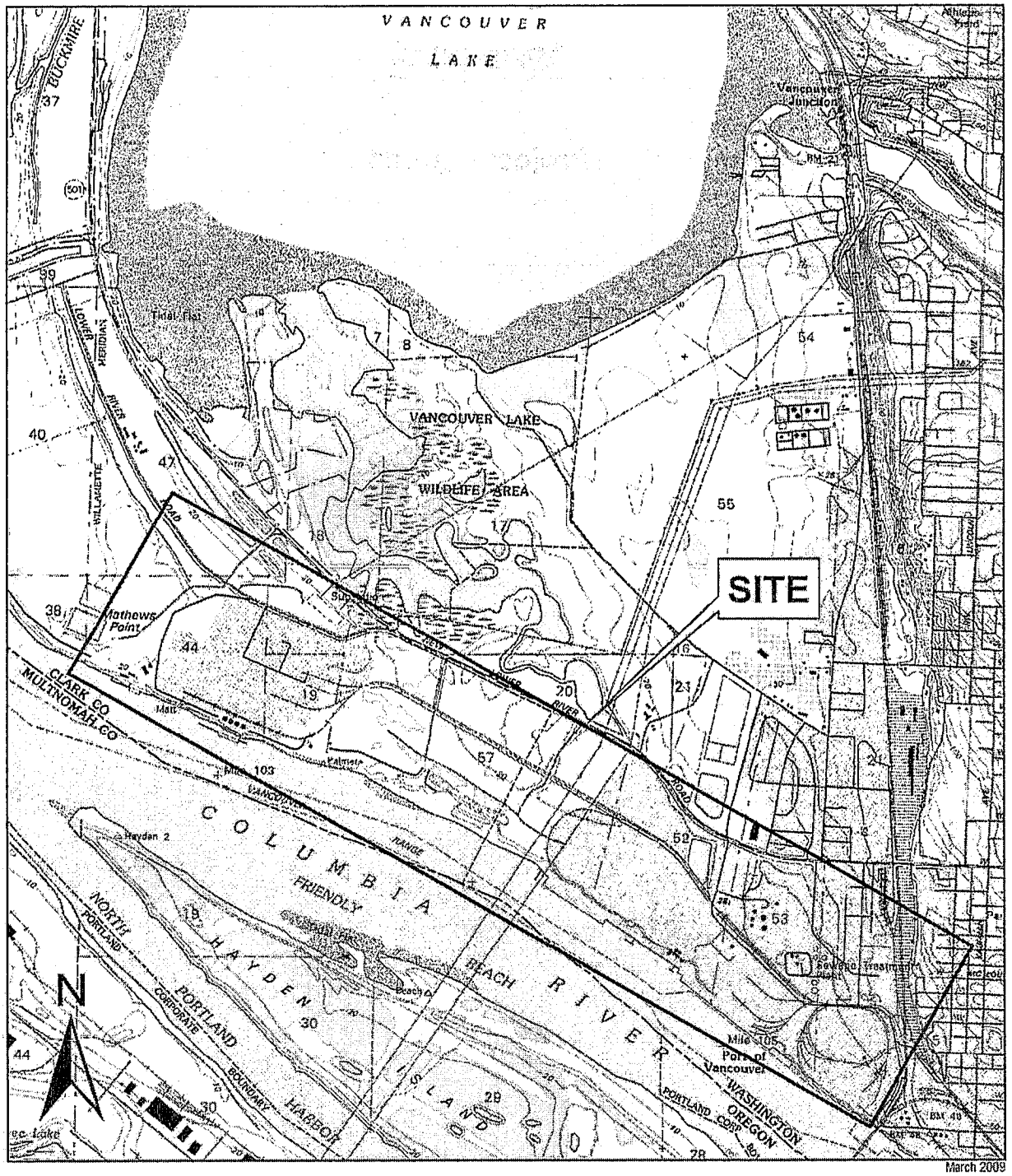


Figure 1. Vicinity Map



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SOURCE: USGS VANCOUVER, WA
TOPOGRAPHIC QUADRANGLE

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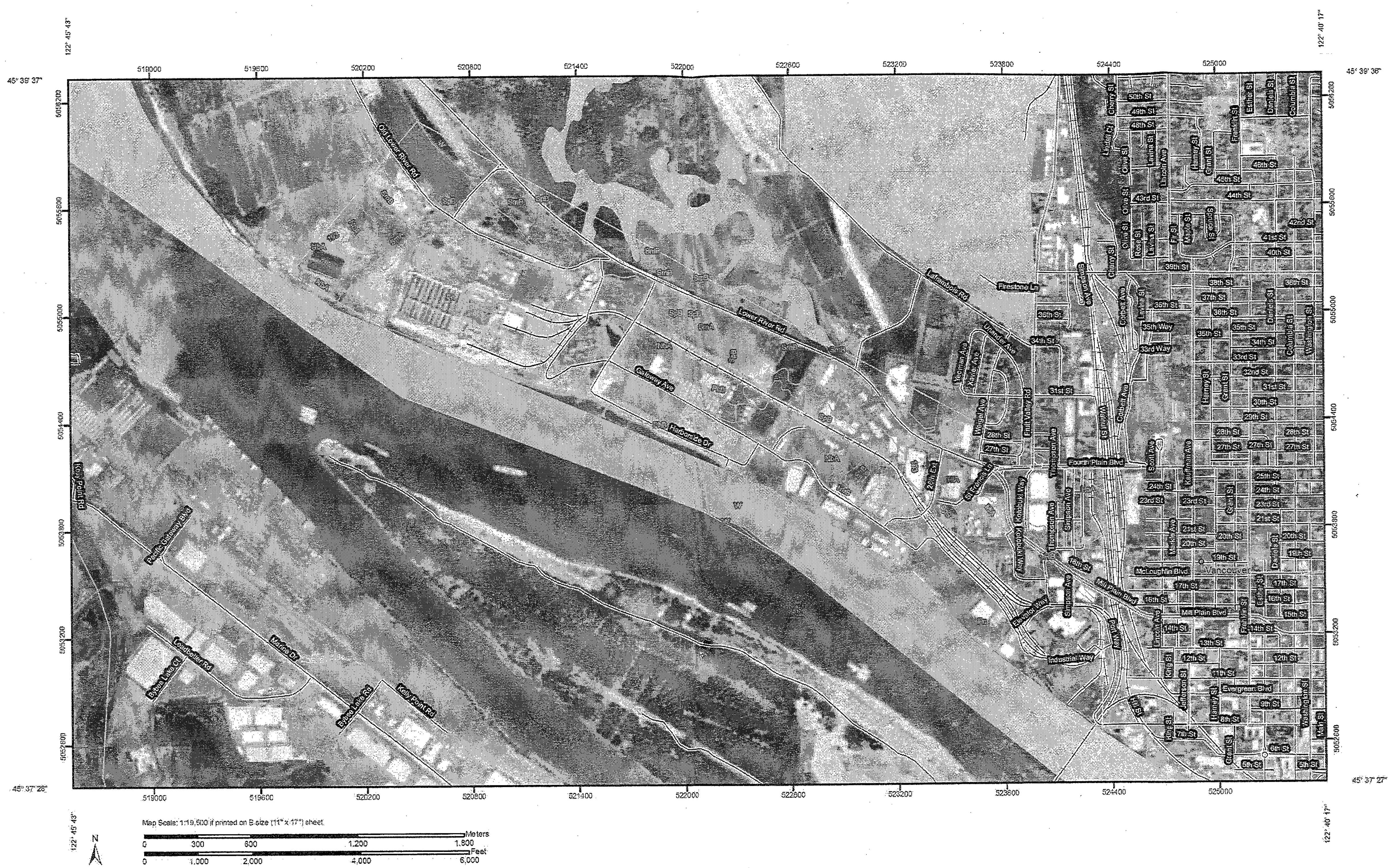
Figure 2. USGS Map



USDA Natural Resources Conservation Service

Web Soil Survey 2.1
National Cooperative Soil Survey

3/11/2009

Figure 3. NRCS Soils Map

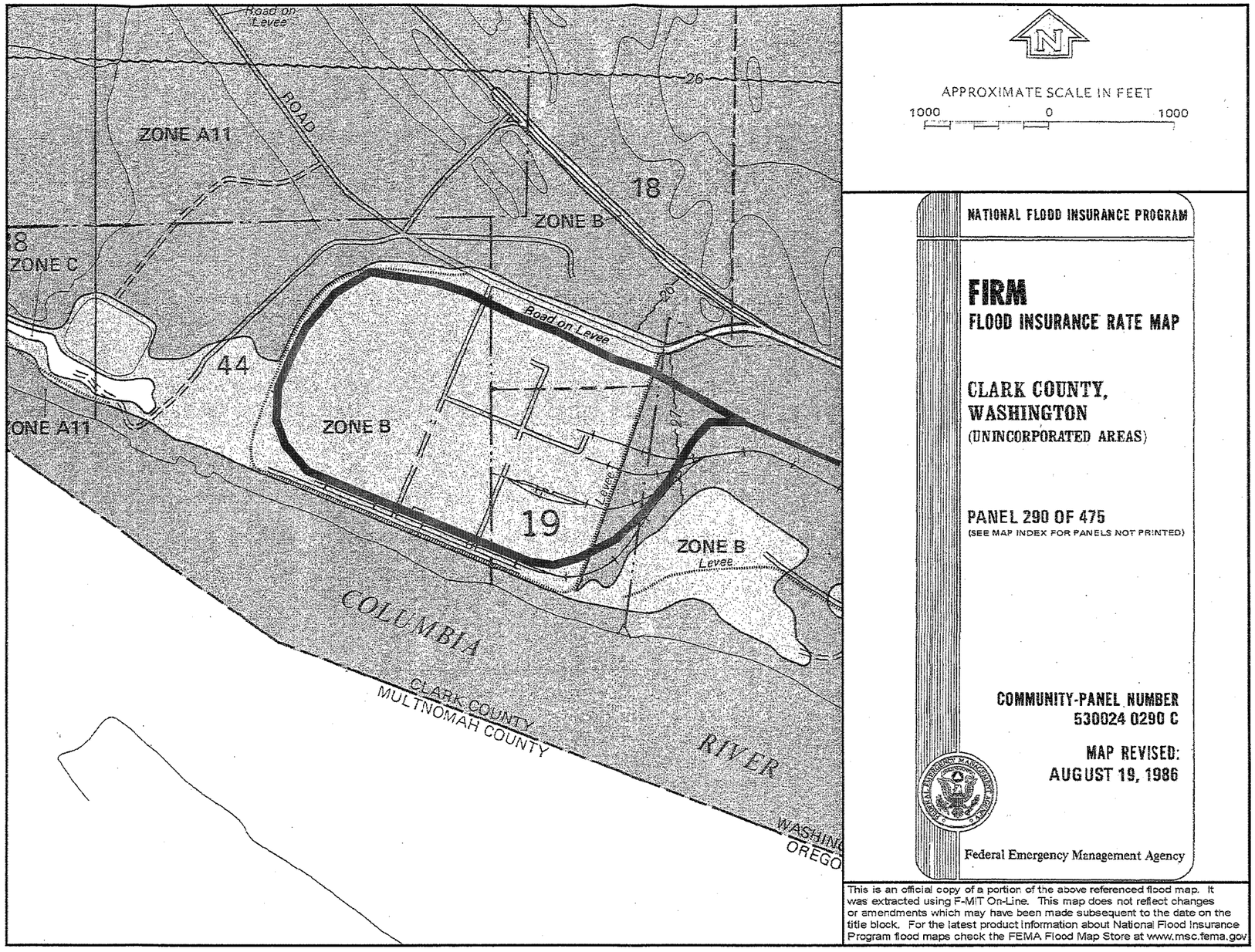
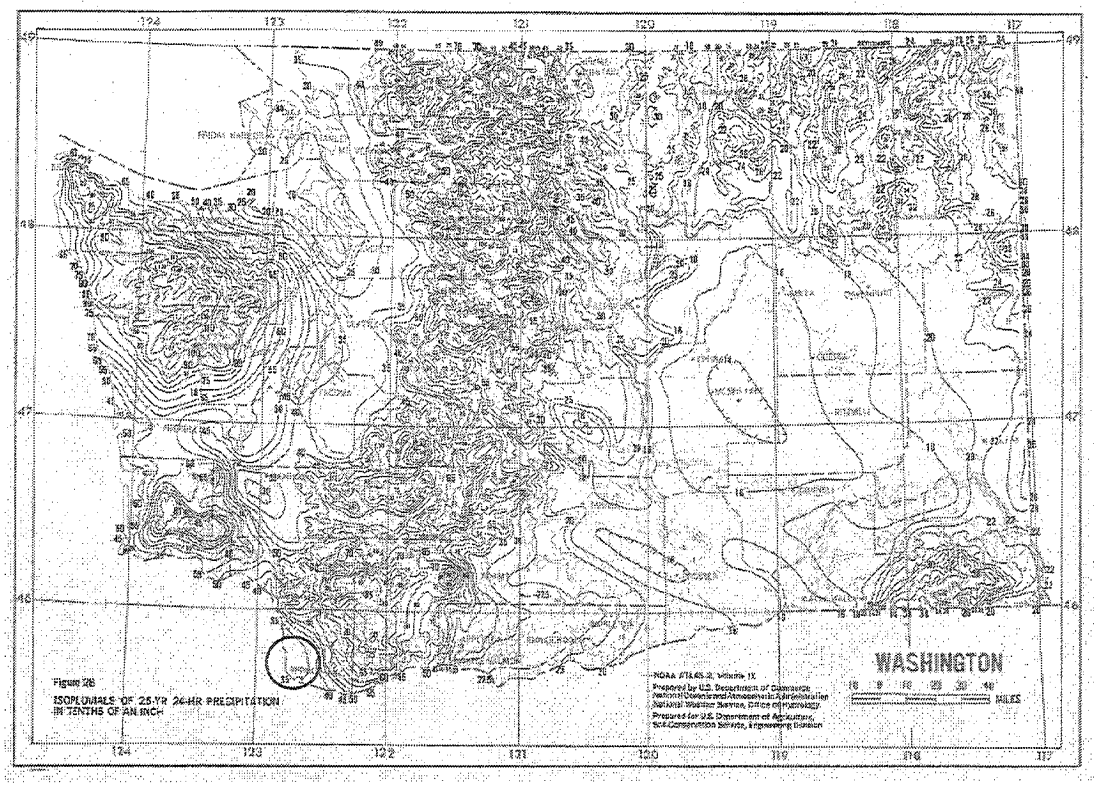


Figure 4. Port of Vancouver Terminal 5 Vicinity Floodplain Map

Key for NRCS soils map:

Clark County, Washington (WA011)	
Map Unit Symbol	**Map Unit Name**
193	Miscellaneous water
Fn	Fill land
HlA	Hillsboro silt loam, 0 to 3 percent slopes
HlB	Hillsboro loam, 3 to 8 percent slopes
HoA	Hillsboro silt loam, 0 to 3 percent slopes
MlA	McBee silt loam, coarse variant, 0 to 3 percent slopes
NbA	Newberg silt loam, 0 to 3 percent slopes
NbB	Newberg silt loam, 3 to 8 percent slopes
PhB	Pilchuck fine sand, 0 to 8 percent slopes
SmA	Sauvie silt loam, 0 to 3 percent slopes
SmB	Sauvie silt loam, 3 to 8 percent slopes
SpB	Sauvie silty clay loam, 0 to 8 percent slopes
W	Water



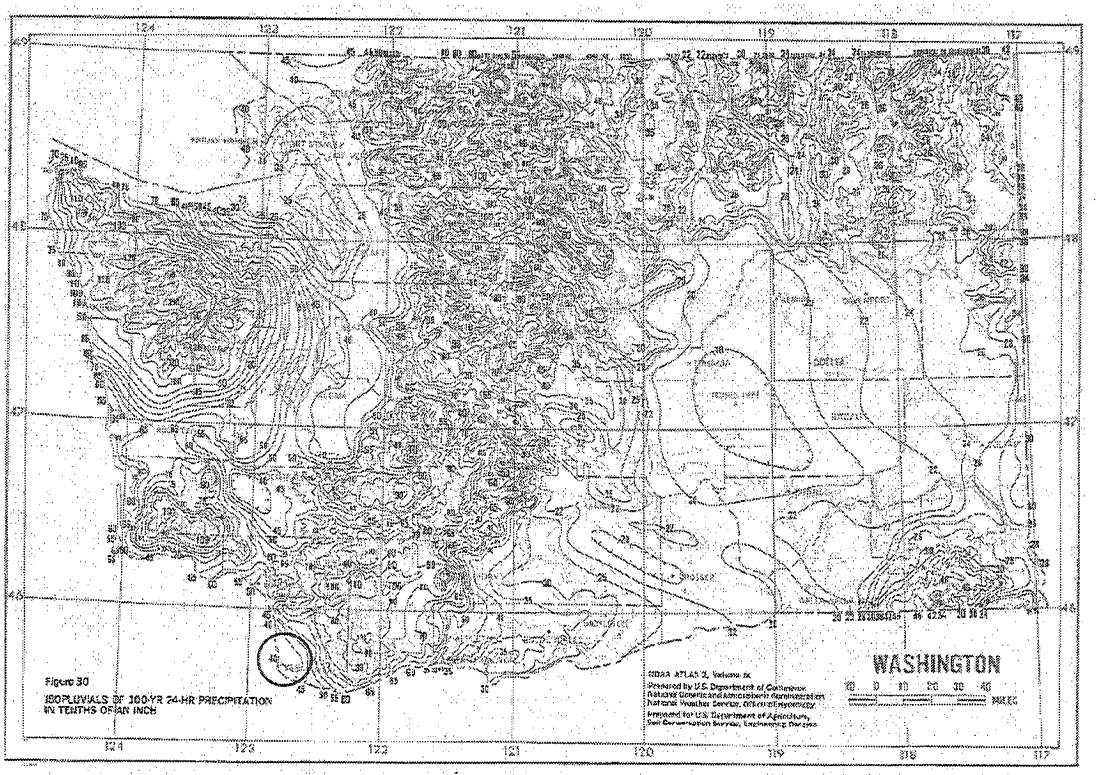


Figure 5. 25-Year and 100-Year 24-Hour Isopluvials

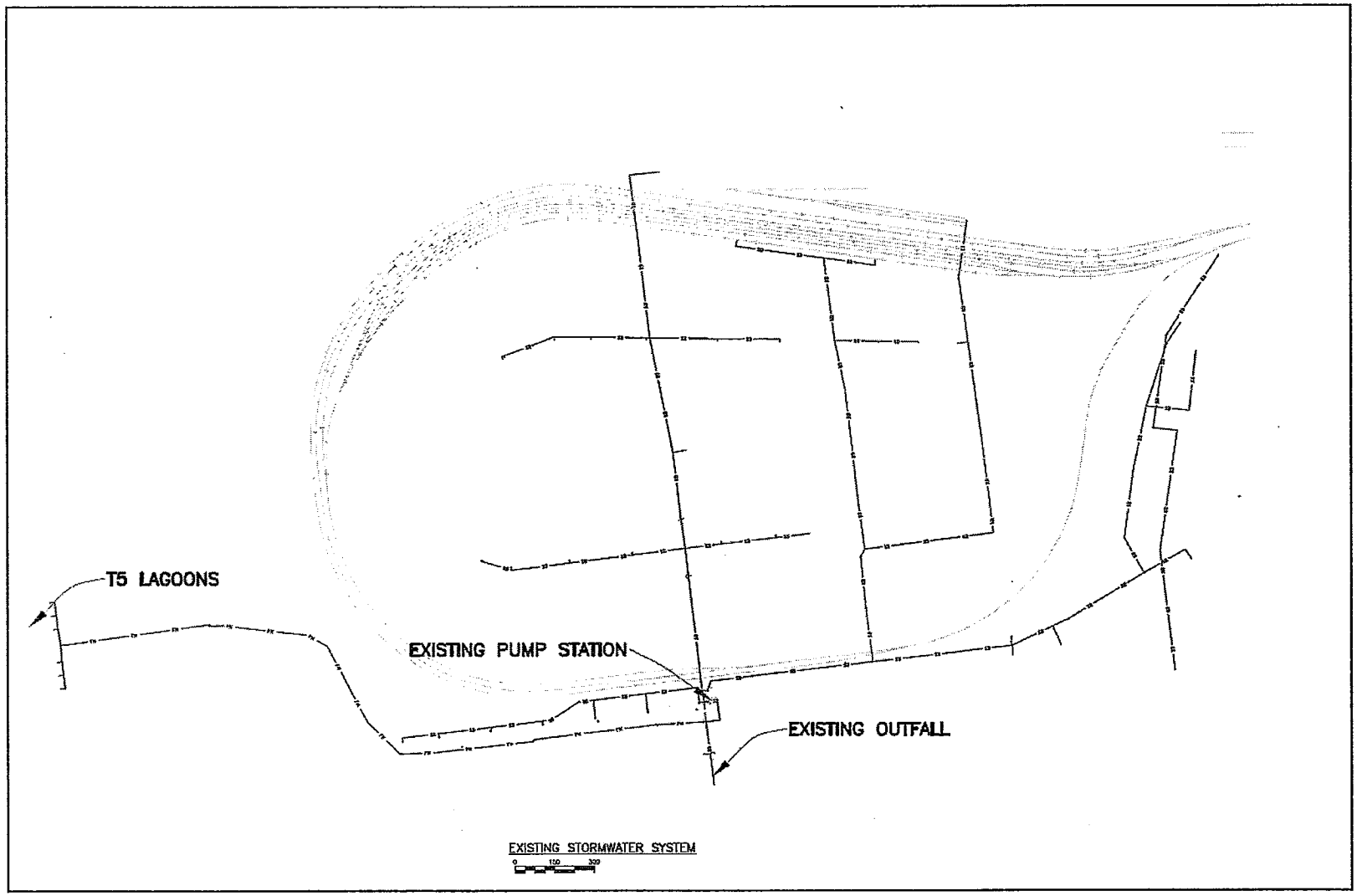


Figure 6. Existing Stormwater System

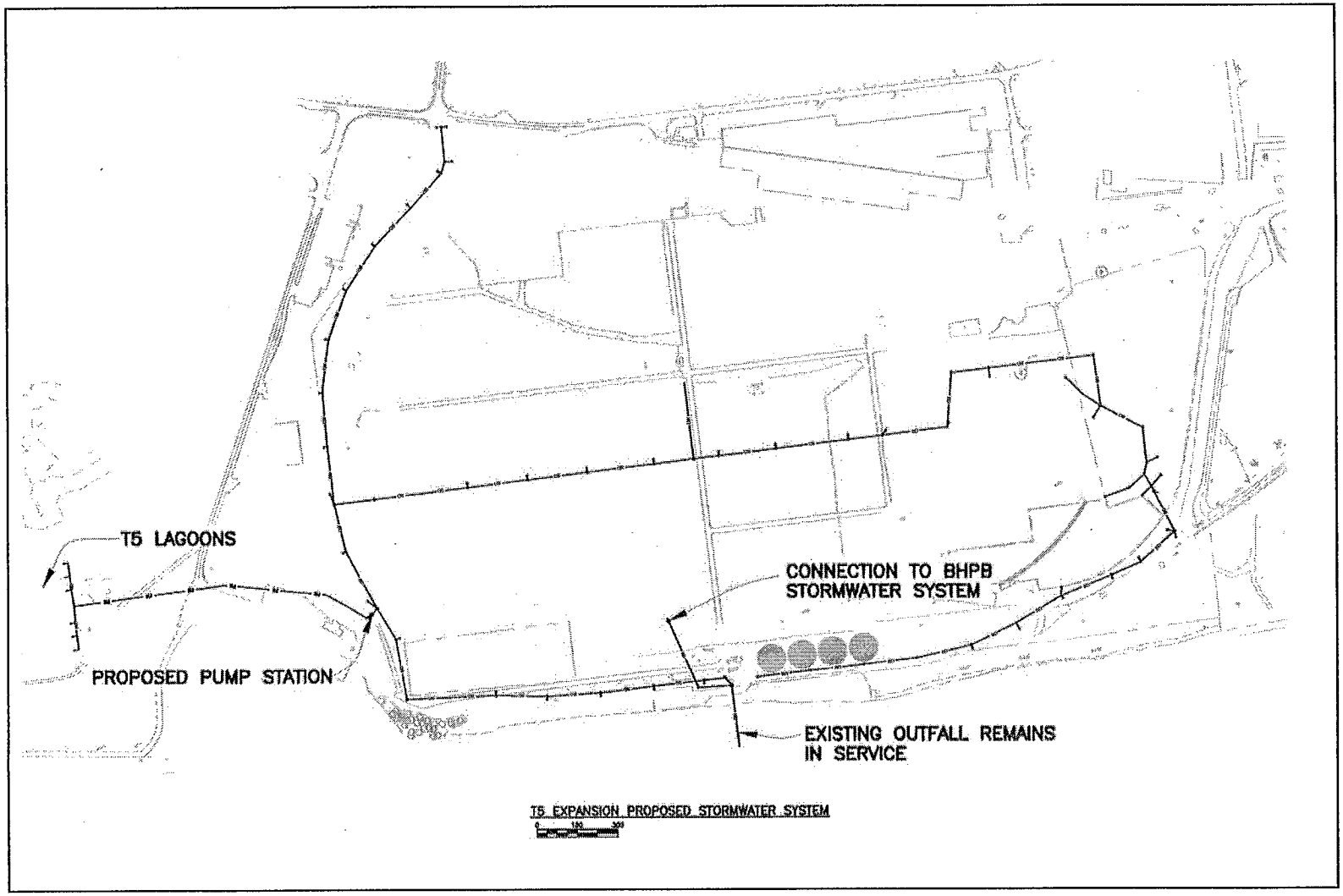


Figure 7. T5 Expansion Proposed Stormwater System

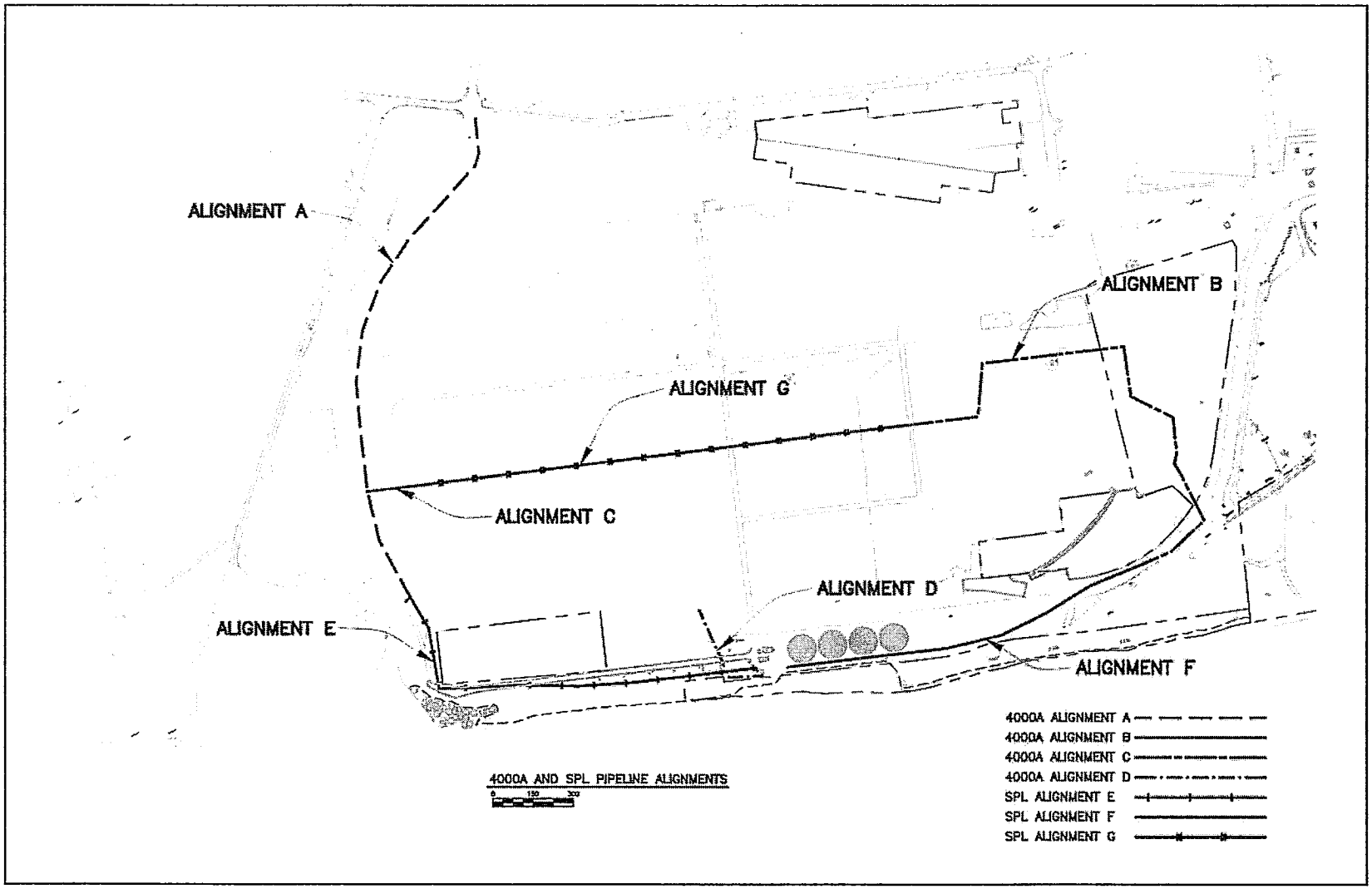


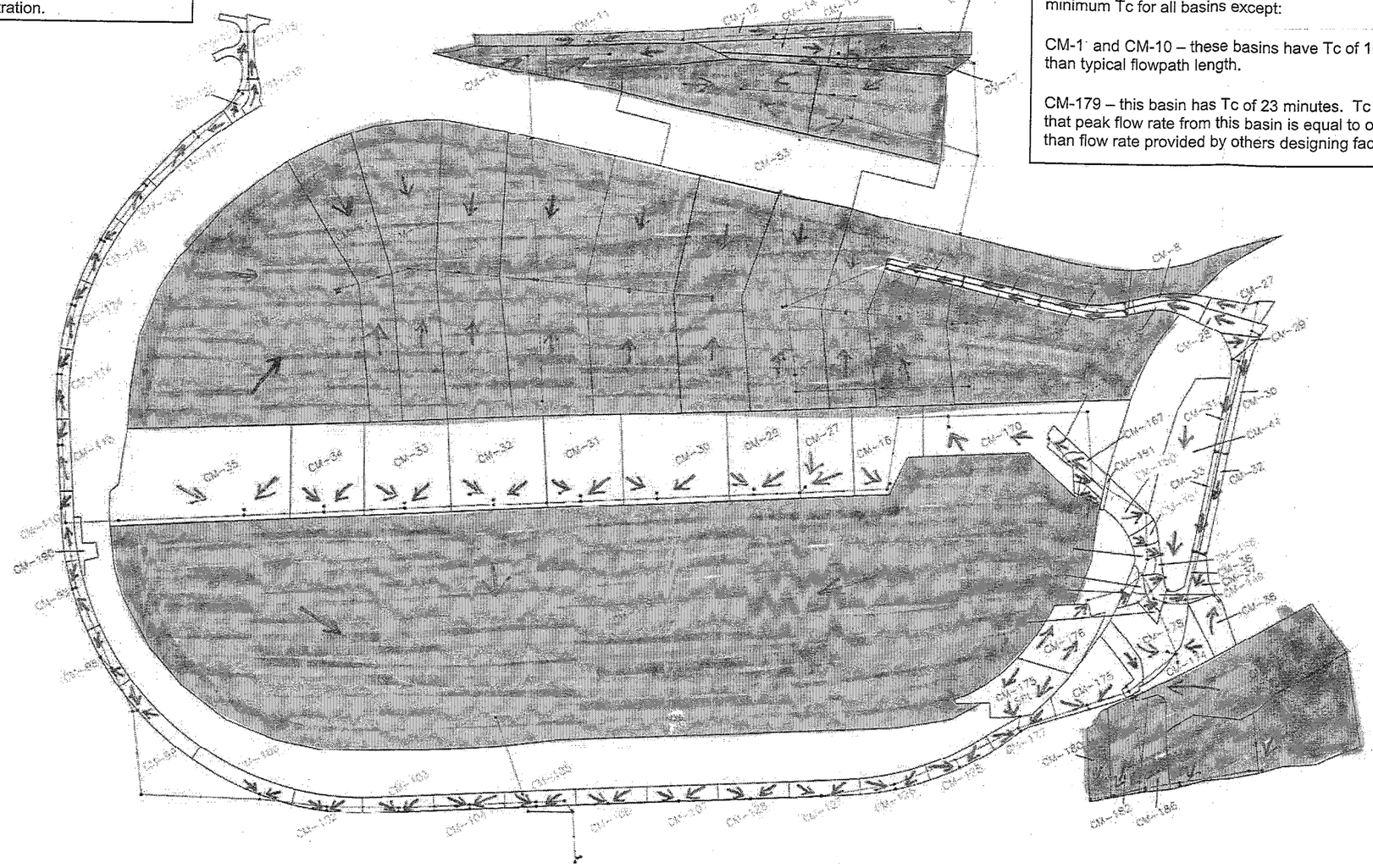
Figure 8. 4000A and SPL Pipe Alignments

See table B1 for basin parameters such as curve number, area, peak flow generated, and time of concentration.

Time of concentration (Tc) was not calculated. Assumed 5 minute minimum Tc for all basins except:

CM-1 and CM-10 – these basins have Tc of 10 mins due to longer than typical flowpath length.

CM-179 – this basin has Tc of 23 minutes. Tc was adjusted such that peak flow rate from this basin is equal to or slightly greater than flow rate provided by others designing facilities in this basin.



Highlighting indicates basins that drain to existing or proposed inlets and conveyance systems designed by others.

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BASIN MAP FOR TERMINAL 5

DATE 5/3/12

FIGURE 1

Figure 9. Basin Map for Terminal 5

APPENDIX B

Hydrology Calculations

Curve Numbers

Curve numbers were selected for each basin based on Table 2.2 in the 2005 SMMWW Vol. III:

Table 2.2
Runoff Curve Numbers for Selected Agricultural, Suburban, and Urban Areas
(Sources: TR 55, 1986, and Stormwater Management Manual, 1992. See Section 2.1.1 for explanation)

Cover type and hydrologic condition.	CNs for hydrologic soil group A	B	C	D
Curve Numbers for Pre-Development Conditions				
Pasture, grassland, or range-continuous forage for grazing:				
Fair condition (ground cover 50% to 75% and not heavily grazed).	49	69	79	84
Good condition (ground cover >75% and lightly or only occasionally grazed)	39	61	74	80
Woods:				
Fair (Woods are grazed but not burned, and some forest litter covers the soil).	36	60	73	79
Good (Woods are protected from grazing, and litter and brush adequately cover the soil).	30	55	70	77
Curve Numbers for Post-Development Conditions				
Open space (lawns, parks, golf courses, cemeteries, landscaping, etc.)[1]				
Fair condition (grass cover on 50% - 75% of the area).	77	85	90	92
Good condition (grass cover on >75% of the area)	68	80	86	90
Impervious areas:				
Open water bodies: lakes, wetlands, ponds etc.	100	100	100	100
Paved parking lots, roofs[2], driveways, etc. (excluding right-of-way)	98	98	98	98
Permeable Pavement (See Appendix C to decide which condition below to use)				
Landscaped area	77	85	90	92
50% landscaped area/50% impervious	87	91	94	96
100% impervious area	98	98	98	98
Paved	98	98	98	98
Gravel (including right-of-way)	76	85	89	91
Dirt (including right-of-way)	72	82	87	89
Pasture, grassland, or range-continuous forage for grazing:				
Poor condition (ground cover <50% or heavily grazed with no mulch).	68	79	86	89
Fair condition (ground cover 50% to 75% and not heavily grazed).	49	69	79	84
Good condition (ground cover >75% and lightly or only occasionally grazed)	39	61	74	80
Woods:				
Poor (Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning).	45	66	77	83
Fair (Woods are grazed but not burned, and some forest litter covers the soil).	36	60	73	79
Good (Woods are protected from grazing, and litter and brush adequately cover the soil).	30	55	70	77

Single family residential[3]: Dwelling Unit/Gross Acre	Should only be used for subdivisions > 50 acres	Average Percent impervious area[3,4]	
1.0 DU/GA		15	Separate curve number
1.5 DU/GA		20	shall be selected for
2.0 DU/GA		25	pervious & impervious
2.5 DU/GA		30	portions of the site or
3.0 DU/GA		34	basin
3.5 DU/GA		38	
4.0 DU/GA		42	
4.5 DU/GA		46	
5.0 DU/GA		48	
5.5 DU/GA		50	
6.0 DU/GA		52	
6.5 DU/GA		54	
7.0 DU/GA		56	
7.5 DU/GA		58	
PUD's, condos, apartments, commercial businesses, industrial areas & & subdivisions < 50 acres	%impervious must be computed	Separate curve numbers shall be selected for pervious and impervious portions of the site	

For a more detailed and complete description of land use curve numbers refer to chapter two (2) of the Soil Conservation Service's Technical Release No. 55 . (210-VI-TR-55, Second Ed., June 1986).

A curve number of 98 was used for pavement.

Table B1. Catchment Modeling Parameters and Results for the 25-year Storm Event

Catchment Name	SCS Curve Number	Scaled Area (acres)	Peak 25-year Flow (cfs)	Time of Concentration (mins)	Unit Hydrograph Method
Alignment A					
CM-121	98	0.167	0.14	5	SCS Unit Hydrograph
CM-113	98	0.161	0.13	5	SCS Unit Hydrograph
CM-110	98	0.160	0.13	5	SCS Unit Hydrograph
CM-95	98	0.168	0.14	5	SCS Unit Hydrograph
CM-98	98	0.159	0.13	5	SCS Unit Hydrograph
CM-118	98	0.100	0.08	5	SCS Unit Hydrograph
CM-119	98	0.072	0.06	5	SCS Unit Hydrograph
CM-120	98	0.082	0.07	5	SCS Unit Hydrograph
CM-117	98	0.260	0.22	5	SCS Unit Hydrograph
CM-123	98	0.114	0.09	5	SCS Unit Hydrograph
CM-115	98	0.157	0.13	5	SCS Unit Hydrograph
CM-124	98	0.158	0.13	5	SCS Unit Hydrograph
CM-114	98	0.158	0.13	5	SCS Unit Hydrograph
CM-190	98	0.100	0.07	5	SCS Unit Hydrograph
Alignment B					
CM-136	98	0.073	0.06	5	SCS Unit Hydrograph
CM-149	98	0.108	0.09	5	SCS Unit Hydrograph
CM-148	98	0.022	0.02	5	SCS Unit Hydrograph
CM-165	98	0.100	0.08	5	SCS Unit Hydrograph
CM-154	98	0.055	0.05	5	SCS Unit Hydrograph
CM-191	98	0.024	0.02	5	SCS Unit Hydrograph
CM-170	98	1.942	1.61	5	SCS Unit Hydrograph
CM-16	98	0.943	0.78	5	SCS Unit Hydrograph
CM-175	98	0.631	0.52	5	SCS Unit Hydrograph
CM-176	98	0.221	0.18	5	SCS Unit Hydrograph
CM-174	98	0.327	0.27	5	SCS Unit Hydrograph
CM-178	98	0.632	0.52	5	SCS Unit Hydrograph
CM-27	98	0.853	0.7	5	SCS Unit Hydrograph
CM-135	98	0.063	0.05	5	SCS Unit Hydrograph
CM-140	98	0.029	0.02	5	SCS Unit Hydrograph
CM-153	98	0.115	0.1	5	SCS Unit Hydrograph
CM-151	98	0.084	0.07	5	SCS Unit Hydrograph
CM-150	98	0.245	0.2	5	SCS Unit Hydrograph
CM-155	98	0.062	0.05	5	SCS Unit Hydrograph
CM-167	98	0.120	0.1	5	SCS Unit Hydrograph
CM-176	98	0.628	0.5	5	SCS Unit Hydrograph
Alignment C					
No catchments in Alignment C. Upstream basins and existing system contribute flow.					

Table B1. Catchment Modeling Parameters and Results for the 25-year Storm Event

Catchment Name	SCS Curve Number	Scaled Area (acres)	Peak 25-year Flow (cfs)	Time of Concentration (mins)	Unit Hydrograph Method
Alignment D					
CM-179	98	37.829	23.9	23	SCS Unit Hydrograph
Alignment E					
CM-105	98	0.197	0.16	5	SCS Unit Hydrograph
CM-104	98	0.197	0.16	5	SCS Unit Hydrograph
CM-103	98	0.196	0.16	5	SCS Unit Hydrograph
CM-102	98	0.193	0.16	5	SCS Unit Hydrograph
CM-100	98	0.292	0.24	5	SCS Unit Hydrograph
CM-99	98	0.265	0.22	5	SCS Unit Hydrograph
Alignment F					
CM-106	98	0.197	0.16	5	SCS Unit Hydrograph
CM-107	98	0.198	0.16	5	SCS Unit Hydrograph
CM-128	98	0.197	0.16	5	SCS Unit Hydrograph
CM-127	98	0.196	0.16	5	SCS Unit Hydrograph
CM-126	98	0.196	0.16	5	SCS Unit Hydrograph
CM-125	98	0.198	0.16	5	SCS Unit Hydrograph
CM-177	98	0.191	0.16	5	SCS Unit Hydrograph
CM-175	98	0.652	0.52	5	SCS Unit Hydrograph
Alignment G					
CM-29	98	1.111	0.83	5	SCS Unit Hydrograph
CM-30	98	1.704	1.27	5	SCS Unit Hydrograph
CM-31	98	1.254	0.92	5	SCS Unit Hydrograph
CM-32	98	1.593	1.31	5	SCS Unit Hydrograph
CM-33	98	1.418	1.17	5	SCS Unit Hydrograph
CM-34	98	1.232	1.02	5	SCS Unit Hydrograph
CM-35	98	2.970	2.46	5	SCS Unit Hydrograph

MGS Flood Water Quality Flow Rate Results

MGS FLOOD
PROJECT REPORT

Program Version: 3.13 Run Date: 01/10/2012 10:01 AM

Input File Name: mgs test.fld
Project Name: POV T5 WQ flow
Analysis Title: POV T5 WQ flow
Comments:

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

Extended Precipitation Timeseries Selected
Climatic Region Number: 20
Full Period of Record Available used for Routing
Precipitation Station : 970044 Vancouver 44 in MAP 10/01/1939-10/01/2060
Evaporation Station : 971044 Vancouver 44 in MAP
Evaporation Scale Factor : 0.750

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

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

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

Number of Subbasins: 1

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

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

	Area(Acres)		
		Developed	
	Predeveloped	To Node	Bypass Node
Till Forest	0.000	0.000	0.000
Till Pasture	0.000	0.000	0.000
Till Grass	0.000	0.000	0.000
Outwash Forest	0.000	0.000	0.000
Outwash Pasture	0.000	0.000	0.000
Outwash Grass	91.320	0.000	0.000
Wetland	0.000	0.000	0.000
Impervious	0.000	91.320	0.000
Subbasin Total	91.320	91.320	0.000

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

Node No: 2
2-Year Discharge Rate : 25.033 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
On-line Design Discharge Rate (91% Exceedance): 14.68 cfs
Off-line Design Discharge Rate (91% Exceedance): 8.65 cfs

APPENDIX C

Hydraulic Calculations

Table C1. Conduit Modeling Parameters and Results for the 25-year Storm Event

Conduit Name	Diameter (in)	Slope (ft/ft)	Maximum 25-year Flow (cfs)	Calculated Design Capacity (cfs)	Maximum Flow to Calculated Design Capacity Ratio
Alignment A					
CO-A5	12	0.020	0.14	5.45	0.03
CO-A10	12	0.020	0.08	5.47	0.01
CO-A15	12	0.002	0.34	1.71	0.20
CO-A20	12	0.020	0.06	5.47	0.01
CO-A25	12	0.002	0.58	1.74	0.33
CO-A30	12	0.020	0.07	5.41	0.01
CO-A35	12	0.002	0.65	1.73	0.38
CO-A40	12	0.020	0.22	5.45	0.04
CO-A45	12	0.002	0.69	1.74	0.40
CO-A50	12	0.020	0.09	5.44	0.02
CO-A55	12	0.002	0.71	1.74	0.41
CO-A60	12	0.020	0.13	5.44	0.02
CO-A65	12	0.002	0.74	1.74	0.43
CO-A70	12	0.020	0.13	5.44	0.02
CO-A75	18	0.002	0.8	5.13	0.16
CO-A80	12	0.020	0.13	5.44	0.02
CO-A85	24	0.002	0.91	11.00	0.08
CO-A90	12	0.020	0.13	5.44	0.02
CO-A95	24	0.002	1.03	10.94	0.09
CO-A100	12	0.020	0.13	5.47	0.02
CO-A105	48	0.002	57.59	69.94	0.82
CO-A110	12	0.020	0.14	5.44	0.03
CO-A115	48	0.002	57.81	66.94	0.86
CO-A120	12	0.020	0.13	5.45	0.02
Alignment B					
CO-B37	12	0.020	0.52	5.40	0.10
CO-B40	30	0.002	3.96	19.99	0.20
CO-B43	12	0.020	0.18	5.44	0.03
CO-B45	30	0.002	7.58	19.63	0.39
CO-B47	12	0.020	0.27	5.48	0.05
CO-B49	12	0.020	0.52	5.48	0.09
CO-B50	30	0.003	8.87	25.07	0.35
CO-B53/300	15	0.005	2.59	4.94	0.52
CO-B55	12	0.020	0.06	5.47	0.01

Table C1. Conduit Modeling Parameters and Results for the 25-year Storm Event

Conduit Name	Diameter (in)	Slope (ft/ft)	Maximum 25-year Flow (cfs)	Calculated Design Capacity (cfs)	Maximum Flow to Calculated Design Capacity Ratio
CO-B55	30	0.003	10.91	25.10	0.43
CO-B60	12	0.020	0.09	5.45	0.02
CO-B63	12	0.005	0.52	2.51	0.21
CO-B65	30	0.002	11.06	19.87	0.56
CO-B70	12	0.020	0.57	5.45	0.10
CO-B75	30	0.002	11.44	19.87	0.58
CO-B80	12	0.020	0.02	5.45	0.00
CO-B85	30	0.002	11.54	19.88	0.58
CO-B90	30	0.002	11.6	19.87	0.58
CO-B95	30	0.002	11.75	19.87	0.59
CO-B100	12	0.020	0.08	5.45	0.01
CO-B105	12	0.020	0.18	5.46	0.03
CO-B110	12	0.020	0.06	5.45	0.01
CO-B120	36	0.002	12.04	32.05	0.38
CO-B125	36	0.002	12.1	32.41	0.37
CO-B126	12	0.020	1.61	5.46	0.29
CO-B127	36	0.002	13.02	32.20	0.40
CO-B130	36	0.002	13.07	32.31	0.40
CO-B135	12	0.020	0.78	5.49	0.14
CO-B140	36	0.002	13.56	32.32	0.42
CO-B150	12	0.020	0.71	5.49	0.13
Alignment C					
CO-C235	48	0.002	53.54	69.69	0.77
Alignment D					
CO-D5	36	0.005	23.83	51.06	0.47
CO-D10	36	0.005	23.80	51.23	0.46
Alignment E					
CO-E1/E3	36	0.025	58.71	115.15	0.51
CO-E5	48	0.002	58.71	69.93	0.84
CO-E10	12	0.020	0.16	5.44	0.03
CO-E15	48	0.002	58.66	69.83	0.84
CO-E20	12	0.020	0.16	5.44	0.03
CO-E25	48	0.002	58.5	69.59	0.84
CO-E30	12	0.020	0.16	5.44	0.03
CO-E35	48	0.002	58.29	69.95	0.83
CO-E40	12	0.020	0.16	5.44	0.03
CO-E45	48	0.002	58.15	69.50	0.84
CO-E50	12	0.020	0.24	5.48	0.04
CO-E55	48	0.002	57.94	69.44	0.83
CO-E60	48	0.002	57.97	69.35	0.84

Table C1. Conduit Modeling Parameters and Results for the 25-year Storm Event

Conduit Name	Diameter (in)	Slope (ft/ft)	Maximum 25-year Flow (cfs)	Calculated Design Capacity (cfs)	Maximum Flow to Calculated Design Capacity Ratio
CO-E65	12	0.020	57.84	5.48	0.04
CO-E70/ A127	48	0.002	58.71	70.62	0.82
Alignment F					
CO-F5	12	0.002	0.16	1.78	0.09
CO-F10	18	0.002	0.33	4.70	0.07
CO-F15	18	0.002	0.49	4.70	0.10
CO-F20	18	0.002	0.65	4.72	0.14
CO-F23	12	0.020	0.16	5.00	0.03
CO-F25	18	0.002	0.95	4.69	0.20
CO-F27	12	0.020	0.16	5.45	0.03
CO-F30	24	0.002	1.73	10.31	0.17
CO-F32	12	0.005	0.54	2.54	0.21
CO-F33	12	0.020	0.16	5.49	0.03
CO-F35	24	0.002	2.96	10.05	0.29
Alignment G					
CO-G155	36	0.002	26.18	34.85	0.75
CO-G160	12	0.020	0.92	5.46	0.17
CO-G165	42	0.002	26.66	52.42	0.51
CO-G170	12	0.020	1.41	5.46	0.26
CO-G175	42	0.002	27.46	52.65	0.52
CO-G180	12	0.020	1.04	5.46	0.19
CO-G185	42	0.002	28.36	52.54	0.54
CO-G187	36	0.002	23.29	31.37	0.74
CO-G190	48	0.002	51.34	69.63	0.74
CO-G195	12	0.020	1.32	5.44	0.24
CO-G200	48	0.002	52.49	69.58	0.75
CO-G205	12	0.020	1.17	5.49	0.21
CO-G210	48	0.002	53.54	69.72	0.77
CO-G215	12	0.020	1.02	5.46	0.19
CO-G220	48	0.002	54.26	69.72	0.78
CO-G225	12	0.020	2.46	5.44	0.45
CO-G230	48	0.002	56.55	69.42	0.81

Table C2. Structures Modeling Results for the 100-year Storm Event

Structure Name	Structure Type	Structure surcharged for the 100-year Storm?
Alignment A		
CB1-A10	WSDOT Catch Basin Type 1	No
CB1-A100	WSDOT Catch Basin Type 1	No
CB1-A110	WSDOT Catch Basin Type 1	No
CB1-A120	WSDOT Catch Basin Type 1	No
CB1-A130	WSDOT Catch Basin Type 1	No
CB1-A20	WSDOT Catch Basin Type 1	No
CB1-A30	WSDOT Catch Basin Type 1	No
CB1-A40	WSDOT Catch Basin Type 1	No
CB1-A50	WSDOT Catch Basin Type 1	No
CB1-A60	WSDOT Catch Basin Type 1	No
CB1-A70	WSDOT Catch Basin Type 1	No
CB1-A80	WSDOT Catch Basin Type 1	No
CB1-A90	WSDOT Catch Basin Type 1	No
MH-A10	WSDOT Manhole Type 3	No
MH-A20	WSDOT Manhole Type 3	No
MH-A30	WSDOT Manhole Type 3	No
MH-A40	WSDOT Manhole Type 3	No
MH-A50	WSDOT Manhole Type 3	No
MH-A60	WSDOT Manhole Type 3	No
MH-A70	WSDOT Manhole Type 3	No
MH-A80	WSDOT Manhole Type 3	No
MH-A90	WSDOT Manhole Type 3	No
MH-A100	WSDOT Manhole Type 3	No
MH-A110	WSDOT Manhole Type 3	No
MH-A120	WSDOT Manhole Type 3	No
Alignment B		
CB1-B100	WSDOT Catch Basin Type 1	No
CB1-B110	WSDOT Catch Basin Type 1	No
CB1-B130	WSDOT Catch Basin Type 1	No
CB1-B140	WSDOT Catch Basin Type 1	No
CB1-B160	WSDOT Catch Basin Type 1	No
CB1-B170	WSDOT Catch Basin Type 1	No
CB1-B180	WSDOT Catch Basin Type 1	No
CB1-B80	WSDOT Catch Basin Type 1	No
CB1-B85	WSDOT Catch Basin Type 1	No
CB1-B87	WSDOT Catch Basin Type 1	No
CB1-B90	WSDOT Catch Basin Type 1	No
CB1-B90	WSDOT Catch Basin Type 1	No
72" STM MH 22	Existing Manhole	No

Table C2. Structures Modeling Results for the 100-year Storm Event

Structure Name	Structure Type	Structure surcharged for the 100-year Storm?
MH-B80	WSDOT Manhole Type 3	No
MH-B85	WSDOT Manhole Type 3	No
MH-B90	WSDOT Manhole Type 3	No
MH-B95	WSDOT Manhole Type 3	No
MH-B100	WSDOT Manhole Type 3	No
MH-B103	WSDOT Manhole Type 3	No
MH-B160	WSDOT Manhole Type 3	No
MH-B165	WSDOT Manhole Type 3	No
MH-B170	WSDOT Manhole Type 3	No
MH-B180	WSDOT Manhole Type 3	No
Alignment C		
MH-C260	WSDOT Manhole Type 3	No
Alignment D		
MH-D10	WSDOT Manhole Type 3	No
MHV-D10	120 Inch Manhole	No
MHV-D20	120 Inch Manhole	No
Alignment E		
CB1-E10	WSDOT Catch Basin Type 1	No
CB1-E20	WSDOT Catch Basin Type 1	No
CB1-E30	WSDOT Catch Basin Type 1	No
CB1-E40	WSDOT Catch Basin Type 1	No
CB1-E50	WSDOT Catch Basin Type 1	No
CB1-E60	WSDOT Catch Basin Type 1	No
MH-E10	WSDOT Manhole Type 3	No
MH-E20	WSDOT Manhole Type 3	No
MH-E30	WSDOT Manhole Type 3	No
MH-E40	WSDOT Manhole Type 3	No
MH-E50	WSDOT Manhole Type 3	No
MH-E60	WSDOT Manhole Type 3	No
MH-E70	WSDOT Manhole Type 3	No
MH-E80	WSDOT Manhole Type 3	No
Alignment F		
CB1-F10	WSDOT Catch Basin Type 1	No
CB1-F20	WSDOT Catch Basin Type 1	No
CB1-F30	WSDOT Catch Basin Type 1	No
CB1-F40	WSDOT Catch Basin Type 1	No
CB1-F50	WSDOT Catch Basin Type 1	No
CB1-F60	WSDOT Catch Basin Type 1	No
CB1-F70	WSDOT Catch Basin Type 1	No
MH-F50	WSDOT Manhole Type 3	No

Table C2. Structures Modeling Results for the 100-year Storm Event

Structure Name	Structure Type	Structure surcharged for the 100-year Storm?
MH-F60	WSDOT Manhole Type 3	No
MH-F65	WSDOT Manhole Type 3	No
MH-F70	WSDOT Manhole Type 3	No
Alignment G		
CB1-G200	WSDOT Catch Basin Type 1	No
CB1-G210	WSDOT Catch Basin Type 1	No
CB1-G220	WSDOT Catch Basin Type 1	No
CB1-G230	WSDOT Catch Basin Type 1	No
CB1-G240	WSDOT Catch Basin Type 1	No
CB1-G250	WSDOT Catch Basin Type 1	No
CB1-G260	WSDOT Catch Basin Type 1	No
MH-G200	WSDOT Manhole Type 3	No
MH-G205	WSDOT Manhole Type 3	No
MH-G210	WSDOT Manhole Type 3	No
MH-G215	WSDOT Manhole Type 3	No
MH-G220	WSDOT Manhole Type 3	No
MH-G230	WSDOT Manhole Type 3	No
MH-G240	WSDOT Manhole Type 3	No
MH-G250	WSDOT Manhole Type 3	No

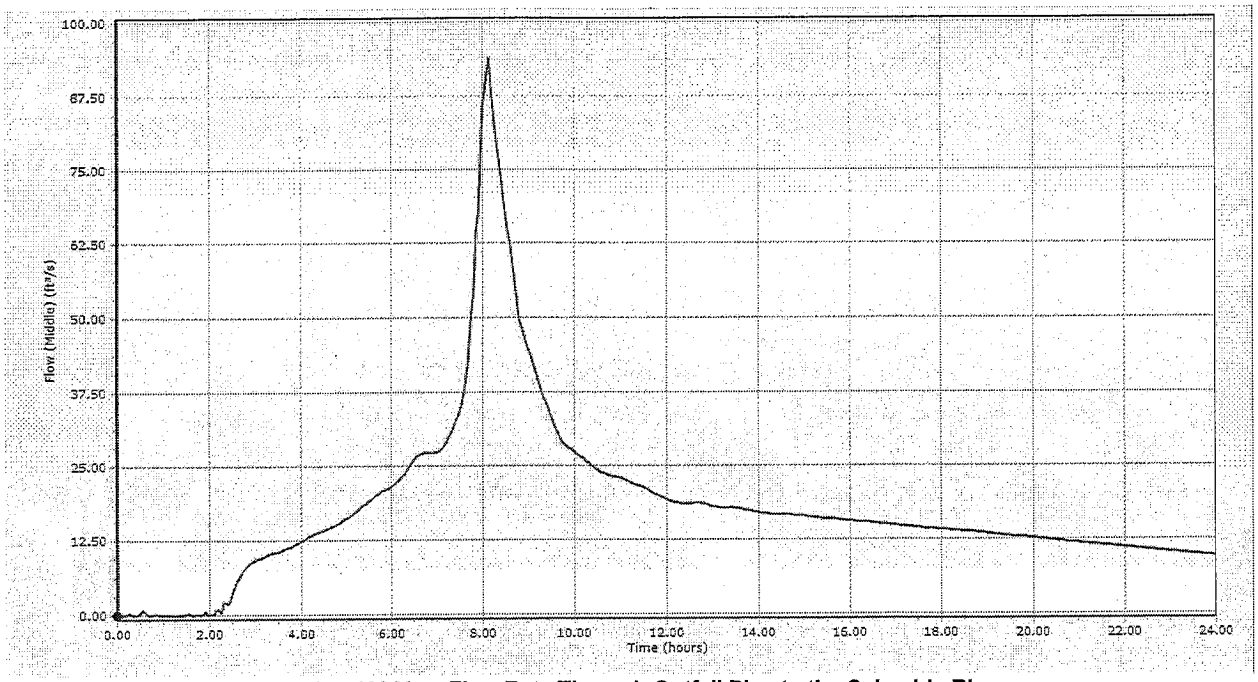

Figure C1. Hydrograph Showing 100 Year Flow Rate Through Outfall Pipe to the Columbia River

BergerABAM

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503/872-4100 • 503/872-4101 Fax • www.abam.com

Memorandum

Date: June 10, 2010

Subject: Port of Vancouver – West Vancouver Freight Access Project
Parcel 1A Drainage Study

From: Shawn Ellis, PE

To: Kurt Reichelt, HDR
Scott Hale, HDR

Route to: Papor-09-121 File

As requested by the Port of Vancouver, we have completed a review of drainage options for the Port's Parcel 1A property. Our understanding for the Port's desired future use of Parcel 1A and the results of our analyses based on this understanding is summarized in this memorandum.

Future Parcel 1A Sub-Basins

The purpose of this study is to determine the feasibility of providing for future drainage facilities for Parcel 1A after it is divided into three sub-basins. Two of the sub-basins will be approximately 22 acres each, and will be developed for light industrial use by outside parties or Port tenants. The balance of the parcel (15 acres) will remain Port property, and be used for rail and other Port access and as a utility corridor along the north side of the existing and future track corridor.

According to Port staff, the two 22-acre parcels will each provide on-site water quality treatment for storm water runoff. Treated storm water will be conveyed by Port-owned conveyance facilities for discharge to the Columbia River via the Port's outfall. The runoff will bypass the Port's existing water quality treatment facility (the T4 Pond). The 15-acre parcel will be conveyed for treatment in the T4 Pond.

Hydrology and Hydraulics

We have completed preliminary analyses to determine peak flows for a 25-year rainfall event from the combined 22-acre parcels and the 15-acre parcel to determine the size of the systems necessary to convey peak flows. The Santa Barbara Unit Hydrograph (SBUH) method was used for the analyses. Calculations are attached to this memo, but are summarized below. The design storm is the 25-year rainfall depth of 3.5 inches. Times of concentration are based on 100 feet of

overland flow for each system, 100 feet of concentrated flow, and the balance as pipe flow. Peak flow from the two combined parcels is predicted to be 30.8 cfs. Peak flow from the 15-acre parcel is predicted to be 9.5 cfs.

Required pipe sizes for the above peak discharges are determined from likely maximum slope requirements for each system based on the elevations for each system connection location. The 44-acre parcels will require a 36-inch pipe with a minimum slope assume to be xxx. The 15-acre parcel will require a 24-inch pipe with a minimum slope of 2.3%.

SBUH Input	**44-acre Parcels**	**15-acre Parcel**
Area (acres)	44 acres	15 acres
Percent Impervious	100%	100%
Curve Number	98	98
25-year Design Event	3.5 inches	3.5 inches
Time of Concentration	98	27.2 minutes
Peak Flow	30.8 cfs	9.5 cfs
Pipe Size	36-inch	24-inch

Grade Requirements For T4 Pond By-pass Conveyance System

The following assumptions and existing conditions have been considered to evaluate the feasibility of extending a gravity conveyance system from the western 22-acre parcel to the manhole south of the T4 pond.

- The conveyance system will be connected to the manhole just south of the T4 pond, and it has an invert elevation of 11.00 feet for the 60-inch pipe proposed from the T4 pond. The existing 60-inch outlet pipe has an invert elevation of 10.50 feet.
- Matching crowns at this manhole would require an invert elevation of 13.00 feet for the 36-inch conveyance pipe from Parcel 1A.
- Approximately 3,650 linear feet of conveyance pipe will be required to convey the two 22-acre sites runoff to the discharge at the Port's manhole south of the T4 pond. Assuming a minimum slope of 0.2% results in a 7.3-foot grade drop to this manhole.
- Approximately 900 linear feet of pipe in the westernmost 22-acre site at a slope of 0.5% will require a 4½-foot grade drop within the site.

- Site elevation in the NW corner of Parcel 1A will be at least 29 feet, based on adjacent survey data.
- The invert elevation for the upstream end of the on-site conveyance system, could be as low as 24.80 feet given the above criteria. The site elevation in the NW corner of Parcel 1A is likely to be at least 29 feet, based on adjacent survey data from Gateway Road and SR 501. Therefore, a depth of 4.2 feet for this upstream point is possible.
- Shallower depth for the on-site system may be required if water quality treatment systems selected by parcel owners/tenants require a hydraulic head to function.

It is recommended that 36-inch conveyance system be constructed as deeply as possible in order to allow for the most flexibility for design of the on-site storm water systems.

Options for Crossing the Track Corridor

An existing 42-inch pipe currently crosses the track corridor, extending towards the T4 pond from an inlet and manhole at the southeast corner of Parcel 1A. Existing Project 6 (Terminal 3 Rail Access) plans show modifications to this pipe system to provide access from Parcel 1A to the T4 pond. This pipe can be used for either the 44-acre conveyance or the 15-acre conveyance, although conditions for each are not ideal (see option discussions below).

For whichever system the 42-inch pipe is used, we recommend that a second storm pipe be installed as part of Project 6 (or partially during Project 6 with completion as part of Project 11). The second pipe will be either for conveyance of the 44-acre parcel or the 15-acre parcel.

Options for providing conveyance for the parallel pipe systems are described below:

- *Existing 42-inch Pipe for 44-acre Conveyance.* The existing 42-inch pipe could be used for conveyance of the 44-acre parcel. However, the pipe does not provide the same upstream or downstream elevations listed in the Grade Requirements above. The downstream end of the pipe on the south side of the track corridor is at elevation 15.31 feet. Approximately 1270 feet of pipe would be required to extend the system to the manhole south of the T4 pond. At a slope of 0.2% the invert at the manhole would be 12.77 feet. This would function hydraulically, but would not allow for matching pipe crowns.

  If the existing 42-inch pipe is proposed for conveyance of the 44-acre sites, a second storm crossing (24-inch pipe) should be installed for conveyance of the 15-acre parcel. The Project 6 plans should be modified to complete the connection as part of the project 6 project, so that future modification to the system won't be necessary, and to ensure that the required configuration of the both systems can function in the limited space available near the northwest corner of the pond.

- ***Existing* 42-inch Pipe for 15-acre Conveyance.** The current Project 6 plans provide for extension of the 42-inch to the T4 Pond. However, the existing pipe is below the pond water surface elevation of 16.65 feet, and is generally partially filled with water except when the pond's water surface drops due to evaporation during very dry periods. If the 15-acre parcel is used by this existing pipe, a second 36-inch storm crossing should be installed for the 44-acre parcel future conveyance.

Conveyance Calculations & Pipe Sizing

Project: West Vancouver Freight Access Project - Project 9
PAPOR-11-127
Date: 4/18/2011

Storm Drain A

Upstream	Downstream	Length	Peak Discharge Calculation									Pipe Design					
			Area (acres)	C	CA	Sum Ca	Tc (min)	Pipe Tc (min)	Sum Tc (min)	I (in/hr)	Q (cfs)	Dia (in)	Slope (ft/ft)	Mannings n	Capacity (cfs)	Velocity (fps)	Q/Qcap
Gateway Ave	MH P9-A1	238	2.030	0.9	1.83	1.83	6.5		6.5	2.31	4.22	18	0.0028	0.013	5.57	3.15	0.76
MH P9-A1	MH P9-A2	300	1.670	0.9	1.50	3.33		1.3	7.8	2.11	7.03	24	0.002	0.013	10.14	3.23	0.69
MH P9-A2	MH P9-A3	300	1.670	0.9	1.50	4.83		1.5	9.3	1.92	9.28	24	0.002	0.013	10.14	3.23	0.92
MH P9-A3	MH P9-A4	300	1.670	0.9	1.50	6.34		1.5	10.9	1.77	11.24	30	0.0015	0.013	15.92	3.24	0.71
MH P9-A4	MH P9-A5	300	1.670	0.9	1.50	7.84		1.5	12.4	1.66	12.99	30	0.0015	0.013	15.92	3.24	0.82
MH P9-A1	MH P9-A6	300	1.670	0.9	1.50	9.34		1.5	13.9	1.56	14.58	30	0.0015	0.013	15.92	3.24	0.92
MH P9-A5	MH P9-A7	300	1.670	0.9	1.50	10.85		1.5	15.5	1.48	16.03	36	0.0012	0.013	23.16	3.28	0.69
MH P9-A1	MH P9-A8	300	1.670	0.9	1.50	12.35		1.5	17.0	1.41	17.39	36	0.0012	0.013	23.16	3.28	0.75
MH P9-A1	MH P9-A9	241	1.670	0.9	1.50	13.85		1.5	18.5	1.35	18.66	36	0.0012	0.013	23.16	3.28	0.81
MH P9-A9	Exisiting MH	358	1.670	0.9	1.50	15.35		1.2	19.8	1.30	20.02	36	0.0012	0.013	23.16	3.28	0.86
		Total Area	17.06														

Storm Drain B

Upstream	Downstream	Length	Peak Discharge Calculation									Pipe Design					
			Area (acres)	C	CA	Sum Ca	Tc (min)	Pipe Tc (min)	Sum Tc (min)	I (in/hr)	Q (cfs)	Dia (in)	Slope (ft/ft)	Mannings n	Capacity (cfs)	Velocity (fps)	Q/Qcap
Farwest	MH P9-B1	5	22.000	0.9	19.80	19.80	98.0		98.0	0.57	11.32	30	0.0015	0.013	15.92	3.24	0.71
MH P9-B1	MH P9-B2	203	0.000	0.9	0.00	19.80		0.0	98.0	0.57	11.31	30	0.002	0.013	18.38	3.75	0.62
MH P9-B2	MH P9-B3	300	5.250	0.9	4.73	24.53		0.9	98.9	0.57	13.95	36	0.002	0.013	29.89	4.23	0.47
MH P9-B3	MH P9-B4	254	5.250	0.9	4.73	29.25		1.2	100.1	0.57	16.53	36	0.0015	0.013	25.89	3.66	0.64
MH P9-B4	MH P9-B5	279	5.250	0.9	4.73	33.98		1.2	101.3	0.56	19.09	42	0.0015	0.013	39.05	4.06	0.49
MH P9-B5	MH P9-B6	279	5.250	0.9	4.73	38.70		1.1	102.4	0.56	21.62	42	0.0015	0.013	39.05	4.06	0.55
MH P9-B6	Existing MH	50	1.000	0.9	0.90	39.60		1.1	103.6	0.56	22.00	42	0.0012	0.013	34.93	3.63	0.63
		Total Area	44.00														

Intensity (I)
From the WSDOT Hydraulics Manual, $I = m/Tc^n$
where m = 6.06 and n = 0.515 for the 25-year return period

Gateway Avenue Contribution to Storm Drain A taken from Project 19 calculations.
Farwest Steel contribution to Storm Drain B taken from Farwest Steel calculations.

Conveyance Calculations & Pipe Sizing

Project: West Vancouver Freight Access Project - Gateway Avenue Grade Separation
PAPOR-11-127
Date: 4/18/2011

Gateway Avenue From Lower River Road to MH-13

Upstream	Downstream	Length	Peak Discharge Calculation									Pipe Design					
			Area (acres)	C	CA	Sum Ca	Tc (min)	Pipe Tc (min)	Sum Tc (min)	I* (in/hr)	Q (cfs)	Dia (in)	Slope (ft/ft)	Mannings n	Capacity (cfs)	Velocity (fps)	Q/Qcap
MH-15	MH-14	294	0.180	0.9	0.16	0.16	5.0		5.0	2.65	0.43	12	0.005	0.013	2.52	3.22	0.17
MH-14	MH-13	109	0.295	0.9	0.27	0.43		1.5	6.5	2.31	0.99	12	0.005	0.013	2.52	3.22	0.39
		Total Area	0.48														

Gateway Avenue From High Point at Station G22+48.47 to MH-13

Upstream	Downstream	Length	Peak Discharge Calculation									Pipe Design					
			Area (acres)	C	CA	Sum Ca	Tc (min)	Pipe Tc (min)	Sum Tc (min)	I (in/hr)	Q (cfs)	Dia (in)	Slope (ft/ft)	Mannings n	Capacity (cfs)	Velocity (fps)	Q/Qcap
MH-7	MH-8	125	0.390	0.9	0.35	0.35	5.0		5.0	2.65	0.93	12	0.0534	0.013	8.25	10.51	0.11
MH-8	MH-9	170	0.000	0.9	0.00	0.35		0.2	5.2	2.59	0.91	12	0.0537	0.013	8.27	10.54	0.11
MH-9	MH-10	134	0.374	0.9	0.34	0.69		0.3	5.5	2.53	1.74	12	0.0446	0.013	7.54	9.60	0.23
MH-10	MH-11	122	0.000	0.9	0.00	0.69		0.2	5.7	2.47	1.70	12	0.019	0.013	4.92	6.27	0.35
MH-11	MH-12	53	0.386	0.9	0.35	1.04		0.3	6.0	2.40	2.49	12	0.0049	0.013	2.50	3.19	0.99
MH-12	MH-13	101	0.262	0.9	0.24	1.27		0.3	6.0	2.40	3.05	15	0.005	0.013	4.58	3.73	0.67
		Total Area	1.41														

Gateway Avenue From MH-13 to Discharge to Conveyance at Parcel 1A Tract

Upstream	Downstream	Length	Peak Discharge Calculation									Pipe Design					
			Area (acres)	C	CA	Sum Ca	Tc (min)	Pipe Tc (min)	Sum Tc (min)	I (in/hr)	Q (cfs)	Dia (in)	Slope (ft/ft)	Mannings n	Capacity (cfs)	Velocity (fps)	Q/Qcap
MH-13	Parcel 1A	238	0.141	0.9	0.13	1.83	6.5		6.5	2.31	4.21	18	0.0028	0.013	5.57	3.15	0.76
		Total Area	2.03	Includes areas from two tables above													

Gateway Avenue From High Point at Station G22+48.47 to discharge into the Terminal 5 System

Upstream	Downstream	Length	Peak Discharge Calculation									Pipe Design					
			Area (acres)	C	CA	Sum Ca	Tc (min)	Pipe Tc (min)	Sum Tc (min)	I* (in/hr)	Q (cfs)	Dia (in)	Slope (ft/ft)	Mannings n	Capacity (cfs)	Velocity (fps)	Q/Qcap
MH-6	MH-5	93	0.512	0.9	0.46	0.46	5.0		5.0	2.65	1.22	12	0.0322	0.013	6.40	8.16	0.19
MH-5	MH-4	260	0.215	0.9	0.19	0.65		0.2	5.2	2.60	1.70	12	0.0396	0.013	7.10	9.05	0.24
MH-4	MH-3	285	0.363	0.9	0.33	0.98		0.5	5.7	2.48	2.43	12	0.0391	0.013	7.06	8.99	0.34
MH-3	MH-2	119	0.319	0.9	0.29	1.27		0.5	6.2	2.37	3.00	12	0.0172	0.013	4.68	5.96	0.64
MH-2	MH-1	69	0.440	0.9	0.40	1.66		0.3	6.5	2.31	3.84	15	0.0077	0.013	5.68	4.63	0.68
MH-1	T5		0.132	0.9	0.12	1.78		0.2	6.8	2.26	4.03	15	0.005	0.013	4.58	3.73	0.88
		Total Area	1.98														

* Intensity (I)
From the WSDOT Hydraulics Manual, $I = m/Tc^n$
where m = 6.06 and n = 0.515 for the 25-year return period