BEAVER SLOUGH DRAINAGE DISTRICT
PROPOSED OUTLET STRUCTURE HYDRAULIC ANALYSIS: VELOCITY-DURATION CURVES

FINAL REPORT

Prepared for:

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On behalf of:

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17 September, 2015

NHC Ref No. 0200079

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EXPIRES 12/31/2015

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1 INTRODUCTION

The Beaver Slough Drainage District (BSDD) is proposing to reconfigure the district into three units for to allow different land and water management uses to occur in each unit. The units will be divided by low berms and canals. Unit 2 will be managed for habitat restoration, while Units 1 and 3 will continue to support agriculture. Drainage from each unit will be routed through a new outlet structure that will replace the existing tide-gated culverts.

The new outlet structures will be concrete box culverts with Nehalem Marine Mfg. Muted Tidal Regulators (MTRs) controlling gate operations. The gates will be adjustable to allow seasonal water regulation and adaptive management based on continued monitoring of the projects performance.

A water management plan is required in advance of project construction. Among other items, the plan describes the water regulation system and water level seasonal management targets. The flow and velocities through the outlet culverts are of interest to the BSDD and regulatory agencies, particularly in regards to fish passage.

This report documents the latest round of hydraulic modeling undertaken by NHC in support of the project. The key output of the modeling are velocity-duration curves for each unit's outlet structure.

2 WATER MANAGEMENT SCENARIOS

Each unit will be operated to regulate water levels within a target range for a given season. For purposes of modeling a single target interior water level was used for each unit and season. For all combinations except Spring – Max Dry-Out the midpoint of the proposed range was used. For the Spring Max Dry –Out phase in Units 1 and 3 the lowest elevation in the target range was used, consistent with the intent of the operations at that time. The unit and season management scenarios are shown in Table 1.

Table 1: Water Management Scenarios by Season and Unit

	Unit 1 & Unit 3			**Unit 2**		
Season	Management Name	Target Range	Model Target	Management Name	Target Range	Model Target
Winter	Over Winter Habitat	4.5-5.5	5.0	Over Winter Habitat	4.5-5.5	5.0
Spring	Max Dry-out	2-4	2.0	Basic Flush	3.5-4	3.75
Summer	Basic Flush	3-3.5	3.25	Basic Flush	3.5-4	3.75

3 AREA-VOLUME CURVES

Surface area and volume by elevation were calculated for each unit using a composite GIS grid consisting of LiDAR for Units 1 and 3, and the latest CAD design surface provided by Tetra Tech for Unit 2. The area and volumes of the canals bounding Unit 2 were assigned to Units 1 and 3. There is additional volume and surface area below 3 foot elevation but most of this is in the canals and ditches and is not captured by the LiDAR and hence was not included in the calculations. The following table and figure give the results.

Table 2: Unit Surface Area and Volume

	Area (Ac)			Volume (Ac-ft)		
Elevation	**Unit 1**	**Unit 2**	**Unit 3**	**Unit 1**	**Unit 2**	**Unit 3**
3.0	68	121	32	77	106	16
3.5	258	201	55	152	189	37
4.0	521	248	78	347	302	70
4.5	736	277	107	665	433	116
5.0	857	336	145	1067	577	179
5.5	919	352	179	1513	749	260
6.0	961	365	201	1983	928	356
6.5	987	370	218	2470	1112	461
7.0	1007	377	233	2969	1298	573
7.5	1022	378	244	3476	1487	693
8.0	1034	378	255	3990	1676	818
8.5	1044	378	263	4510	1865	947
9.0	1053	378	269	5035	2054	1080
9.5	1061	378	275	5563	2243	1216
10.0	1068	378	279	6096	2433	1355
10.5	1074	378	281	6631	2622	1495
11.0	1079	378	282	7169	2811	1636
11.5	1084	378	284	7710	3000	1777
12.0	1087	378	284	8253	3189	1919

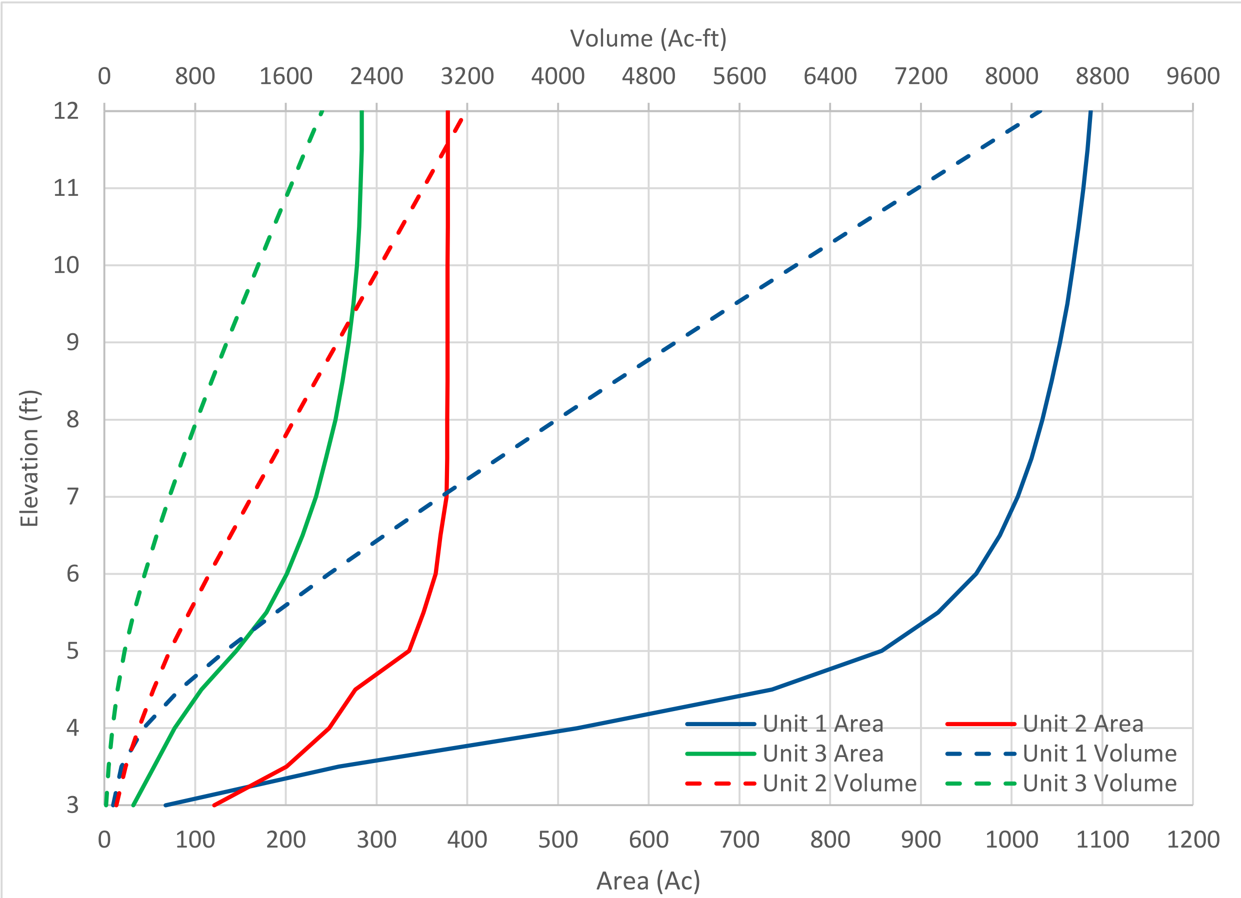

Figure 1: Unit Surface Area and Volume

4 HYDRAULIC MODELING

4.1 Model Hydrology and Boundary Conditions

The water levels that are regulated within BSDD are a function of river levels and inflow to the district. Under normal flows (the focus of the report) river levels are governed by a combination of river flow and tides. Local inflows to the District include China Camp Creek, other minor streams and seeps, and groundwater. Previous calibration efforts have shown that local inflow is dominated by groundwater under normal flow conditions.

Three seasonal simulations were conducted, using data from February 2012, April 2012, and August 2014 for the winter, spring and summer seasons respectively (Figure 2). For the hydraulic modeling of the winter and summer seasons a constant average seasonal flow was used: by removing variability in river and local inflows flow the project performance is more easily analyzed over a neap-spring tide cycle. A period of average river flow for each season was selected based on flows at the USGS South

Fork Coquille River near Powers gage. Observed river stage at the project site for the selected period was used for the model lower boundary condition (Figure 2). Constant local inflow to the BSDD was estimated based on previous calibration of the system, with adjustments for the season (Table 3).

For the Spring period a recession from flood conditions was selected based on observed Coquille River stages at the project site (Figure 2). This simulates the District transitioning from an “out of system” state back down to the operational goal range as quickly as possible, consistent with the Water Management Plan goals. Constant local inflows were again used (Table 3).

Table 3: Constant Baseflow Inputs to Model (cfs)

	Summer	**Spring**	**Winter**
Unit 1 local	2.5	5	5
Unit 1 China Camp Cr	10	20	20
Unit 2	10	20	20
Unit 3	5	10	10
Total	**27.5**	**55**	**55**

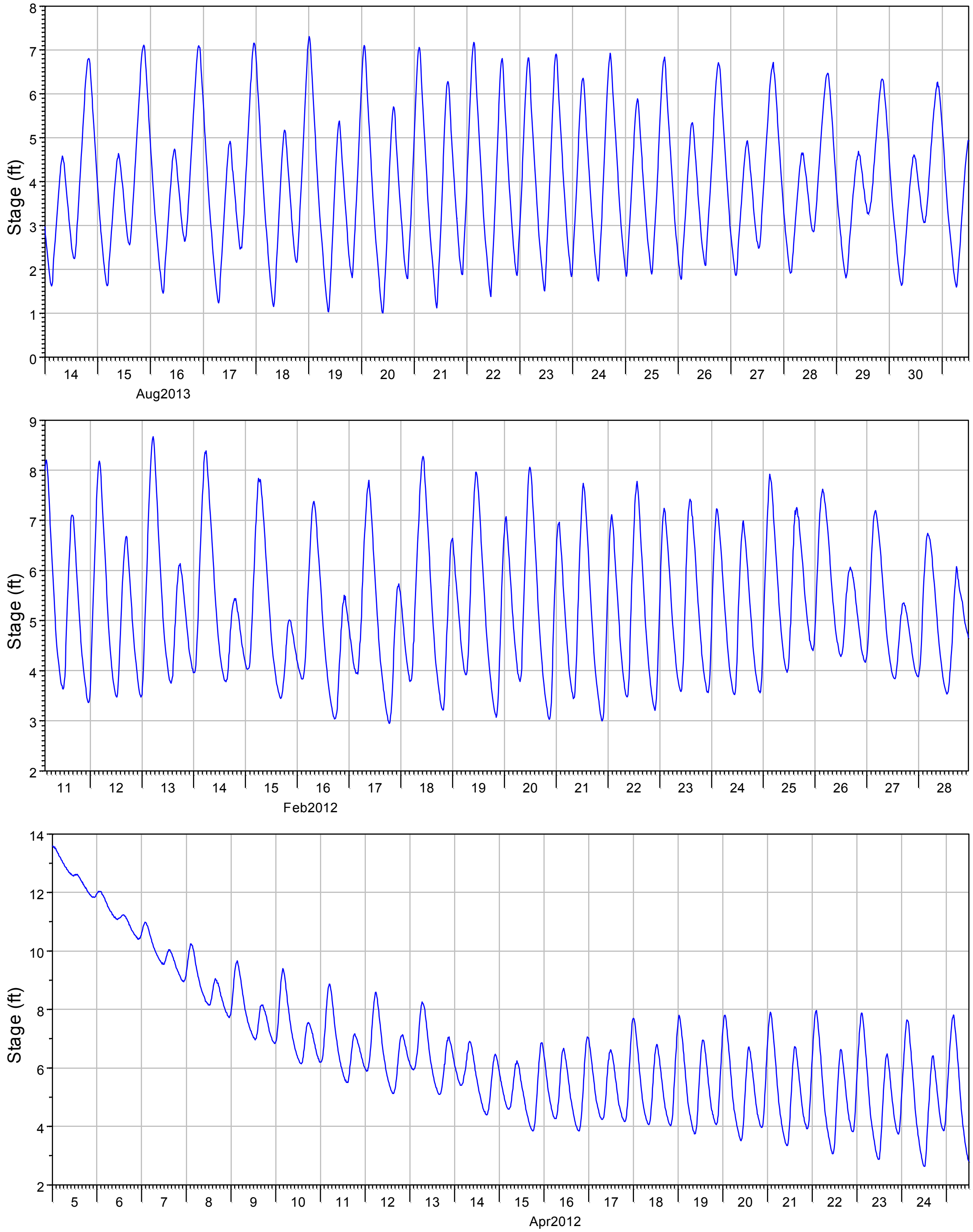

Figure 2: Observed Coquille River Stage (top-Summer, middle-Winter, bottom-Spring)

4.2 Model Geometry

The model geometry was developed from two sources. Units 1 and 3 used NHC developed geometry of existing conditions, derived from LiDAR and bathymetric survey. These units represent the main canals with reaches, and overbank areas with storage areas. Unit 2 geometry was provided by Tetra Tech as a CAD file, and represents the latest restoration design for Unit 2.

The proposed outlet control structures are Nehalem Marine side-hinge tide gates mounted on a vertical slide gate frame. All gates are 8 feet high and 10 feet wide and fixed to concrete box culverts of the same nominal dimension. The tide gate ensures that the gates will always be fully open on an outgoing tide. The vertical slide gate position will be controlled by an MTR based on an interior water level setpoint. The control structures were simulated in HEC-RAS using slide gates set in a lateral structure. Logic control rules were used to control gate position. The gates are still under design: for the modeling it was assumed that an interior water level change of 2 feet was required to move the gate from a fully open to fully closed position, and that the change was linear. Therefore, when the interior water level was more than 2 feet below the setpoint (i.e. target water management level), the gate was fully open. When water levels were between 2 feet below and the setpoint elevation the gate was partially closed (proportional to the distance between the actual and setpoint water level), and it was fully closed when water levels were above the setpoint. As mentioned above, when interior water levels were higher than river levels the gate was fully open and functioning as an open tide gate, regardless of the water elevation.

4.3 Results

Typical results for the three seasons simulated are shown in Figure 3. Observed water levels for the same period are shown for comparison. For the winter and summer periods the proposed project results in slightly lower low tides compared to existing conditions: this is attributed to the greater conveyance capacity of the new system. High tide levels are higher and of longer duration, as is expected with the MTR operations. The greater conveyance capacity of the proposed project results in faster post-flood drawdown, as shown in the spring period.

Velocity durations and gate open time are shown in Figure 4 and Table 4. The curves differ substantially from previous work, due to the design change from side-hinge to vertical slide gate MTRs. Side hinge MTRs slam shut due to the pressure head on the gate once a closure threshold is reached, typically when the gate edge is around a foot or two from the culvert face. In contrast, a vertical slide gate is not affected by the head and can be held open a fraction of a foot without issue. As a result, the vertical slide gate design stays partially open when the side hinge gate has shut. This increases the gate open time. However, when the gate is mostly shut on an incoming tide the high head and low gate open area result in high velocities through the gate. These velocities are highly localized, because the culvert barrel itself has much more area to convey the flow and hence much lower velocities. The high velocities also represent times that a side hinge MTR would be completely closed. Overall, the vertical hinge design offers greater open times than the side hinge design. The design also significantly improves open time compared to existing conditions (Table 4).

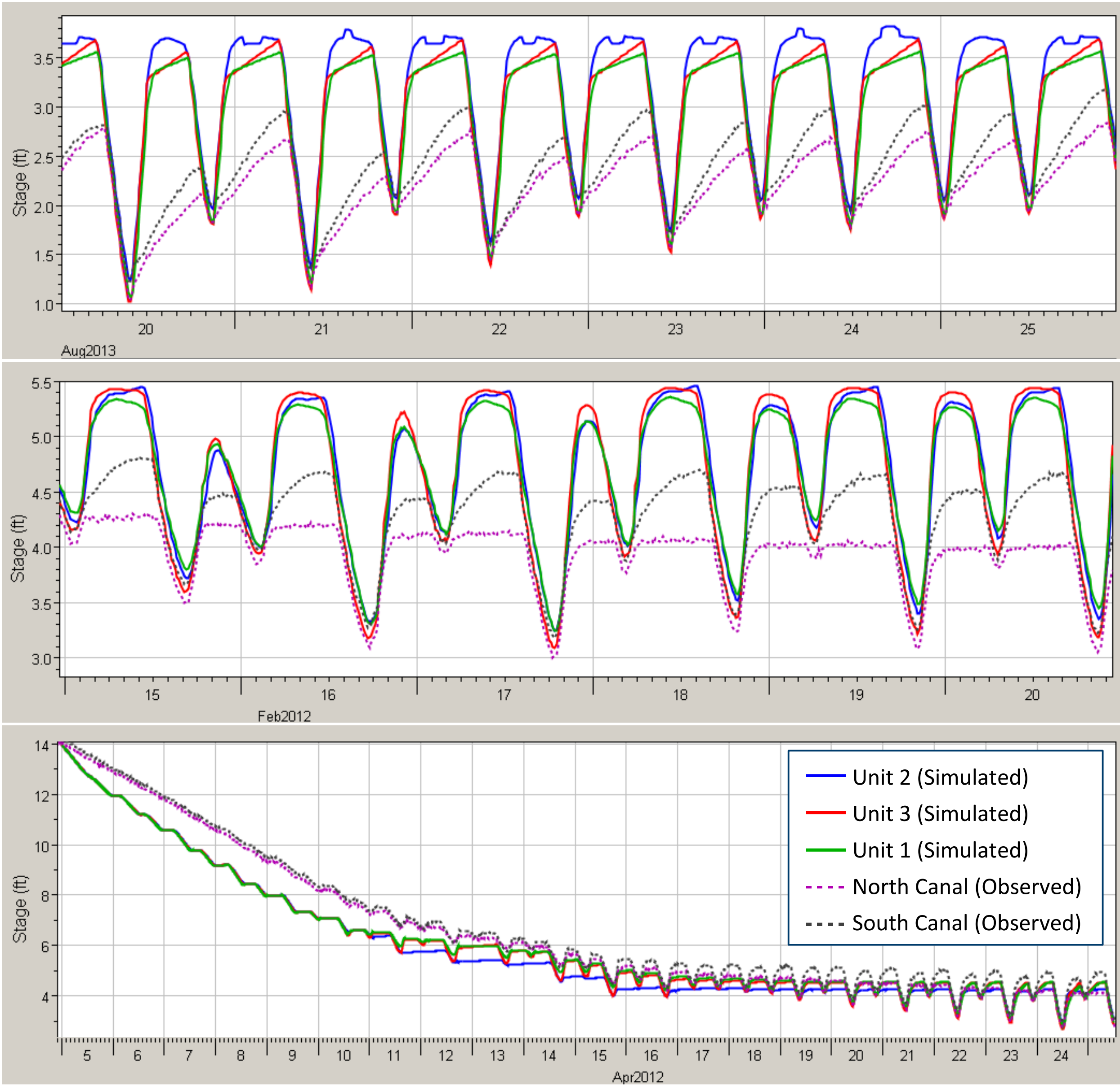

Figure 3: Typical Proposed and Existing BSDD Water Levels – Summer (top), Winter (middle), Spring (Bottom)

Table 4: Percent time of low velocities and gate open

	With-Project (Simulated)			Existing Condition (Observed[1])	
Season	**Unit**	**Percent Time Velocity +/- 2 ft/s**	**Total Percent Time Open**	**Total Percent Time Open[2,3]**	
Summer	Unit 1	34%	51%	North Canal	22%
	Unit 2	23%	99%	East Canal	12%
	Unit 3	44%	56%		
Winter	Unit 1	19%	100%	North Canal	74%
	Unit 2	17%	100%	East Canal	69%
	Unit 3	56%	100%		
Spring	Unit 1	14%	52%	North Canal	37%
	Unit 2	13%	43%	East Canal	13%
	Unit 3	24%	51%		

Notes: 1) Based on BSDD recorded water level data from the period simulated (Figure 1), assuming 0.05 ft of head is required to open the tidegates. 2) The existing tidegates only allow positive (outgoing) flow. 3) Due to reconfiguration of the district the proposed units do not correspond to the existing canals.

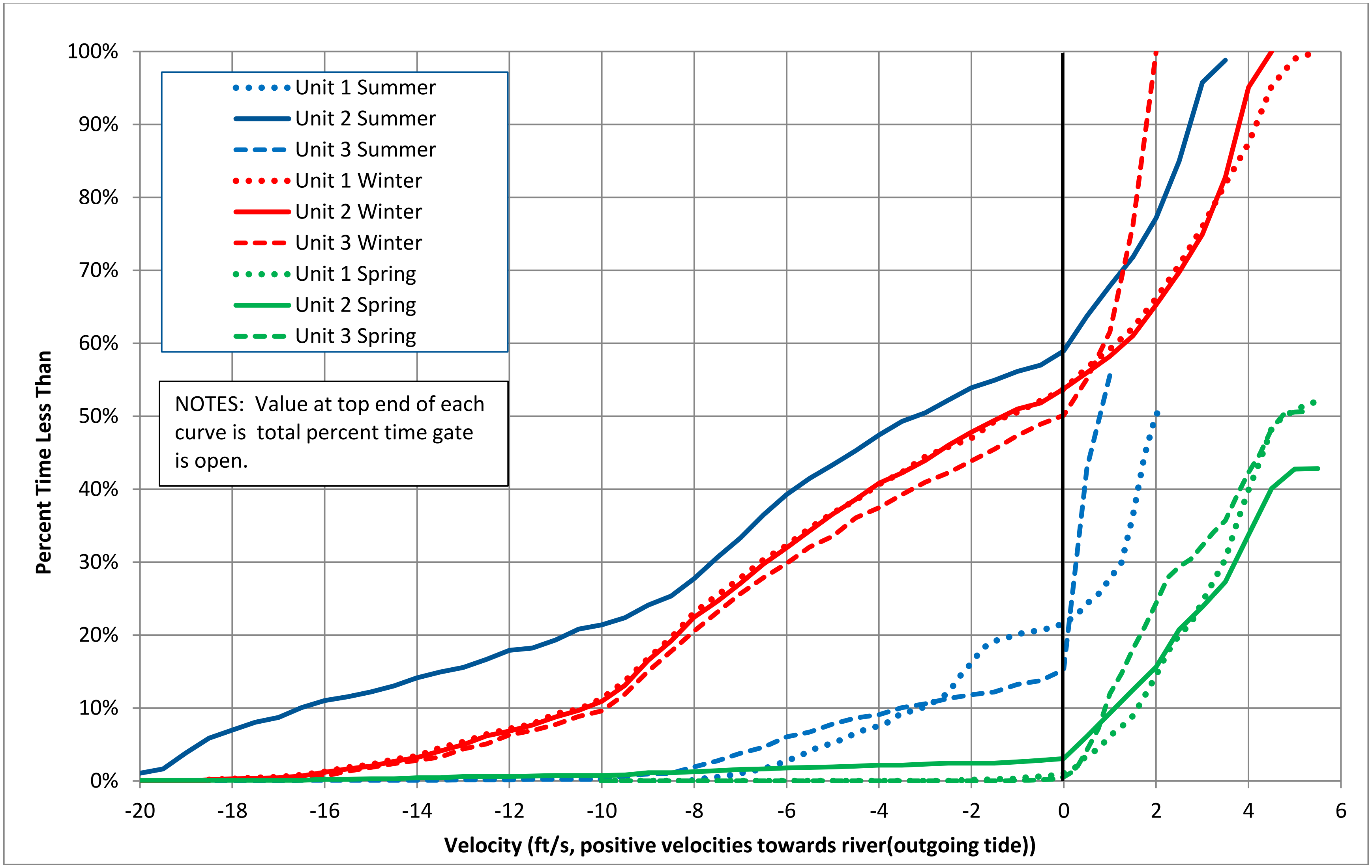

Figure 4: Velocity-Duration Curves