

APPENDIX A  
SUPPLEMENTAL HYDRAULICS INVESTIGATION

DRAFT EIS - JULY 82  
FINAL E.I.S.  
APRIL 83

Hydraulics

Previous hydraulic investigations reported on July 12, 1982 (SUMMARY REPORT FOR E.I.S. Hydraulic Investigations: Cascade Mall at Burlington) are revised herein based on information furnished in response to the draft EIS.

The most significant input in regard to the hydraulics was provided by Robert C. Boudinot, Jr., P.E., City Engineer, City of Burlington, who provided data on land forms in the city that would restrict flood flows through the city. The land forms include the Burlington Railroad grade from Fairhaven Avenue to Gages Slough. At Gages Slough the railroad has recently filled in the trestle on the south bank of Gages Slough with sands and gravels. In the opinion of John Norman, the fill would wash out during a major flood. The other land forms include a ridge running northwesterly across the Burlington Railroad's 40 acres to the north of Gilkey Road and the District 12 dike which runs along the Burlington Railroad grade to Whitmarsh Road south of Pease Road.

The land forms in Burlington emphasize the split in flows around the City of Burlington. During a major flood event such as a 100-year flood, the flows would be in three major areas when passing Burlington:

1. passing northwesterly of the northeast side of Burlington Hill;
2. passing southwesterly between the right bank of Gages Slough and the right bank of the Skagit River; and
3. down the Skagit River.

These land forms do not allow the 8,000 cubic feet per second previously reported by Mr. Norman to flow through the area north of the drive-in theater. These flows would be forced southward towards the Skagit River. An elevation of 33 feet was used in the draft EIS for the 100-year flood with the floor elevation of the mall set at 34 feet. The backwaters studies were revised using the information furnished by the city. This resulted in changes in the 100-year flood elevations previously reported from 31.8 feet at the west side of the project and 34.0 feet just to the east of Garl Street, to 32.8 feet and 33.2 feet, respectively.

The area between the west side of I-5 and the east side of the Burlington Railroad grade, and between Burlington Hill to the west and the Skagit River to the south was divided into five portions. I-5 acts as a dam causing flood flows to back up behind it. The water flows through the bridges at Gages Slough and over I-5 which acts as a weir. Downstream of I-5 the water spreads out in the flood plain. A summary of water surface elevations, velocities, and flows is tabulated below for both the existing condition and the situation that would exist with the project in place. This data assumes that no work such as excavation will take place within Gages Slough. A computer printout of the data on which this summary is based is attached to this report.

For purposes of orientation, it should be noted that I-5 is at station 356+00 to 358+000; the project buildings are at station 366+00 to 368+00;

Garl Street is at station 372+00; and Burlington Northern Railroad is at station 393+00. Portion 1 is overbank between the Skagit River and Gages Slough; portion 2 is Gages Slough; and the Cascade Mall and drive-in theater are in portion 3. It is assumed that 250 feet of Burlington Northern Bridge embankment will wash out at Gages Slough station 393+00 during a 100-year flood.

	<u>Station (feet)</u>	<u>Elevation (feet)</u>	<u>Flow (cfs)</u>	<u>Velocity (fps)</u>
Existing Condition				
	313+00	25.00		
Portion 1			0	0
Portion 2			0	0
Portion 3			28,500	3.5
Portion 4			10,700	2.2
Portion 5			21,800	1.9
	345+00	29.63		
Portion 1			14,600	1.2
Portion 2			33,400	3.0
Portion 3			12,000	1.4
Portion 4			1,700	0.8
Portion 5			300	0.3
	356+00	29.89		
IS Portion 1			8,500	0.8
Portion 2			26,000	3.1
Portion 3			18,000	1.8
Portion 4			3,500	1.5
Portion 5			5,000	1.6
	358+00	32.50		
IS Portion 1			14,600	2.2
Portion 2			11,900	9.3
Portion 3			19,700	3.3
Portion 4			14,800	2.5
Portion 5			0	0
	359+00	32.65		
Portion 1			18,900	2.6
Portion 2			14,200	11.0
Portion 3			19,200	3.1
Portion 4			8,700	2.0
Portion 5			0	0
	360+00	32.80		
Portion 1			26,700	1.0
Portion 2			15,400	22.4
Portion 3			14,600	1.1
Portion 4			4,300	0.6
Portion 5			0	0

# EXISTING CONDITIONS

	<u>Station</u> <u>(feet)</u>	<u>Elevation</u> <u>(feet)</u>	<u>Flow</u> <u>(cfs)</u>	<u>Velocity</u> <u>(fps)</u>
	362+00	32.82		
Portion 1			28,700	1.0
Portion 2			15,500	2.6
Portion 3			14,900	1.1
Portion 4			1,900	0.4
Portion 5			0	0
	366+00	32.87		
Portion 1			28,200	1.0
Portion 2	PROJECT SITE		16,900	2.8
Portion 3			13,800	1.1
Portion 4			2,100	0.5
Portion 5			0	0
	368+00	32.91		
Portion 1			29,800	1.1
Portion 2	PROJECT SITE		16,900	2.7
Portion 3			12,900	1.1
Portion 4			1,400	0.4
Portion 5			0	0
	371+00	32.94		
Portion 1			23,800	1.3
Portion 2			21,600	3.6
Portion 3			15,600	1.3
Portion 4			0	0
Portion 5			0	0
	372+00	32.99		
Portion 1			29,800	2.0
Portion 2	GARL STREET		19,300	4.7
Portion 3			11,900	1.5
Portion 4			0	0
Portion 5			0	0
	373+00	33.16		
Portion 1			30,700	1.4
Portion 2			19,400	2.9
Portion 3			10,900	2.9
Portion 4			0	0
Portion 5			0	0
	383+00	33.50		
Portion 1			37,800	1.4
Portion 2			20,600	2.7
Portion 3			2,600	0.5
Portion 4			0	0
Portion 5			0	0

	Station (feet)	Elevation (feet)	Flow (cfs)	Velocity (fps)
	393+00	35.8		
Portion 1			200	0.6
Portion 2			<del>80,400</del>	10.1
Portion 3			400	1.1
Portion 4			0	0
Portion 5			0	0

**WITH PROJECT**

(313+00 to 360+00 same as above)

	362+00	32.81		
Portion 1			32,200	1.1
Portion 2			17,200	2.9
Portion 3			9,300	1.3
Portion 4			2,300	0.5
Portion 5			0	0

	366+00	32.88		
Portion 1			33,600	1.2
Portion 2			19,800	3.3
Portion 3			5,000	1.2
Portion 4			2,600	0.6
Portion 5			0	0

	368+00	32.93		
Portion 1			31,600	1.2
Portion 2			17,600	2.9
Portion 3			10,300	1.3
Portion 4			1,500	0.5
Portion 5			0	0

	371+00	32.99		
Portion 1			23,900	1.3
Portion 2			21,500	3.6
Portion 3			15,600	1.3
Portion 4			0	0
Portion 5			0	0

	372+00	33.03		
Portion 1			29,800	2.0
Portion 2			19,100	4.6
Portion 3			12,100	1.5
Portion 4			0	0
Portion 5			0	0

	373+00	33.20		
Portion 1			30,700	1.4
Portion 2			19,300	2.9
Portion 3			10,900	1.0
Portion 4			0	0
Portion 5			0	0

	<u>Station (feet)</u>	<u>Elevation (feet)</u>	<u>Flow (cfs)</u>	<u>Velocity (fps)</u>
	383+00	33.53		
Portion 1			37,800	1.4
Portion 2			20,500	2.7
Portion 3			2,700	0.5
Portion 4			0	0
Portion 5			0	0
	393+00	35.80		
Portion 1			200	0.6
Portion 2			60,400	10.1
Portion 3			400	1.1
Portion 4			0	0
Portion 5			0	0

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### Surface Runoff

The surface runoff for the proposed Cascade Mall site was determined based on procedures in Urban Hydrology For Small Watersheds, Technical Release No. 55, published by the Soil Conservation Service. The soil groups (types) are shown on page 10 of the DEIS. The soils are Puyallup, Sumas Silt Loam, and Urban. Hydrologic groups are B except for the Sumas Silt Loam which is B/C. The CN values usually used are an average between dry and wet conditions. (CN values (runoff "curve numbers") indicate the runoff potential of a watershed; the higher the CN the higher the potential.) For the Cascade Mall the critical condition would be winter storms which occur during wet soil conditions. The CN values used in this report are for wet conditions. Data relating to surface water runoff for both the existing conditions and with the proposed mall are tabulated below.

	<u>Existing</u>	<u>Proposed</u>
A. Total Area	75.5 acres	
Excluded from development (Gages Slough)		9.5 acres
Development		66.0 acres
B. Impervious area (CN=99)	8.0 acres	55.0 acres
Landscaped area (CN=78)		11.0 acres
Urban area (CN=90)	4.0 acres	
Cultivated area (CN=92)	54.0 acres	
Total Area	66.0 acres	66.0 acres
Composite CN	92.7	95.5
C. Rainfall, 24-hour storm		
2-year	1.8 inches	1.8 inches
10-year	2.6 inches	2.6 inches
25-year	3.1 inches	3.1 inches
50-year	3.4 inches	3.4 inches
100-year	3.7 inches	3.7 inches

As noted in the Supplemental Hydraulics Investigation included as Appendix A to this FEIS, the present "flap gate" between Gages Slough and the Skagit River closes when river flows are higher than 32,000 cfs or at a river stage of 19.0 msl. As explained in the responses to comments 2, 11, and 13, the project has been designed for a "worst case" condition to retain on-site accumulated runoff in excess of existing runoff for one storm of a 25-year duration, one storm of a two-year duration, and two storms of less than a two-year duration. These storms could be expected to occur (worst-case) during a one-month period when the Skagit River flow volumes would cause the flap gate to be closed. Using this design factor, excess storm water from the project site will not adversely impact downstream properties because the water will be retained on-site until the flap gates open as indicated by a receding water level in the slough area near the project site.

However, it should be noted that the project sponsor has indicated his willingness to participate, as one of the landowners along the slough, should the city or some other agency undertake a project to provide for a pumping station on Gages Slough.

25. Storm sewers will be installed in accordance with City of Burlington requirements.
26. The control for flow from the Skagit Basin to the Samish Basin is between Burlington and Sterling Hills and the water has to pass over Highway 20. A profile of Highway 20 in this area was surveyed by John Norman and used to check the amount of flow during a 100-year flood event. The flow was presented as 53,000 cubic feet per second in the DEIS; based on the new survey information this estimate has not been revised. The existing conditions analysis outside the project area was based on the Corps of Engineers' studies, which were based on data that did not include consideration of special land forms. The studies by Mr. Norman were revised to include special land forms in the area. This resulted in elimination of the 8,000-cubic-foot-per-second flows from passing north of the existing drive-in theater. In the area adjacent to the project area the flow is then projected at 63,000 cubic feet per second of overbank flow, which is distributed as follows: 34,000 cubic feet per second between the Skagit River and Gages Slough (this would be 29,000 without the project); 20,000 cubic feet per second in Gages Slough (17,000 without the project); 11,000 cubic feet per second across the project area (15,000 without the project); no flow in the overbank area north of the drive-in theater (with or without the project); and 2,000 cubic feet per second into overbank storage (with or without the project).
7. See the response to comment 26.
8. See the response to comment 26.
9. See the response to comment 26. The velocity of the 100-year flood water flowing across I-5 at the project site would be approximately 4.2 feet per second.