King County
Brightwater
TREATMENT SYSTEM

TECHNICAL MEMORANDUM

DATE: April 22, 2009

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Cindy Rathbone, Washington State Department of Natural Resources
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FROM: Scott Mickelson, King County Marine and Sediment Assessment Group

SUBJ: Brightwater Treatment System Marine Outfall
Baseline Benthic Community Characterization – Construction Trench
Results of the 2007 Monitoring Event

This technical memorandum transmits results of the 2007 monitoring event for the baseline benthic community characterization at the Brightwater Treatment System marine outfall construction trench. This baseline characterization was performed as part of the environmental monitoring required under King County's Aquatic Lands Outfall Easement and Hydraulic Project Approval (HPA) Permit. The project goal is to assess nearshore benthic community recovery following construction of the marine outfall.

This monitoring work was designed to partially fulfill requirements of the County's Aquatic Lands Outfall Easement No. 51-076776, issued by the Washington State Department of Natural Resources (WDNR) for the Brightwater Treatment System (WDNR 2005). The scope of work also fulfills one requirement of the County's HPA Permit No. 100180-1, issued by the Washington Department of Fish and Wildlife (WDFW) as part of the outfall construction permitting process (WDFW 2005).

The 2007 monitoring event, conducted in October of that year, represented the second of a planned three-year benthic community characterization study that began in October 2006. Outfall construction activities, including nearshore trenching, occurred prior to October 2008 and, as a result, the planned third year of baseline monitoring was not undertaken.

Project Background

King County's new Brightwater Treatment System includes a marine outfall that will discharge highly treated effluent to Puget Sound. The final treatment facility site, conveyance system route, and general outfall location were selected in December 2003, with the marine outfall located at Point Wells, along the King-Snohomish county line. The outfall consists of a single

84-inch diameter pipeline starting on land at the Point Wells portal. This single pipeline continues to a water depth of 0 feet, referenced to mean lower low water (MLLW), where it bifurcates into twin 63-inch diameter pipelines and continues underwater approximately one mile offshore to a depth of about –600 feet MLLW. Staggered 250-foot diffusers at the end of the pipes provide a total diffuser length of 500 feet with an available 62 diffuser ports that will disperse the effluent into Puget Sound. The outfall was sited and designed to provide efficient mixing and dilution of the effluent, to be protective of water quality standards and the health of Puget Sound, and to maintain proper hydraulic performance over the design life of the outfall.

The goal of the 2006 monitoring event was to begin establishing a benthic community baseline at the location of the Brightwater Treatment System marine outfall construction trench, prior to commencement of construction activities. Additional sampling events, to be conducted in 2007 and 2008, were planned to fully characterize the benthic community, thus providing a baseline, against which data from future, post-construction monitoring events could be compared to assess benthic community recovery. The trench was a 20-foot wide corridor; 10 feet on either side of the outfall pipe centerline. The construction technique consisted of sheeted trench from 0 to -30 feet MLLW and open trench from -30 to -80 feet MLLW.

Due to a mapping error during the planning phase of the benthic baseline study, the sampling locations for the 2006 monitoring event were placed approximately 100 feet south of the eventual construction trench. Samples were collected in October 2006 and the benthic community characterized at that location. The mapping error was discovered prior to the 2007 monitoring event, the stations relocated, and the second monitoring event occurred in October 2007, correctly placed along the outfall alignment (see Figure 1). Three sampling stations were placed along the trench centerline to be able to monitor recovery in the area in which the benthic community was completely removed. Four sampling stations (two on either side) were placed just outside of the trenching corridor to act as proximal reference stations.

This technical memorandum will report only the data from the October 2007 monitoring event. Data from the October 2006 monitoring event are available by request. The first year of post-construction benthic community monitoring will occur in October 2009 with a follow-up sampling event in October 2011. During both of the post-construction sampling events, samples will be collected from the seven stations sampled in 2007 as well as from two or more of the stations sampled in 2006. In the event that the four stations just outside the construction trench show evidence of impact from construction activities, the stations 100 feet south of the construction zone will provide additional benthic reference data. Multi-year data from the stations south of the construction trench zone will also be used as reference information to assess spatial and temporal variations in the benthic community as a whole.

Sample Collection and Analysis

Sediment samples were collected from the seven stations shown in Figure 1 on October 8, 2007 and submitted for physical and chemical analysis of sediment conventional parameters and for enumeration and identification of benthic fauna. Sediment conventional parameters included percent solids, particle size distribution (PSD) and total organic carbon (TOC), both of which can affect the composition of the benthic community. The seven stations are named BWT-BTHC-1A through BWT-BTHC-7A and are designated in Figure 1 as 1A through 7A.

Sample Collection

All sample collection followed protocols outlined in the Puget Sound Estuary Program's (PSEP) Puget Sound Protocols (PSEP 1987, 1997, and 1998). Sediment was obtained using two modified, stainless steel, 0.1 m^2 van Veen grab samplers deployed in tandem from King County's research vessel *Liberty*. The *Liberty* is equipped with a differential global positioning system (DGPS). The DGPS is a satellite-based navigation system that operates using a receiver to calculate ground position by triangulating scrambled data transmitted by a constellation of satellites operated by the Department of Defense (DOD). The ship-board "differential" receiver receives both the scrambled DOD signal and "corrected" signals originating from base stations operated by various agencies including the Coast Guard and King County. System software applies the differential correction and calculates a precise, real-time navigational position. To increase sampling accuracy, the DGPS system was enhanced by the addition and integration of an ultra-short baseline acoustical navigation system that continuously calculated the three-dimensional position of the submerged grab samplers, relative to that of the surface vessel. Pitch-and-roll motion sensors and an electronic compass were also used to nullify shipboard movement and reference all underwater directional data to magnetic north.

Upon contact of the grab sampler with the bottom, the coordinate data representing the actual sediment grab impact point were electronically recorded in real time. Positioning information included local time and date that a position was recorded, comments, and coordinate data in both latitude/longitude and NAD 83 State Plane formats. Coordinates for each grab deployment are shown in Table 1 and are compared to the prescribed study coordinates.

A minimum of three successful deployments of the tandem grab samplers was required at each station. These multiple deployments would result in three benthic replicates at each station and a single sediment chemistry sample, comprised of sediment collected from three separate grabs. Each successful grab deployment would result in one benthic replicate being collected from one of the tandem grabs and a sediment aliquot for the composite sediment chemistry sample being collected from the other grab.

Sediment collected for physical and chemical analysis was removed from the grab with a stainless-steel spoon and placed into a stainless-steel bowl for thorough homogenization, after sediment from three grabs had been obtained. All sample aliquots were split out after homogenization and placed into labeled, pre-cleaned containers supplied by the King County Environmental Laboratory.

Samples were stored in ice-filled coolers from the time of collection until delivery to the King County Environmental Laboratory. Samples were delivered under chain-of-custody and were maintained as such throughout the analytical process. Percent solids and TOC samples were stored frozen at a temperature of -18°C until analysis, and PSD samples were stored refrigerated at approximately 4°C.

Benthic samples were comprised of the entire contents of each of the three replicate grabs at each station. Sediment samples were immediately sieved through a one-millimeter screen and all material retained on the screen was preserved with a 10% buffered formalin solution and stored for later analysis. Benthic samples were rescreened at the contract laboratory from the 10% buffered formalin solution to 70% ethanol as recommended by the Puget Sound Protocols.

Sample Analysis
Conventional analyses included PSD, TOC, and percent solids (for dry weight-normalization of TOC data). Percent solids analysis was performed according to Standard Method (SM)2540-G (APHA 1998), which is a gravimetric determination. TOC analysis was performed following EPA Method 9060 (PSEP 1986), high-temperature combustion with infrared spectroscopy. PSD analysis was performed according to ASTM Method D422, which is a combination of sieve and hydrometer methodologies (ASTM 2002).

All benthic taxonomy work was performed following accepted regional guidelines (PSEP 1987). Organisms were identified to species level, whenever possible, and then grouped into four categories of taxa for reporting purposes and calculation of biomass. The four taxa categories reported were Annelida, Crustacea, Mollusca, and miscellaneous taxa. A total biomass measurement was reported for each of the four taxa categories, representing the combined weight of all organisms in each taxon and reported in grams. QA/QC procedures included resorting 20% of each processed sample to check sorting efficiency. Five percent of the samples from each major taxonomic group were sent to an independent expert for re-identification, referred to as the voucher collection.

Sediment Conventionals – Analytical Results
Sediment conventional results are summarized in Table 2. PSD results indicated a very sandy environment in the construction trench zone with total fines (clay plus silt) values all less than 3%. Percent sand results ranged from 94.7 to 98.1%. TOC results for the seven stations were all similar, ranging from 1,180 to 1,920 milligrams per kilogram on a dry weight basis (mg/Kg DW) or approximately 0.12 to 0.19%. TOC results less than 0.2% are considered low for Puget Sound (Ecology 1992).

Benthic Community Analysis
A complete list of all species identified from this monitoring event, along with biomass results, is included as Appendix A. Table 2 summarizes the benthic community analysis results, along with summaries of physical characteristics for each sediment sample.

There are several indices that can be used to evaluate benthic community assemblages and compare results between sampling stations. These indices include:

- Total Richness, which is the number of species per 0.1 m^2 (the area sampled by a standard van Veen grab sampler);
- Total Abundance, which is the number of individual organisms per 0.1 m^2;
- Total Biomass, which is the combined mass (weight) of all organisms found in a 0.1 m^2 sample;
- Shannon-Wiener Diversity Index, which is a measure of the relationship between taxa richness and abundance;
- Pielou's Evenness Index, which is expressed as the observed diversity in a sample as a proportion of the maximum possible diversity; and
- Swartz's Dominance Index, which is defined as the minimum number of species comprising 75% of the total abundance in a given sample.

All of these indices have been calculated for this study based on averages over the three replicate samples collected from each station. These indices have been calculated on all benthic fauna, including both infauna and epifauna, to assess recovery of all species lost during trenching.

Species Distribution and Biomass
Total richness values ranged from 91 to 122 species. Total richness values at the four shallower stations; BWT-BTHC-1A, -2A, -3A, and 4A, were very similar, ranging from 91 to 93 species. The three deeper stations; BWT-BTHC-5A, -6A, and -7A, ranged from 105 to 122 species. Annelids represented the greatest number of species at all seven stations, ranging from 31 to 55 species. Similar numbers of crustacea and mollusca species were recorded at all seven stations.

Total abundance values ranged from 885 to 2,106 individuals. The total abundance value of 885 individuals, recorded at the deepest station (BWT-BTHC-7A), was somewhat lower than the other six stations, which ranged from 1,397 to 2,106 individuals. In terms of total abundance, molluscan species were dominant at all seven stations, with mollusca abundance values ranging from 512 to 1,565 individuals. Although molluscs were the most abundant species overall, a single crustacean species, *Euphilomedes carcharodonta* (an ostrocod), was the most-abundant organism at the three shallowest stations; BWT-BTHC-1A, -2A, and -3A

Total biomass is expressed in grams per 0.1 square meter (g/0.1 m^2). Reported total biomass measurements ranged from 6.02 to 11.18 g/0.1 m^2. Although always measured, total biomass is not a particularly useful comparative tool for assessing benthic community assemblages, given such confounding factors as differences in shell or carapace size, or the presence of one large individual in a sample.

Benthic Community Indices
The Shannon-Wiener index is one of the most widely-used diversity indices due to its ease of calculation and its relative independence of sample size. This index uses the total number of species in a sample as well as the abundance of single species to determine diversity. Shannon-Wiener diversity values ranged from 3.29 to 4.53.

Pielou's Evenness index is another measure of diversity that is commonly used in conjunction with the Shannon-Wiener index. Evenness is a measure of the observed diversity in a sample as a proportion of the maximum possible diversity. Evenness values close to 1.0 represent a sample composed of several different species while low evenness values indicate a sample composed of only a few dominant species. Pielou's Evenness values ranged from 0.48 to 0.67 and were well-correlated with the Shannon-Wiener values.

Swartz's Dominance index is the third diversity indicator, which measures the minimum number of species whose abundance comprises 75% of the total sample abundance. Low values indicate a sample with little diversity while higher numbers indicate a sample comprised of many species. Swartz's Dominance values ranged between 3 and 13 species. Table 2 shows the species that comprises the Swartz's dominance list for each station.

The benthic community at all seven stations is dominated by three species: the ostrocod *Euphilomedes producta*; the clam *Parvilucina tenuisculpta*; and the snail *Alvania compacta*. These three species comprise 57 to 76% of the total abundance at all seven stations.

Since both benthic infauna and epifauna were used to calculate all of the indices, is not possible to compare these indices to other studies in which epifauna may have been removed to achieve specific project goals. The calculation of these baseline benthic community indices, compromised of both benthic infauna and epifauna, will provide reference data, against which post-construction monitoring benthic indices may be compared.

Future Sampling and Analytical Activities
Post-construction, benthic community monitoring events in the construction trench zone will occur in October 2009 and 2011. These monitoring events will assess the recovery of the benthic community in the impacted area approximately one and three years after completion of construction activities. A final report, assessing recovery of the benthic community at the Brightwater marine outfall construction trench will be issued in 2012.

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Should you have questions regarding any of the information contained in this technical memorandum, please contact me.

Sincerely,

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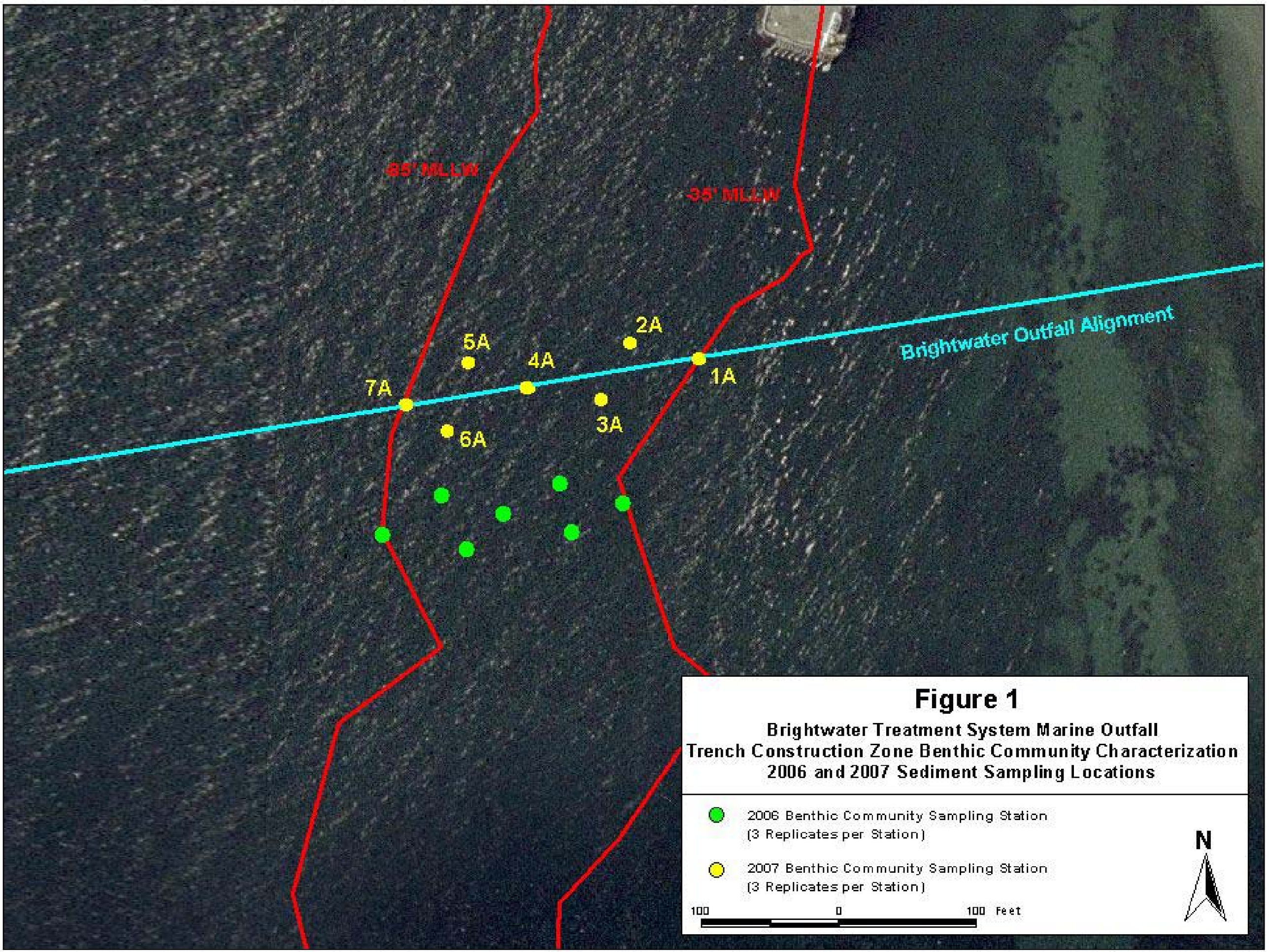

Figure 1

Brightwater Treatment System Marine Outfall
Trench Construction Zone Benthic Community Characterization
2006 and 2007 Sediment Sampling Locations

Table 1
Sampling Coordinates
Brightwater Treatment System Marine Outfall
Construction Trench Corridor Monitoring

Sampling Coordinates[1] - October 2007

		Grab 1		Grab 2		Grab 3		Average		Prescribed[3]		Offset (feet)	
Station	**Depth[2]**	**Northing**	**Easting**	**Northing**	**Easting**	**Northing**	**Easting**	**Northing**	**Easting**	**Northing**	**Easting**	**Northing**	**Easting**
BWT-BTHC-1A	30	288183	1255493	288182	1255494	288180	1255493	288182	1255493	288180	1255495	2	2
BWT-BTHC-2A	45	288189	1255444	288193	1255446	288191	1255444	288191	1255445	288191	1255445	0	0
BWT-BTHC-3A	47	288150	1255423	288150	1255422	288151	1255427	288150	1255424	288150	1255424	0	0
BWT-BTHC-4A	66	288158	1255369	288159	1255372	288159	1255372	288159	1255371	288159	1255371	0	0
BWT-BTHC-5A	80	288171	1255327	288177	1255331	288177	1255331	288175	1255330	288177	1255327	2	3
BWT-BTHC-6A	82	288129	1255314	288129	1255314	288129	1255310	288129	1255313	288127	1255312	2	1
BWT-BTHC-7A	93	288148	1255285	288148	1255285	288148	1255285	288148	1255285	288146	1255282	2	3

[1]State Plane Coordinate System NAD83 Washington North (4601)
[2]Feet referenced to mean lower low water (MLLW)
[3]Sampling and Analysis Plan Addendum - King County 2007

Table 2

2007 Benthic Community Analysis

Brightwater Treatment Facility Marine Outfall

Construction Trench Corridor Monitoring

Physical Sediment Properties	BWT-BTHC-1A	BWT-BTHC-2A	BWT-BTHC-3A	BWT-BTHC-4A	BWT-BTHC-5A	BWT-BTHC-6A	BWT-BTHC-7A
% Fines	2.6	1.7	1.2	1.2	1.7	1.2	1.8
% Clay	0.7	1.1	0.6	0.6	1.1	1.2	1.2
% Silt	1.9	0.6	0.6	0.6	0.6	0	0.6
% Sand	95.6	97.6	96.9	95.8	98.1	94.9	94.7
% Gravel	0.9	0.5	1.1	0	0.3	0.5	0.6
TOC (mg/Kg DW)	1,430	1,200	1,230	1,180	1,800	1,590	1,920
TOC (% DW)	0.14	0.12	0.12	0.12	0.18	0.16	0.19
Depth (ft MLLW)	30	45	47	66	80	82	93

Benthic Indices	BWT-BTHC-1A	BWT-BTHC-2A	BWT-BTHC-3A	BWT-BTHC-4A	BWT-BTHC-5A	BWT-BTHC-6A	BWT-BTHC-7A
Total Abundance	**1,397**	**1,612**	**1,561**	**1,835**	**2,106**	**1,613**	**885**
Annelida Abundance	116	111	118	142	238	205	148
Crustacea Abundance	568	627	586	424	273	304	201
Mollusca Abundance	689	855	835	1,249	1,565	1,071	512
Miscellaneous Abundance	24	19	23	20	30	33	24
Total Richness	**93**	**92**	**91**	**93**	**122**	**120**	**105**
Annelid Richness	34	34	31	36	55	47	43
Crustacea Richness	26	25	25	21	25	28	22
Mollusca Richness	24	24	25	25	29	30	28
Miscellaneous Richness	9	9	10	10	13	15	12
Total Biomass	**7.95**	**8.22**	**7.97**	**11.18**	**10.34**	**9.19**	**6.02**
Annelida Biomass	1.48	1.27	1.45	2.75	2.98	2.70	2.20
Crustacea Biomass	1.41	1.58	1.60	1.76	0.83	1.14	0.42
Mollusca Biomass	4.86	5.26	4.80	6.56	6.30	5.21	3.30
Miscellaneous Biomass	0.21	0.12	0.12	0.11	0.23	0.14	0.10
Shannon-Wiener Diversity Index	**3.97**	**3.48**	**3.55**	**3.29**	**3.33**	**3.89**	**4.53**
Pielou's Evenness Index	**0.61**	**0.53**	**0.54**	**0.50**	**0.48**	**0.56**	**0.67**
Swartz's Dominance Index	**7**	**4**	**4**	**3**	**4**	**8**	**13**

Dominant Species

BWT-BTHC-1a

Euphilomedes carcharodonta (C)
Parvilucina tenuisculpta (M)
Alvania compacta (M)
Tellina modesta (M)
Nutricola lordi (M)
Rochefortia tumida (M)
Aoroides inermis (C)

BWT-BTHC-2a

Euphilomedes carcharodonta (C)
Parvilucina tenuisculpta (M)
Alvania compacta (M)
Rochefortia tumida (M)

BWT-BTCH-3a

Euphilomedes carcharodonta (C)
Parvilucina tenuisculpta (M)
Alvania compacta (M)
Nutricola lordi (M)

BWT-BTHC-4a

Alvania compacta (M)
Parvilucina tenuisculpta (M)
Euphilomedes carcharodonta (C)

BWT-BTHC-5a

Alvania compacta (M)
Parvilucina tenuisculpta (M)
Euphilomedes carcharodonta (C)
Rochefortia tumida (M)

BWT-BTHC-6a

Alvania compacta (M)
Parvilucina tenuisculpta (M)
Euphilomedes carcharodonta (C)
Rochefortia tumida (M)
Prionospio steenstrupi (A)
Tellina modesta (M)
Pododesmus macrochisma (M)
Mediomastus californiensis (A)

BWT-BTHC-7a

Alvania compacta (M)
Parvilucina tenuisculpta (M)
Euphilomedes carcharodonta (C)
Rochefortia tumida (M)
Nutricola lordi (M)
Rhepoxynius abronius (C)
Prionospio steenstrupi (A)
Tellina modesta (M)
Mediomastus californiensis (A)
Pododesmus macrochisma (M)
Glycinde armigera (A)
Byblis millsi (C)
Diopatra ornata (A)

Appendix A

Benthic Taxonomy and Biomass Data - October 2007

Brightwater Treatment Facility Marine Outfall
Construction Trench Corridor Monitoring

Station	BWT-BTHC-1A			BWT-BTHC-2A			BWT-BTHC-3A			BWT-BTHC-4A			BWT-BTHC-5A			BWT-BTHC-6A			BWT-BTHC-7A		
Replicate	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
ANNELIDA																					
Ampharete acutifrons														1			2	1			1
Ampharete cf crassiseta													1					1			
Ampharete sp															1	1	2	1			
Ampharetidae													2								
Anobothrus gracilis												1		2	1			1			
Aricidea lopezi				1	1			1	3	1	1			1					2	1	1
Aricidea ramosa												1	1					2		2	
Aricidea sp																1					
Aricidea wassi	2		6	7	2	2	7	2	13	4	6	5		3	2	2	2	2	1	5	
Asabellides lineata													4	2							
Axiothella rubrocincta	3	1	3		4	2		3	1		1	1	1			2	1	2			6
Boccardia pugettensis																		1		1	
Capitella capitata Cmplx	2	1	1												1					1	
Capitellidae														1							
Caulleriella pacifica	2	4	8	6	3	6	2	4		2	23	5	14	7	7	9	8	10		3	3
Chaetozone acuta													1	2		2	1				1
Chaetozone sp					1							1		2	1	2					1
Chaetozone sp N2	2			2	2	2	3	5	12	2	1	1		1	4	3	1	2	3	2	
Chone magna						1			1												
Cirratulidae																1					
Cirratulus sp													2								2
Diopatra ornata	2	4	4	2	5	9	10	4	1	5	13	7	10	15	12	9	16	13	6	11	6
Dipolydora cardalia		1																			
Dipolydora socialis											1		2	2		4		4			1
Dorvillea longicornis															1						
Dorvilleidae juv		1																			
Eteone sp			2								1	1	2	2	2	3	1		1		3
Euclymene cf zonalis																		1			
Euclymeninae	3	6		3	6	7	7		5	5	3	2	4	1	3	4	3	3	2	4	3
Eudistylia sp																					1
Eudistylis catherinae																1					
Eulalia sp N1		1	1			2	2				3	1	3	6	1	2	5	3	1	1	4
Eumida longicornuta	1		4		1	4			1	2	1		11	5	1	6	3	7	2		4
Eusyllis blomstrandi													2								
Eusyllis habei						1							1	1							3
Exogone dwisula												1									
Exogone lourei					1								3	1	1	1	1	4			4
Galathowenia oculata														2							
Gattayana cirrosa													2							1	3
Glycera americana	1		1			2	1			1				1			1				
Glycera nana	1	2					1		1	2	3	3	3		2	1	1			2	1
Glycera sp juv					3																
Glycinde armigera	12	19	10	16	14	8	12	12	16	15	7	2	5	5	11	5	9	11	10	10	8
Glycinde picta										1	2		3	2	1	1	2	1			1
Glycinde sp juv	2	1	5			5	2	9	3	4	6	14	8	11	15	12	11	5	1	11	5
Harmothoe imbricata			1			3	1				1		4	2	1	2	3	1	2		1
Harmothoe multisetosa													3		1					2	1
Hesionidae juv		1																			
Hirudinea															1						
Lanassa venusta						1															
Leitoscoloplos pugettensis	1	7		2	1	1	3			5	3		5	1	9	5	5	3	1	3	1
Lepidasthenia longicirrata																					1
Lumbrineris californiensis			1	2		1					2		12	3	1	6	10	4	1		3
Magelona longicornis	2	1				5	4	5	6	2	1	3	6	3	1	2	3	11	4	2	10
Magelona sacculata				2																	
Magelona sp juv			1																		
Maldanidae juv	2																				
Malmgreniella bansei				1					1		1							1		1	2
Malmgreniella macginitie													2	1	3	2					1
Mediomastus californiensis	10	24	1	10	4	4	10	7	7	18	32	8	27	27	13	28	10	16	9	19	14
Micropodarke dubia	1	2	2			1	4	1		2	4	1	5	1		2	1				1
Monticellina serratiseta												1									
Neosabellaria cementarium			1			1		1					1					2	1	1	1
Nephtys caeca											1										
Nephtys caecoides			1		1		2						3			2					
Nephtys ferruginea		2	3	2	3	4	2	3	5	2	5	5	9	7	1	3	6	8	9	1	5
Nephtys sp	3	2	3	1	3	1	1	1	1			2	4	4	3	1	4	3	1	2	4
Nereis procera	3	2	2	6	3	7	4	1	3	1	4	1	2		1			3	1		
Nicolea zostericola														2	1			2			1
Notomastus hemipodus												1	1								
Notomastus latericeus	2	3		5	1	3		4	4		1	1	4		2	1	2	2	3		2
Notomastus sp				1			2								1						
Odontosyllis phosphorea										1			2	1							1
Oligochaeta	2	1		2	1	2	7	2	5	1	1	2			3	1	1	1	2	1	
Onuphidae juv				1		1		2	1												
Onuphis elegans	5	1	3	2	1	3	3	5		8	1	1	2	1	2		2	2	1	2	1
Onuphis iridescens									1				1								
Onuphis sp juv		1	1			4				2		2		3			4	1		1	
Ophelina acuminata														1							
Ophiodromus pugettensis														3	2		1				
Owenia fusiformis							1							1		1					
Owenia sp		1											1								
Paleanotus bellis		4	3			3				1	1	1	1	2		1		2	1	1	1
Parandalia fauveli								1													1
Pectinaria granulata		3	8	2		5	5	10	6	2	7	3	21	28	16	23	11	8	2	4	14
Pherusa plumosa													1								
Pholoe minuta			1				1						3	1	1	3					1
Pholoides asperus		1	3		1			1		1	1		13	13		6	13	5	6	1	10
Phyllochaetopterus prolifica		3											2		2					3	4
Phyllodoce cuspidata																	1				
Phyllodoce groenlandica						1														1	
Phyllodoce hartmanae											1										
Phyllodoce longipes	1	1		1	1								1			1		1			
Phyllodoce sp juv					2			1													
Phyllodoce williamsi		1																			
Pista elongata															1		3				
Pista estevanica													1		1					1	
Pista sp juv				1			1	1	1	1		1									
Platynereis bicanaliculata	9	9	36	2		25	15	6	2	10	16	10	24	15	12	7	11	15	4	8	7
Podarkeopsis glabrus													4	1	2					2	
Polycirrus californica	2	2		2	1		1	1		3	1	1	2	1	1		1	1	1		3
Polycirrus sp		1	1	1		1	1			1			1	3	5	1	4	2	1	2	5
Polycirrus sp A				1	1	1					2				1		1		4		1
Polycirrus sp V							2	4	2		3	2					2		2		1
Prionospio lighti						1					2		2					1			
Prionospio multibranchiata		2											1	3			1				
Prionospio sp				1																	
Prionospio steenstrupi	5	14	5	12	10	16	10	6	13	15	20	23	35	16	16	29	36	19	16	17	25
Protodorvillea gracilis			2			1				1		1	4						5		
Schistocomus hiltoni																		1			1
Scionella japonica											1		2				1	1			
Scoloplos acmeceps			1						1												
Scoloplos sp			1																		
Sigalion spinosus					2										1					1	
Sphaerodoropsis sphaerulifer		1		2				2					3	6		4	1	3	1	2	1
Spio limicola		1																			
Spiochaetopterus pottsi	1	2			2				1			1		1				1			
Spiophanes berkeleyorum			1			1							1	2					1		
Sthenelais berkeleyi							1				2		1	1		2	1	1			2
Sthenelais sp juv														1		1					
Streblosoma bairdi			1																		
Syllidae							1														
Tenonia priops	2				3	1		1	1	2					1				1		

Appendix A

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Station	BWT-BTHC-1A			BWT-BTHC-2A			BWT-BTHC-3A			BWT-BTHC-4A			BWT-BTHC-5A			BWT-BTHC-6A			BWT-BTHC-7A		
Replicate	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Terebellidae juv						1															
Thelepus setosus																					1
Typosyllis caeca	3									1			2		5	3	1	1	4		7
Typosyllis cornuta																			1		
Annelida Abundance	**87**	**134**	**128**	**99**	**84**	**150**	**129**	**106**	**118**	**124**	**186**	**117**	**304**	**231**	**178**	**209**	**210**	**197**	**114**	**133**	**197**
Annelida Richness	**29**	**38**	**35**	**30**	**30**	**41**	**33**	**30**	**29**	**33**	**40**	**36**	**62**	**54**	**49**	**46**	**46**	**50**	**37**	**37**	**55**
Annelida Biomass	**1.33**	**1.28**	**1.84**	**0.65**	**1.14**	**2.01**	**1.80**	**1.66**	**0.89**	**2.78**	**4.06**	**1.42**	**3.51**	**2.46**	**2.96**	**1.91**	**4.01**	**2.17**	**2.09**	**1.62**	**2.89**
CRUSTACEA																					
Americhelidium rectipalmum			1		1	1	1	1					1	3	1	1	1	1			
Americhelidium setosum								5	1				1								
Americhelidium shoemakeri	3	4	7	1		2	1	1	5	2			1	1		1	1	2	1		1
Americhelidium variabilum					1		1														
Ampelisca agassizi																		2			
Ampelisca careyi																1					
Ampelisca cristata					1			1													
Ampelisca hancocki																				1	
Ampelisca lobata														1			1				
Ampithoe sp.			2				1	1													
Aoroides columbiae			3													1					
Aoroides inermis	22	25	43		9	14	41	18		4	7	2	2	1		5		5	2		
Aoroides sp.	5	1	3		2	1	1	1			1	5	1	2		1				3	3
Balanus crenatus												1				1					
Byblis millsi		1	1		1	3		1	2	5	4	1	1	20	3	15	4	11	13	8	5
Campylaspis hartae										1			1			1			3	1	1
Cancer oregonensis		2	2			1					1		1	1				1	1		
Cancer productus			1													1				1	
Caprella kennerlyi				1													2				
Caprellidae juv.	1		1																		
Cheirimedeia sp.				1	1	1		1												1	
Crangon alaskensis							1	1													
Crangonidae				1				1				1		1		1		1			
Crassicorophium crassicorne	1				2	1								1							1
Cylindroleberididae				4	2	1		2	5	3	8	2		1	1	1	1	3	3	3	1
Desdimelita desdichada		1	4		1			2			3	5	7	6	3	1	1	15	3	2	1
Diastylis santamariensis			2		5	4	5	2					1	1	1				2		2
Dyopedos sp.																	1				
Eobrolgus chumashi	2	4	2	1					1											1	
Erichthonius cf. brasiliensis	1	6				5	3									2					
Eualus sp. juvenile			16	1		12	5			1	3		13	5		6	15	2			2
Eualus subtilis													2			1	13				
Euphilomedes carcharodonta	435	368	498	437	521	649	421	459	592	397	298	323	203	212	170	224	137	252	118	136	146
Foxiphalus similis					1									2			1				
Foxiphalus sp.																1					
Gammaropsis ellisi														1							
Gammaropsis thompsoni	5	3	10		1	12	11	7	1	2	5	10	4	1			7	19	1		
Haliophasma geminatum											1		1							1	
Heterophoxus conlanae													1	1			1				1
Hippomedon coecus																					1
Leptochelia dubia	9	23	9	6	2	5	3	7	3	10	6	5	8	5	4	8	7	12	1	3	3
Lophopanopeus bellus											1										
Mesocrangon munitella	1	1	19		2	10	9			5			4	5	2	2	6	5	1	6	
Nebalia sp.						1															
Neotrypaea sp.	1			2		1	2	1		3	1		1	1		1	2		1	1	2
Opisa tridentata																		2		1	
Orchomene decipiens											2	1	2		3		5	6	3		
Orchomene pacificus	4	3	1	7	5	4	1	5	2	12	5	9	1	2	4	2		2	4	1	3
Orchomene pinguis	17	9	4	1	2	2			2			1		2						6	
Oregonia gracilis														2			1				
Pachynus barnardi																			1		
Pacifoculodes sp.			1	1				2	1		2	2	3				2	1	1		
Pagurus armatus							1					2									
Pagurus sp.			1		1	3	1			1	3	2	1	1		3	3	1	3	1	
Pardalisca tenuipes							1														
Photis bifurcata									1												
Photis brevipes		3	7		1	5	3				1		1								
Photis spp.	4	2	1	1			2	1	1												
Pinnixa occidentalis complex											1			5			4	1	1		1
Pinnixa schmitti													2								
Pinnixa sp.	1		1				1					2	1		3	2					
Pleurogonium rubicundum	1					1		1						1				1			
Pleusymtes sp.	2	4	3	6	1	1	4	5	1	3	2	3	1	1				2		1	2
Pontogeneia rostrata			2			1	1														
Protomedeia prudens	20	13	8	10	9	4	7	9	7	4	5	6		1	2		1	5	2	3	
Rhacotropis sp.															1						
Rhepoxynius abronius	3	4	4	12	24	9	11	13	15	29	13	13	5	29	16	12	6	14	26	20	18
Rhepoxynius dabouis	2			1			1		2												
Rutiderma lomae		1									1					1	1			1	1
Spirontocaris prionata																	2	1			
Themisto pacifica	1					1		3	1		1							1	1		
Thorlaksonius sp.	1						1														
Tiron biocellota				1								1									
Tritella pilimana		1	4	1				1									2	1			
Westwoodilla tone	2	10	10	9	5	19	9	4	9	5	3	11	6	9	4	9	1	9	4	4	6
Crustacea Abundance	**544**	**489**	**671**	**505**	**601**	**774**	**550**	**556**	**652**	**487**	**378**	**408**	**277**	**325**	**218**	**305**	**229**	**378**	**196**	**206**	**201**
Crustacea Richness	**24**	**22**	**31**	**21**	**24**	**29**	**29**	**28**	**19**	**17**	**25**	**22**	**29**	**31**	**15**	**27**	**28**	**28**	**23**	**23**	**20**
Crustacea Biomass	**1.31**	**1.13**	**1.80**	**1.17**	**1.76**	**1.80**	**2.04**	**1.28**	**1.49**	**0.95**	**1.03**	**3.30**	**0.97**	**1.14**	**0.39**	**1.25**	**1.15**	**1.03**	**0.50**	**0.43**	**0.34**
MOLLUSCA																					
Acila castrensis		1																		1	
Acteocina sp.																1					
Aeolidiacea sp.			2			3		1	2				2				2	2		1	
Alvania compacta	7	222	120	27	25	814	554	255	132	479	1156	502	539	2358	409	444	1063	437	106	82	369
Alvania rosana	1											1	1	3	4	2	1				2
Astyris gausapata		1	1	3		3	4	8	4	6	3	8	1	7	6	1	2	6	3	2	2
Axinopsida serricata	6	3	4	11	2	10	4	4	5	5	7	5	4	10	9	7	5	6	7	10	5
Cardiomya pectinata																		1			
Chlamys hastata													3	5	1		1	1	1	1	2
Clincocardium nuttallii	11	9	17	18	18	22	13	23	29	8	6	7	1	1	1	1	2	3	1	3	
Clinocardium sp. juv.																			1		
Crepipatella dorsata		1	2															1			1
Cryptonatica affinis		1	2		1						1		2		1		3	2		2	
Cyclostromella concordia																			1		
Cylichna alba				2	1	2	1		2	1	1	1	1	1		1	3	1			
Cylichna attonsa																			1	5	3
Ennucula tenuis													1								
Euspira lewisii	1																				
Hiatella arctica	2	12	9	1		4	1			2	2	2	9	12	2	1	3	4	3		8
Kurtzia arteaga												1			1					1	1
Lacuna vincta			2			3	1	1	1					1	1					1	1
Lirularia lirulata	2		2			2	1		1	2		1		1			3	1			1
Lucinoma annulatum	2			5	4	4	4	2	3	2	3	8	5	6	6	3	1	3	1	4	3
Lyonsia californica	2	4	1	5	5	16	10	12	25	7	8	14	11	12	6	5	8	18	6	7	7
Macoma nasuta	7	2	8	2		3	3	4	4	2	3	4	7	3	3	3	3	9	2	2	2
Macoma sp. juv.		3	4			5	3	1	1		3		13	5	3	11	8	5	1	1	1
Macoma yoldiformis	1	1		2	2				2		2	2	13	6	6	7	3	4	4	3	9
Mactridae sp.	11	6	9	6	4	15	2	6	13	1	1	1	2		1			2	1	1	1
Margarites pupillus						2	1	1			4		14	9	1	6	29	6	2	5	2
Melanochlamys diomedea			1	1		1															
Modiolus modiolus							1	1					1	8		4		2		2	2
Modiolus sp. juv.						2							2		2		7		2		
Mya arenaria			3	2	3	4	4	5	8	1	2	2	1		2	1	1	1		1	
Mya sp. juv.																1					
Mytilus sp. juv.		1	4		1	3	2		1			2		4				1			1
Nassarius mendicus			1						2			1					2	2			
Neaeromya rugifera														1							

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Station	BWT-BTHC-1A			BWT-BTHC-2A			BWT-BTHC-3A			BWT-BTHC-4A			BWT-BTHC-5A			BWT-BTHC-6A			BWT-BTHC-7A		
Replicate	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Nucella sp.			1																		
Nutricola lordi	55	53	57	30	24	37	35	33	61	37	27	53	16	19	13	19	15	15	31	33	13
Odostomia spp.								1			3		1	4		6	1		5		2
Olicella baetica				2	4	1	2			2	1	1		1				1			
Onchidoris bilamellata			1																		
Pandora filosa								1	2			1			2	1	1	1		2	
Panopea abrupta														1							
Parvilucina tenuisculpta	400	279	297	345	330	469	383	322	310	317	416	296	235	147	353	238	167	264	171	217	167
Pectinidae sp.						1					2	1		2		1	1				1
Pododesmus macrochisma	3	13	54	1		53	13	3	1	7	35	19	44	37	16	12	11	39	14	5	12
Protothaca staminea	2		3	3	2	3	7	1	3		1	1						1	1	2	
Retusa sp.			1																		
Rochefortia tumida	56	39	48	36	33	42	35	18	25	47	38	30	63	75	49	90	37	53	20	38	50
Solamen columbianum		1	2	2	2	1	1			1			1	4	3	2		1		1	1
Solen sicarius	3	3	6	2	5	7	1	1	5	2	1	7			2			4			
Tellina modesta	53	43	83	21	24	16	18	14	41	50	30	40	13	24	20	14	10	41	15	20	12
Tellina nuculoides																					1
Turbonilla sp.	9	19	18	8	4	5	3		1	1	4	1	1		3	1	4		4	2	4
Mollusca Abundance	**634**	**717**	**763**	**535**	**494**	**1553**	**1107**	**718**	**684**	**980**	**1760**	**1012**	**1007**	**2767**	**926**	**883**	**1397**	**938**	**404**	**455**	**686**
Mollusca Richness	**20**	**22**	**30**	**23**	**20**	**30**	**27**	**23**	**26**	**21**	**26**	**28**	**29**	**29**	**28**	**27**	**29**	**33**	**25**	**29**	**30**
Mollusca Biomass	**4.89**	**6.28**	**3.40**	**4.78**	**3.99**	**7.01**	**5.87**	**4.22**	**4.30**	**5.17**	**9.74**	**4.76**	**5.54**	**6.06**	**7.30**	**4.01**	**6.04**	**5.59**	**3.14**	**3.36**	**3.41**
MISCELLANEOUS																					
Amphiodia urtica/periercta																			1		
Amphipholis squamata													3	5		2	8	3	1	2	1
Amphiporus spp.			1				1				1			3	2	1	1	1			
Anoplodactylus sp.										1											
Arhynchite pugettensis													1								
Asteriidae sp.							1														
Carinoma mutabilis							1		1	1		1			1						
Cerebratulus spp.			1																		
Crossaster papposus																1	3				
Dendraster excentricus					2				1												
Dendrochirotida spp.		1	1								2		1	2						1	
Echinoidea sp.							1														
Edwardsia sipunculoides	1			1	1	2		2	2		2	1	4	1	1	2	1	2	2	1	3
Eupentacta quinquesemita																	1				
Euphysa ruthae				3																	
Euphysa sp.	1																				
Hirudinea sp.														1							
Leptosynapta transgressor																		1			
Lineidae spp.	3	3	5	1	1	3	3	4		3	3		4	3	3	2	3	2	1	1	2
Micrura wilsoni						1											1				
Molgula sp.							1		1												
Nematoda		5	6	1		5		2	2	3	2	5	1	4		3	2	4	1	2	3
Nemertea sp.															1						
Nynantheae spp.	1								2					1					1		
Ophiura sp.																			1		
Ophiurida spp.	1	1		1		1	4	1	1	1	2	3	1	1	2		5	3		3	1
Pachycerianthus fimbriatus																			1		
Paleonemertea sp. A	11	3	6	6	2	10	1		16		5	3	4	2	1	5	1	7	3	4	5
Pentamera lissoplaca						1		1		1	1		7		1	2	2	1			1
Pentamera populifera					1														1		
Pentamera sp.																		1			
Pentamera sp. B of Lambert												1	2				1	1			1
Phoronis sp.	1			1	2				2			1	1	2		2	1	1	1		2
Phoronopsis harmeri																					1
Polycladida spp.			4									1	1								
Ptilosarcus gurneyi		1	2	3		3	2	4	2	2	1	1	2	4	1	2	4	1	1	4	9
Styela gibbsii																	1				
Tetrastemma dorsale							1														
Tetrastemma spp.			1	1					1	6	1		4	5	3	3	3		2	2	2
Thysanocardia nigra			1			1		3		1			2			2	1	2	1	2	
Tubulanus pellucidus/polymorphus	2			1	2	1		2	2	2		1						1	1		
Tubularia spp.	1	1																			
Tubulariidae sp.																	1				
Zygonemertes virescens		2	4										2				1				
Miscellaneous Abundance	**22**	**17**	**32**	**19**	**11**	**28**	**16**	**19**	**33**	**21**	**20**	**18**	**40**	**34**	**16**	**27**	**41**	**31**	**19**	**22**	**31**
Miscellaneous Richness	**9**	**8**	**11**	**10**	**7**	**10**	**10**	**8**	**12**	**10**	**10**	**10**	**16**	**13**	**10**	**12**	**19**	**15**	**15**	**10**	**12**
Miscellaneous Biomass	**0.21**	**0.04**	**0.33**	**0.22**	**0.09**	**0.05**	**0.10**	**0.06**	**0.19**	**0.21**	**0.08**	**0.04**	**0.48**	**0.15**	**0.07**	**0.09**	**0.24**	**0.08**	**0.08**	**0.07**	**0.14**