

# **Elliott Bay/Duwamish Restoration Program: Intertidal Habitat Projects Monitoring Report 2007 Report**



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**Prepared for the Elliott Bay/Duwamish Restoration Program Panel**

**By: U.S. Fish and Wildlife Service, Western Washington Fish and Wildlife  
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# **Elliott Bay/Duwamish Restoration Program: Intertidal Habitat Projects Monitoring Report**

## **2007 Report**

**Prepared By:  
U.S. Fish and Wildlife Service  
Western Washington Fish and Wildlife Office**

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## **CONTRIBUTORS**

The Elliott Bay/Duwamish Restoration Program: Intertidal Habitat Projects Monitoring Report, 2007 Report, was prepared by personnel at the Western Washington Fish and Wildlife Office, U.S. Fish and Wildlife Service, Lacey, Washington. This report was compiled and edited by Jeff Krausmann and incorporates the 2001, 2002, 2003, and 2005 Intertidal Habitat Projects Monitoring Reports and findings from the 2007 field season. Lead contributors for this report were Paco Rodriguez and Judy Lantor.

## **ACKNOWLEDGMENTS**

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Aerial photos of restoration sites courtesy of Google Earth and Microsoft Virtual Earth. Report photos provided by Judy Lantor, Jeff Krausmann, and Paco Rodriguez.

*Cover photo:* Goose excluder fencing on the Kenco Marine restoration site.

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## INTRODUCTION

This report contains monitoring data collected in 2007 and summary comparisons to data collected in 2001, 2002, 2003 and 2005 for three intertidal habitat restoration projects and their reference sites in the lower Duwamish River, Washington. This report also contains initial monitoring data for the Kenco Marine site. These data were collected as part of the Elliott Bay/Duwamish Restoration Program (EBDRP).

The EBDRP Panel was established as part of a 1991 Consent Decree between the City of Seattle, Metro (now King County Department of Natural Resources) (DNR), and natural resource trustees<sup>1</sup>. In 1990, a lawsuit was filed against the City of Seattle and Metro by the United States of America on behalf of the Department of Commerce's National Oceanic and Atmospheric Administration (NOAA) under its authority as a natural resource trustee provided by the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA). The lawsuit was filed to recover damages "for injury to, destruction of, and loss of natural resources resulting from releases of hazardous substances... into the environment in and around the Duwamish River and Elliott Bay, for the costs of restoring, replacing or acquiring the equivalent of the affected natural resources, and for the costs of assessing the damage to the affected natural resources" (U.S. vs. City of Seattle & Metro, 1991). Rather than engage in lengthy and costly litigation, the City of Seattle and Metro, along with the natural resource trustees, worked out a settlement agreement to establish a program to help restore and replace natural resources of Elliott Bay and the lower Duwamish River.

The EBDRP Panel of Managers is comprised of the City of Seattle, King County DNR, and the natural resource trustees. The projects' construction and monitoring are under the sponsorship and guidance of the EBDRP Panel and follow the Intertidal Habitat Projects Monitoring Program monitoring plan (EBDRP 2000). The monitoring plan describes a 10-year project with monitoring scheduled for Years 1-3, 5, 7, and 10. Physical success and biological success criteria were identified in the monitoring plan to determine if project restoration goals are being met. Five specific criteria were identified to be monitored under the physical success criteria and eight under the biological success criteria (Table 1). Data collection methods and post-construction site monitoring schedules were followed as described in the monitoring plan unless otherwise stated.

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<sup>1</sup> National Oceanic and Atmospheric Administration, U.S. Fish and Wildlife Service, Washington State Department of Ecology, the Muckleshoot Indian Tribe, and the Suquamish Tribe.

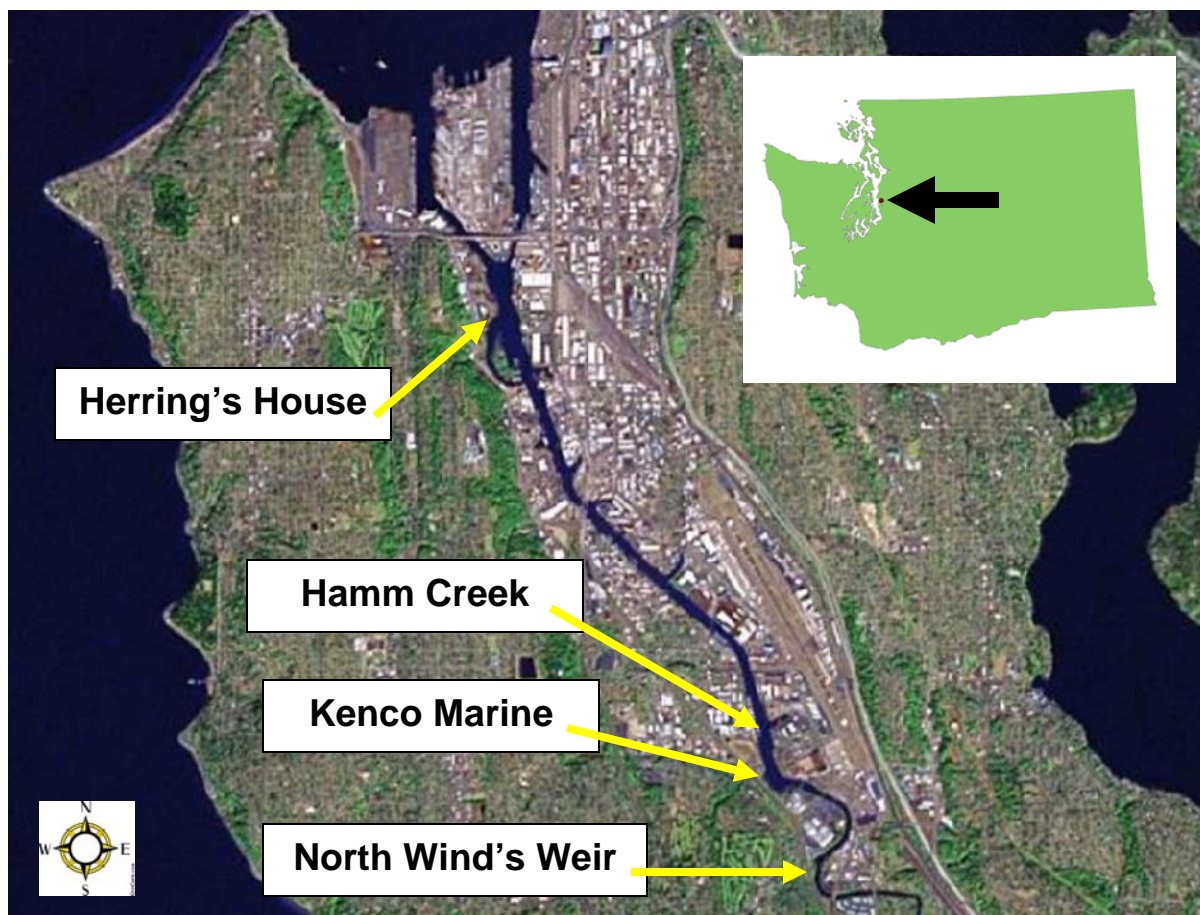


**Table 1. Physical and biological success criteria monitored at the Elliott Bay/Duwamish Restoration Program sites (EBDRP 2000).**

Physical Success Criteria	Biological Success Criteria
1. Intertidal Area	1. Marsh Vegetation Establishment - <i>Marsh vegetation area</i>
2. Tidal Regime	2. Marsh Vegetation Establishment - <i>Species composition</i>
3. Slope Erosion	3. Marsh Vegetation Establishment - <i>Plant vigor</i>
4. Sediment Structure**	4. Riparian Vegetation Establishment - <i>Areal extent/ invasive plant coverage</i>
5. Sediment Quality*	5. Riparian Vegetation Establishment - <i>Survival</i>
	6. Bird Use** - <i>Presence/absence</i>
	7. Fish** - <i>Access/presence</i>
	8. Invertebrate Prey Resource Production - <i>under separate report</i>

\* *for Herring's House site only - eliminated by EBDRP as a monitoring criteria in 2003.*

\*\* *discontinued after 2005.*



**Figure 1. Location of Duwamish River restoration sites in the lower Duwamish River.**



## Restoration Sites

Monitoring efforts in 2007 for the EBDP were conducted at the four restoration sites described in the monitoring plan (EBDP 2000). Hamm Creek, Herring's House (formerly Seaboard Lumber), North Wind's Weir (formerly Cecil B. Moses Park), and Kenco Marine restoration sites are shown in **Figure 1**. A marsh reference site was located directly across the river from the North Wind's Weir site. The reference site near Herring's House and Kellogg Island was dropped due to other enhancement work being conducted at that site. Hamm Creek and Herring's House restoration sites were constructed in 2000 and monitoring began in 2001. Construction on the North Wind's Weir restoration site began in December 2002 and monitoring commenced in 2003. The Kenco Marine site was constructed and initially planted in 2006 with some replacement planting in 2007. This was the first year of monitoring for this site.

## Reference Sites

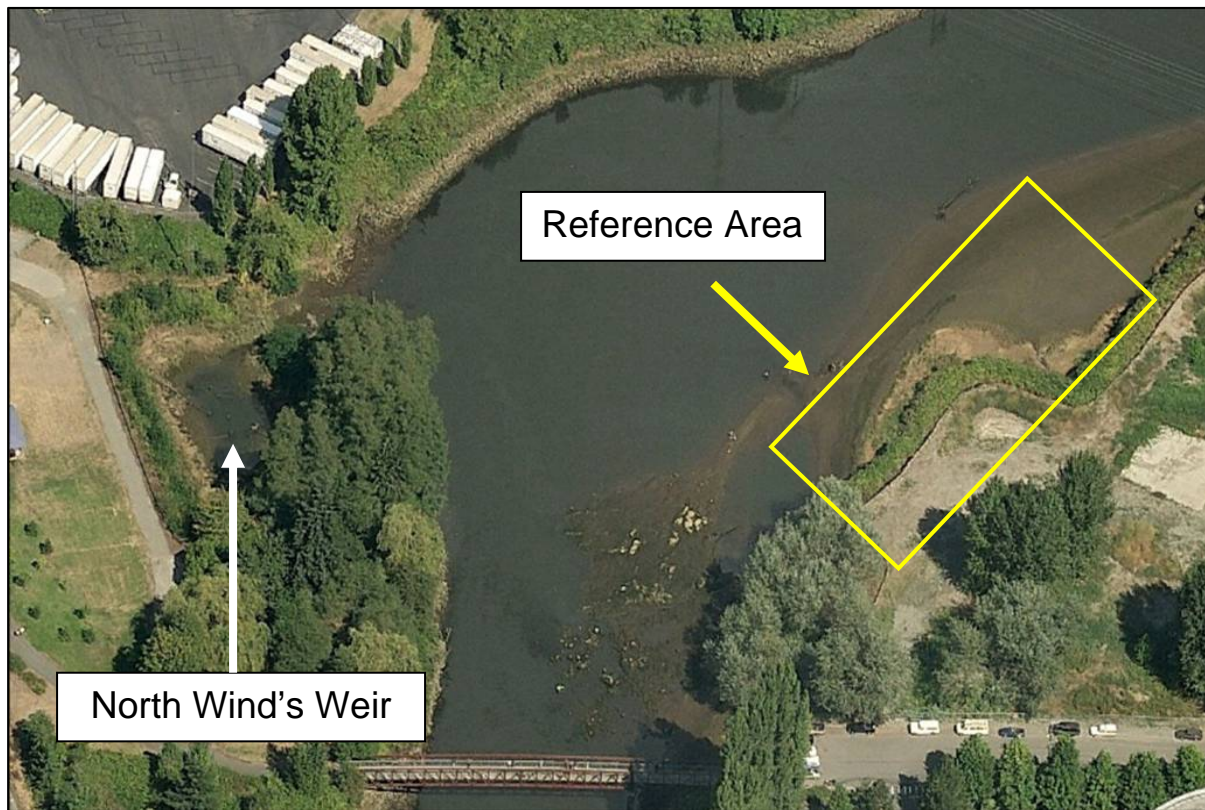
To gauge the success of biological criteria monitored at each restoration site, reference sites were selected for comparison. Due to the scarcity of 'natural' intertidal habitat remaining in the lower Duwamish River estuary, it was not possible to select reference areas containing all biological criteria to be measured. The location and number of reference areas vary for each restoration site based on the availability of similar sites and requirements for each monitoring criteria.

### Hamm Creek, Kenco Marine, and North Wind's Weir

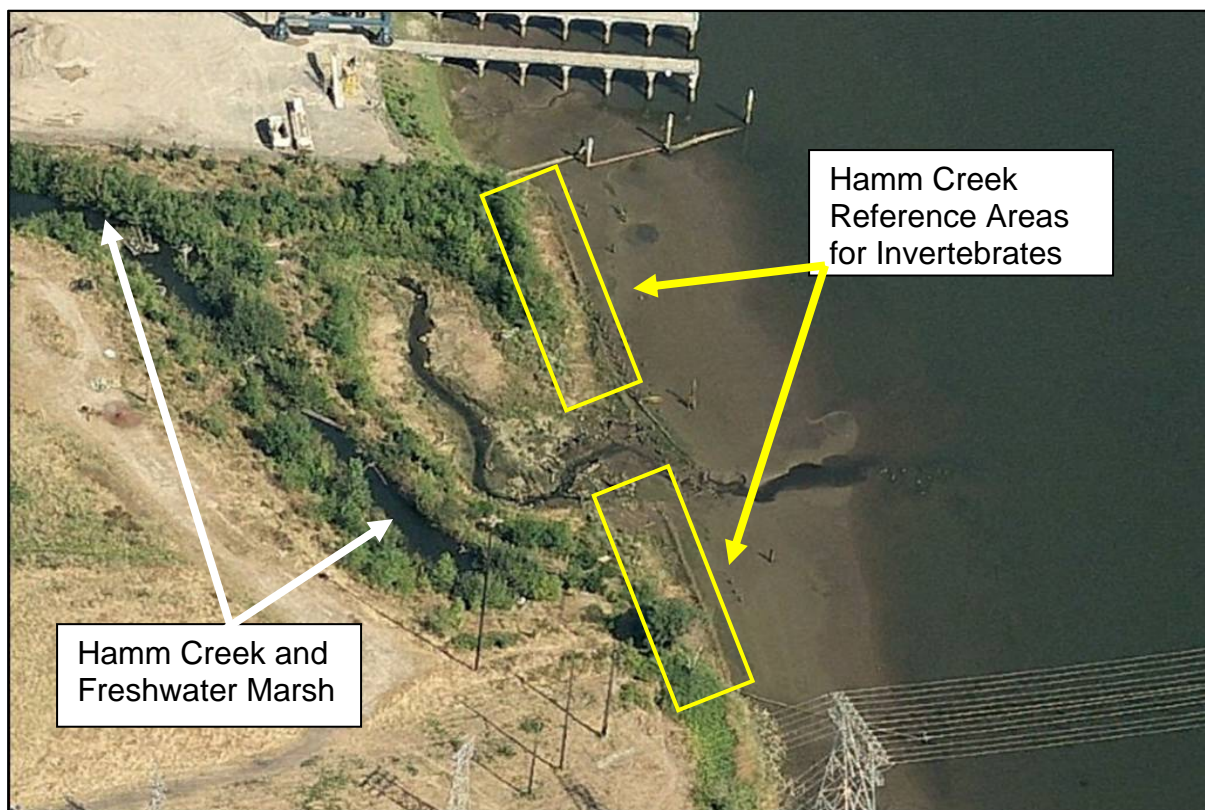
The Hamm Creek, Kenco Marine, and North Wind's Weir restoration sites are located at approximately river miles 5.5, 6.5 and 7, respectfully, and share the same reference site. The reference site, a small marsh on the eastern bank of the Duwamish River across from North Wind's Weir, was used as a reference site for marsh vegetation (**Figure 2**). This same site also served as the macroinvertebrate reference site for North Wind's Weir and Kenco Marine. The Hamm Creek reference site for macroinvertebrates was a small fringe marsh located along the Duwamish River shoreline adjacent to the restoration site (**Figure 3**).

### Herring's House

The Herring's House reference site previously used for comparison of marsh vegetation was eliminated from the 2007 sampling effort due to independent enhancement actions that occurred at the site (**Figure 4**). This site, a small area of naturally occurring Lyngby's sedge (*Carex lyngbyei*) and bulrush (*Scirpus validus*) located just upstream of the Herring's House restoration site, was still used in 2007 as a reference site for the macroinvertebrate sampling.

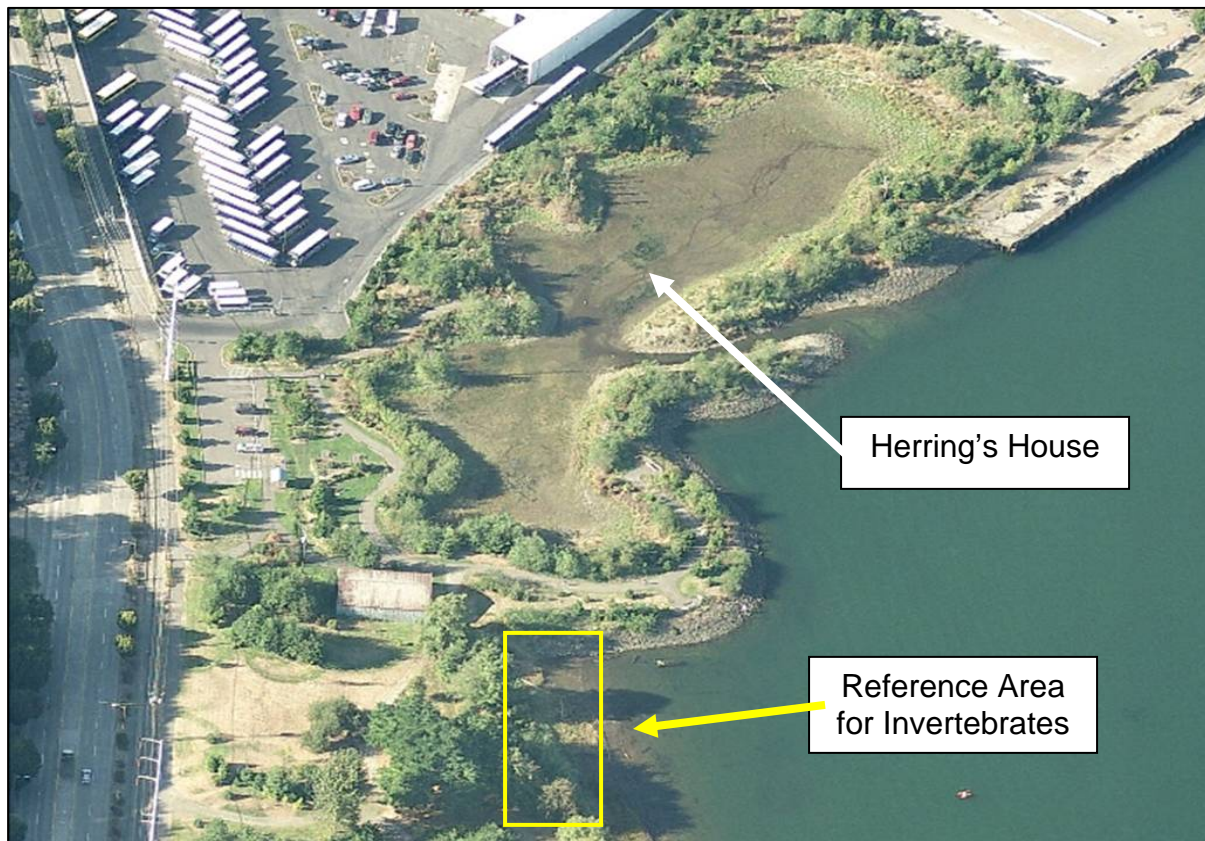


**Figure 2. Location of reference sites for Hamm Creek, Kenco Marine and North Wind's Weir.**



**Figure 3. Location of invertebrate reference sites for Hamm Creek.**





**Figure 4. Location of reference sites for Herring's House.**

## **PHYSICAL CHARACTERISTICS**

### **Intertidal Area (Physical Success Criterion 1)**

*Total restored area between an elevation of +12.0 ft Mean Low Low Water (MLLW) and -2.0 ft MLLW will be at least 90% of the target intertidal elevation for each site. Target intertidal area for the Hamm Creek is 4,047 m<sup>2</sup> (1.0 acre), Herring's House is 8,094 m<sup>2</sup> (2.0 acres), and North Wind's Weir is 4,047 m<sup>2</sup> (1.0 acre) (EBDRP 2000).*

With the approval of the EBDRP Panel, the Hamm Creek and Herring's House restoration sites were not monitored for intertidal area in 2007. Previously collected data indicated that these sites have been stable since construction (USFWS 2006). Intertidal area was collected at North Wind's Weir so there would be a consistent number of years for comparison between the sites. Baseline information was collected for the Kenco Marine restoration site.

It should be noted that in all prior monitoring years the total restored area for each of the sites was measured to different low-elevation boundaries. At Herrings House and North Winds Weir, total restored area was measured to the mouth of the inlet. At Hamm Creek the site was measured to the end of the taller boundary fence. For 2007, it was determined to not be economically feasible to collect this information for this site to -2.0 ft MLLW with the current project budget as defined in the physical success criterion due to an unanticipated level of effort required to collect the information. This may account for some of the discrepancy in achieving the performance criteria for some of the sites. These discrepancies may be more apparent for the Hamm Creek site, where the entire length of

the property boundary is adjacent to the riverbank and less so for Herring's House and North Wind's Weir where only a narrow channel of the site is adjacent to the riverbank.

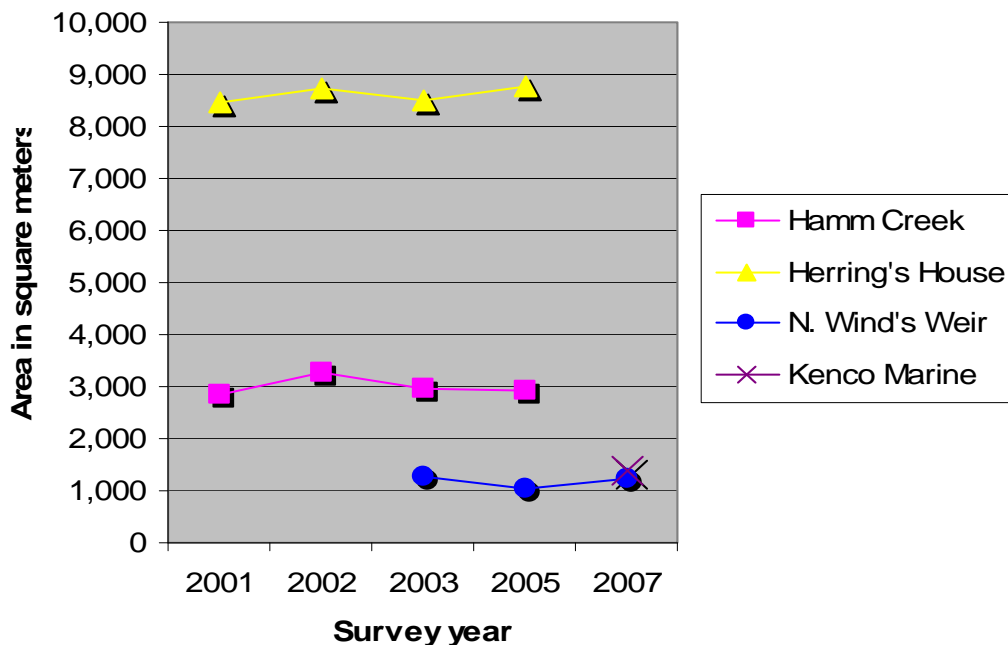
### Methods

In 2007 the intertidal area for the North Winds Weir and Kenco Marine sites were mapped by walking a continuous line along the perimeter of the intertidal area, outlined by flags placed at +12 ft MLLW based on tide, using a Trimble<sup>2</sup> GeoExplorer 3 Global Positioning System (GPS) ( $\pm 1$ -3 meter precision for each point with differential correction). The data points were downloaded, differentially corrected, and transferred to Geographical Information System (GIS), ArcView 3.1 software for analysis. Due to time and budget restraints, surveying the intertidal area using a Nikon Total Station was discontinued after 2003.

At North Wind's Weir, the survey area included the basin and the outlet channel to the Duwamish River. At Kenco Marine the survey area included the area between the suspected property lines (determined by the approximate location of the goose excluder fence to the north and the large sign at the southern end of the site) to approximately 10 ft beyond the goose excluder fence. This was estimated to be an elevation of approximately 2.3 ft MLLW.

### Results

The intertidal area estimates for the restoration sites are provided in **Figure 5** from the data in **Table 2**.



**Figure 5. Intertidal area measurements by survey year for restoration sites.**

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<sup>2</sup>For informational purposes only. In all instances, use of brand names in this report does not constitute endorsement by the U.S. Government.

**Table 2. GPS intertidal area measurements by survey year for restoration sites in the Duwamish River estuary.**

<b>Site</b>	<b>Area in m<sup>2</sup> (acres)</b>					<b>Mean</b>
	<b>2001</b>	<b>2002</b>	<b>2003</b>	<b>2005</b>	<b>2007</b>	
Hamm Creek	2,833 (0.7)	3,278 (0.8)	2,967 (0.7)	2,920 (0.7)	-	3,000 (0.7)
Herring's House	8,449 (2.1)	8,737 (2.2)	8,504 (2.1)	8,782 (2.2)	-	8,618 (2.1)
N. Wind's Weir	-	-	1,278 (0.3)	1,030 (0.3)	1,232 (0.3)	1,180 (0.3)
Kenco Marine	-	-	-	-	1,403 (0.3)	1,403 (0.3)

### Discussion

The intertidal area at North Wind's Weir has remained at 0.3 acre since construction. The small difference in estimated intertidal area from 2003 to 2005 (-248 m<sup>2</sup>) is likely due in part to random error and measurement error. From visual observations, the site continues to appear stable with no noticeable signs of erosion or deposition of sediments. The intertidal area estimate does not meet Physical Success Criterion 1 of 0.9 acre (90 percent of 1 acre) for the site. The monitoring plan (EBDRP 2000) states that the entire area of the North Wind's Weir site is 1 acre in size. The 0.7-acre difference in intertidal area between the estimated value and the expected value (1 acre) suggests that the site was not constructed as originally planned and/or does not take into consideration the riparian area around the basin.

The Kenco Marine site was constructed and initially planted in 2006 with some replacement planting occurring in 2007. Measurements for area were taken using the goose excluder fence as a reference point and extending approximately 10 ft beyond fence line to approximately the 2.3 ft MLLW line. Hamm Creek and Herring's House sites continue to appear stable since their construction and were not monitored for intertidal area in 2007.

### **Tidal Regime (Physical Success Criterion 2)**

*Tidal amplitude, as determined by both timing and elevation of high and low tide events, is equivalent inside and outside of the project area (EBDRP 2000).*

With the approval of the EBDRP Panel, none of the sites were monitored for tidal regime in 2007. Previously collected data indicated that tidal exchange between the restoration sites and Duwamish River estuary was unimpeded (USFWS 2004).

### **Slope Erosion (Physical Success Criterion 3)**

*No evidence of erosion that threatens property, infrastructure, or is otherwise unacceptable, is observed after a period of initial site stabilization (EBDRP 2000).*

### Methods

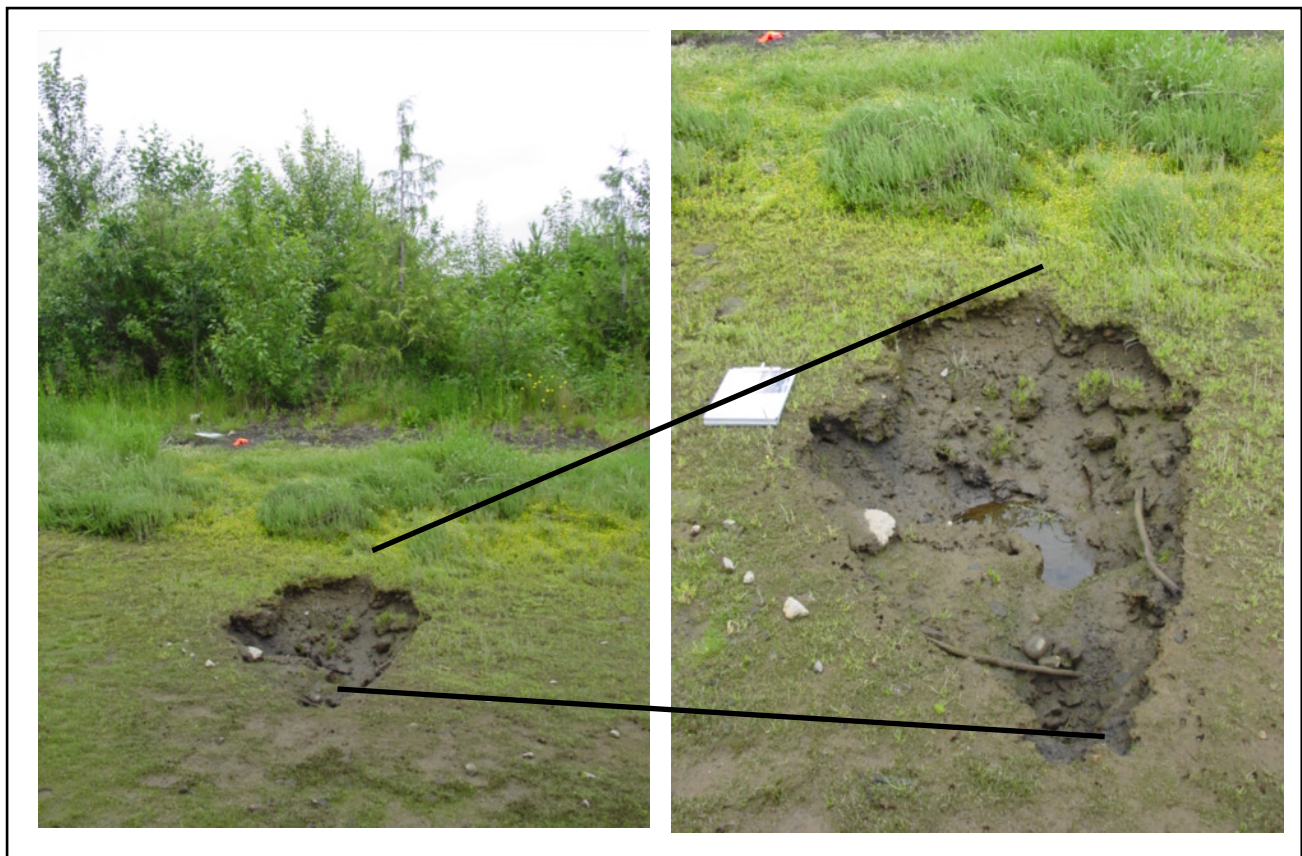


During site visits, visual inspections were made and photographs taken to detect any obvious bank erosion.

### Results

The only sign of erosion-related change at Herring's House was the 'sink hole' first observed in the intertidal area in 2005 (**Figure 6**). This sink hole has doubled in size to approximately 1.5- meters wide by 3-meters long (**Figure 7**). The North Wind's Weir site has remained stable since construction was completed. No signs of erosion were seen at the Kenco Marine site.

Major erosion occurred at the Hamm Creek restoration site during winter storm events in 2006/2007. In addition, beaver dams along the creek have caused water to back up and create a new creek channel cutting through the berm that previously separated the freshwater and saltwater marshes (**Figure 8**). The County currently has permits pending to restore the site to its prior condition.



**Figure 6. Sink-hole erosion located in the intertidal area at Herring's House restoration site in 2005.**



**Figure 7. Expanding sink-hole in the intertidal area at Herring's House restoration site in 2007.**

### Discussion

Herring's House and North Wind's Weir sites appear to be stable. Both sites are basins connected to the Duwamish River via riprapped channels. Hamm Creek in 2005 showed signs of erosion along both banks and in the creek channel at its mouth but experienced considerable erosion in 2007.

The Hamm Creek site was not constructed with riprap or armoring where the creek flows into the Duwamish River. The confluence of the creek with the Duwamish River is a dynamic area and the creek's course continues to meander. After the erosion event in 2002, King County strategically placed large boulders, cobble, and root wads along the north bank of the creek to protect the eroding peninsula and slow the rate of erosion at the site. In 2005 that erosion appeared to have slowed considerably. However, in 2007 there was further erosion on the north bank at the mouth of the creek and considerable erosion caused by the creek cutting a new channel through the freshwater marsh.

Herring's House, North Wind's Weir and Kenco Marine meet Physical Success Criterion 3. The Hamm Creek site will undergo reconstruction and does not yet meet Physical Success Criterion 3.

### **Sediment Structure (Physical Success Criterion 4)**

*Over time, sites will accumulate fine-grained material and organic matter. This would be evidenced by a decrease in mean grain size, and an increase in organic carbon in surface sediments (EBDRP 2000).*

With the approval of the EBDRP Panel the restoration sites were not monitored for sediment structure in 2007. In 2005, it was determined that without threshold values, it would be too difficult to ascertain statistically whether the restoration projects have or will successfully meet Physical Success Criterion 4 as listed in the monitoring plan (EBDRP 2000).





**Figure 8. Stream channel changes and erosion at Hamm Creek in 2007.**

**Sediment Quality (Physical Success Criterion 5)**

*No evidence of contamination due to sediment transport or on-site migration of upland contaminants to groundwater or aquatic areas (Herring's House only) (EBDRP 2000).*

Originally, the monitoring plan allocated funds for the installation of three groundwater monitoring wells at the Herring's House site to evaluate the success of Criterion 5. Following discussions with their cooperators in 2003, the EBD RP Panel decided not to install monitoring wells at the Herring's House site; therefore, this criterion was not implemented.

## BIOLOGICAL CHARACTERISTICS

### Marsh Vegetation Establishment (Biological Success Criteria 1-3)

*The areal extent of vegetation should be stable or increasing (Criterion 1), species composition of native wetland plants should be comparable to appropriate reference sites (Criterion 2) and plant vigor should be comparable to appropriate reference sites (Criterion 3) (EBDRP 2000).*

#### Methods

##### *Areal Extent (Criterion 1)*

Areal extent of marsh vegetation was surveyed at the Kenco Marine restoration site only in 2007. Following the border between riparian and marsh vegetation, the extent of marsh vegetation was mapped by walking a continuous line along the perimeter of the marsh vegetation area using GPS ( $\pm 1$ -3 meter precision for each point with differential correction). The area of the resulting polygon was calculated using GIS/ArcView software. The Hamm Creek, Herring's House and North Winds Weir restoration sites meet Biological Success Criterion 1 for areal extent and therefore with the approval of the EBD RP Panel, these restoration and associated reference sites were not surveyed for areal extent of marsh vegetation in 2007.

For 2007, individual marsh vegetation patches (Lyngby's sedge and bulrush) were measured for each site to the nearest 0.1 meter using a measuring tape to determine total area. This method differed from 2001 when GPS was used to estimate the area of individual marsh vegetation patches. Because the areas of some vegetation patches were too small to be effectively measured with GPS equipment due to resolution limitations, the direct measurement method was deemed to be a better technique for this parameter. The difference in sampling methodology does not allow a direct comparison of 2001 marsh vegetation measurements with those from subsequent years. The measuring tape methodology was used in 2002, 2003, 2005, and 2007 and patch area can be compared for those years.

##### *Species Composition (Criterion 2)*

Vegetation surveys for species composition occurred along previously established transects at the Hamm Creek, Herring's House, and North Wind's Weir restoration sites and the shared reference site for Hamm Creek, North Wind's Weir, and Kenco (**Figures 9 and 10**). Hamm Creek marsh transect 2 was compromised by the newly cut creek channel. The new creek channel cut through transect 2 just above its turning point and removed plots 2-5 and 2-6. Baseline transects were established for the Kenco Marine site. Species composition was determined by identifying and estimating the percent coverage of plant species within a 0.25 m<sup>2</sup> quadrat placed at points along each transect. Percent coverage for the target species, Lyngby's sedge and bulrush, were estimated separately from non-target species.

Non-target species included all native, nonnative, and invasive plant species except Lyngby's sedge (*Carex lyngbyei*) and bulrush (*Scirpus spp.*). The EBD RP monitoring plan lists four species as invasive species of special concern: cordgrass (*Spartina spp.*), purple loosestrife (*Lythrum salicaria*), reed canarygrass (*Phalaris arundinacea*), and common reed (*Phragmites communis*).

Besides the four plant species listed in the EBDP monitoring plan as invasive species of special concern, other invasive species were noted during monitoring events. These species included yellow flag iris (*Iris pseudacorus*) and perennial pepperweed (*Lepidium latifolium*). Yellow flag iris is listed as a Class C noxious weed and perennial pepperweed is listed as a Class B weed in Washington State (WSNWCB 2006).

While narrowleaf cattail (*Typha angustifolia*), is not a state-listed weed, its prior range was restricted to the Atlantic Coast, west to Colorado, Nebraska, Missouri and occasionally into Wyoming, Montana, and Eastern Washington. It is currently migrating into the Southwest and along the Pacific Coast (Cooke, 1997). Unlike broadleaf cattail (*Typha latifolia*), *Typha angustifolia* grows in brackish waters. *Cotula coronopifolia* (brassbuttons), an invasive colonizer of mudflats, also is not a state-listed weed. It occurs in estuarine salt marshes and on tidal mudflats. It is a native of South Africa but is now widespread around the world. In the Pacific Northwest it is found from the coast of British Columbia, south to California (Cooke, 1997).

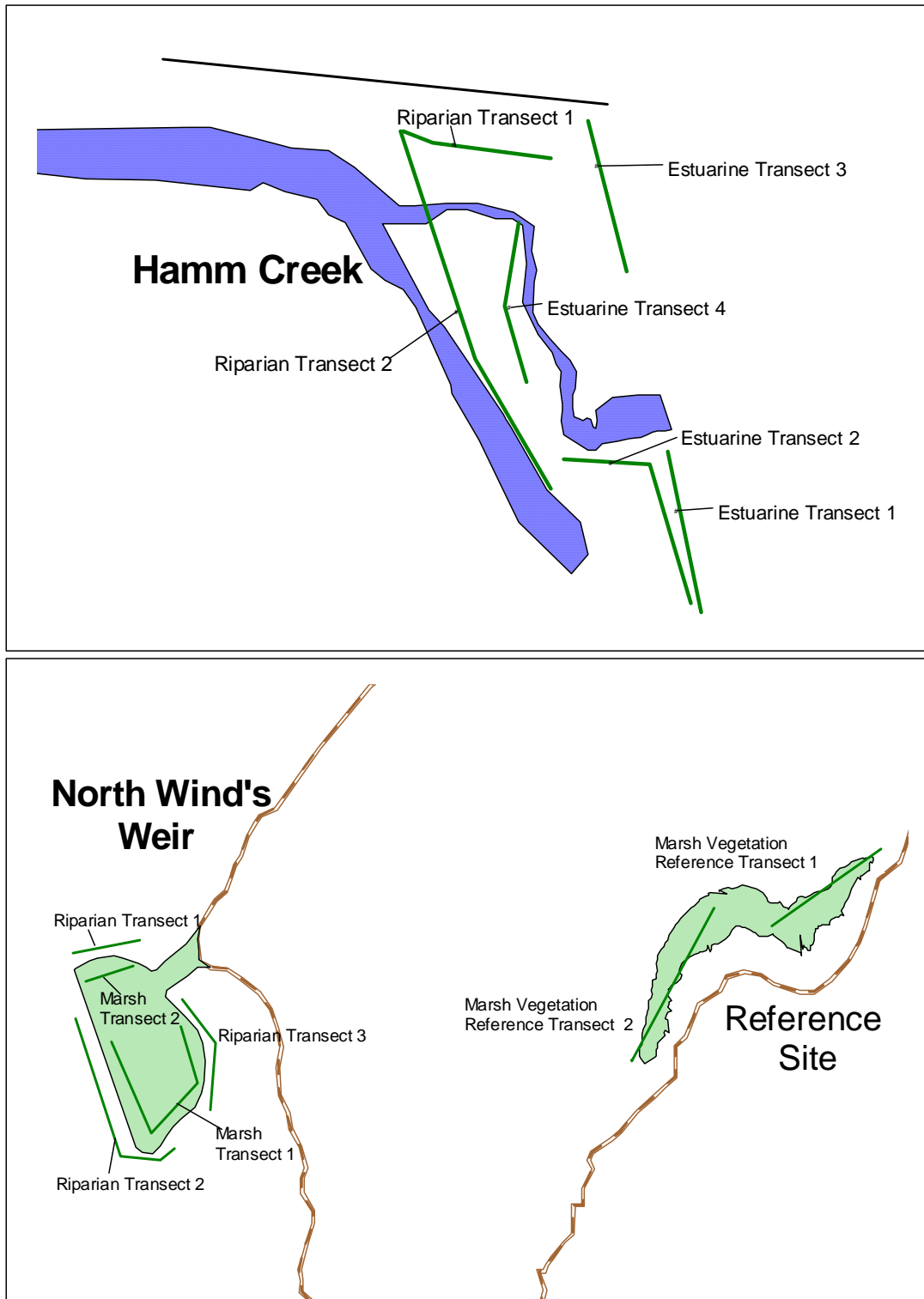
#### *Plant Vigor (Criterion 3)*

Shoot height and density of the target species, Lyngby's sedge and bulrush, were measured within the quadrats (0.25 m<sup>2</sup>) to estimate plant vigor. The heights of the three tallest shoots of each species were measured to the nearest centimeter. Differences in mean maximum shoot height between the restoration sites and their respective reference sites were determined using a t-test (Zar 1999). Shoot density was determined by counting the number of shoots for each species. Differences between restoration sites and their respective reference sites were examined by using a Mann-Whitney U test (Zar 1999) for comparing two means with non-normal distributions.

### Results

#### *Areal Extent (Criterion 1)*

Kenco Marine was the only site that was surveyed for areal extent in 2007. This marsh was just re-planted in the spring of 2007. Kenco Marine marsh vegetation extent was measured at 0.06 acre. The total area of marsh vegetation patches (Lyngby's sedge and bulrush) was estimated for the restoration sites and the remaining reference site (**Table 3**). Hamm Creek, North Winds Weir and their reference site had decreases in the total area of marsh vegetation patches between 2005 and 2007 (**Figure 11**). Herrings House has had a consistent increase in the total area of marsh vegetation patches between 2002 and 2007, increasing by 27% between 2005 and 2007.



**Figure 9** Placement of vegetation transects at the Hamm Creek (top figure) and North Wind's Weir restoration and reference (bottom figure) sites.

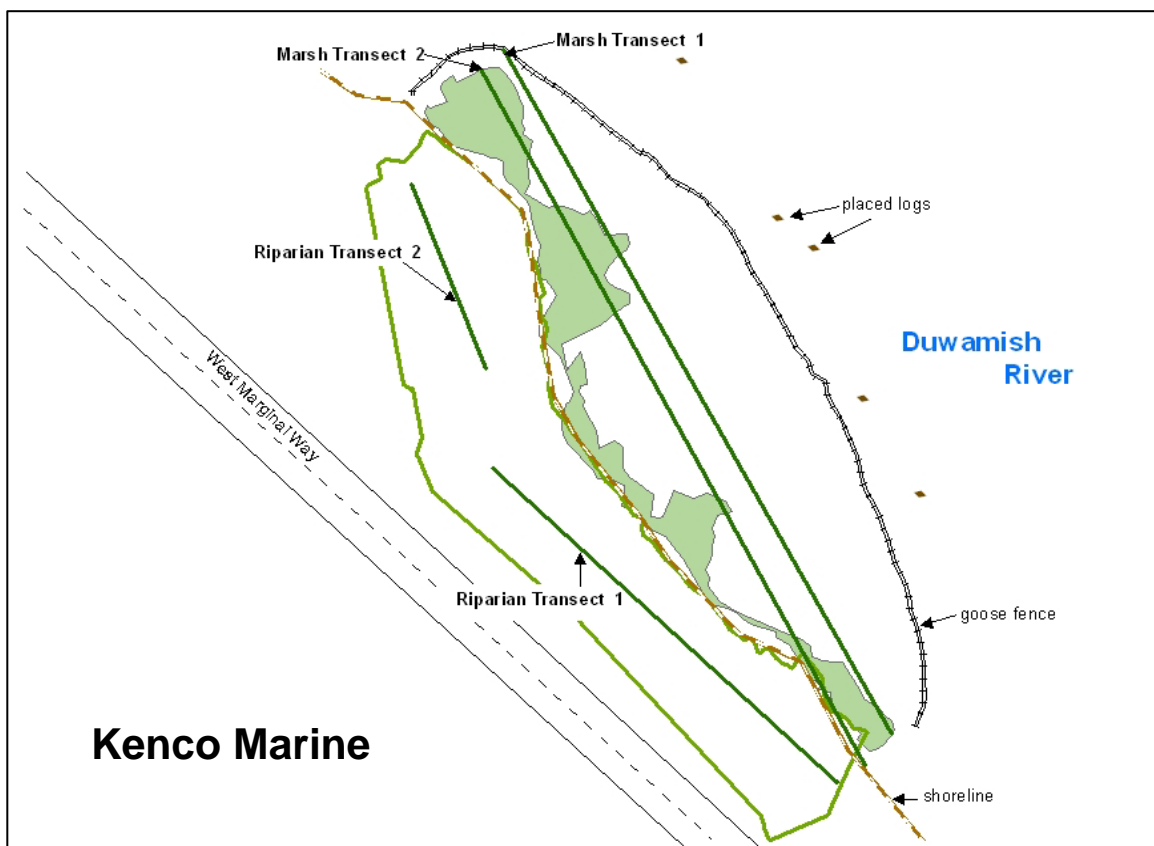
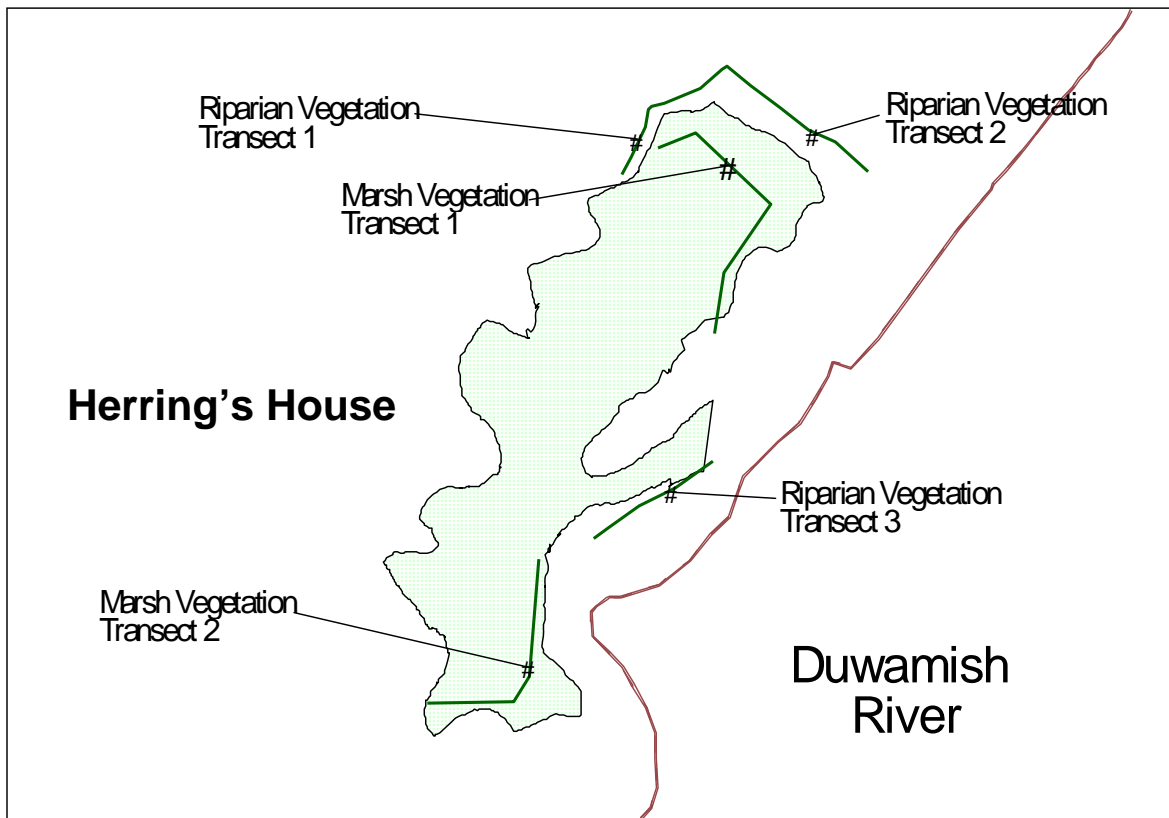


Figure 10 Placement of vegetation transects at the Herring's House and Kenco Marine.

The area of marsh vegetation patches at the Hamm Creek restoration site stayed around 1,000 m<sup>2</sup> between 2002 and 2005, and dropped to 760 m<sup>2</sup> in 2007, a decrease of 27% between 2005 and 2007. Between 2003 and 2005 the total area of marsh vegetation patches at the North Wind's Weir restoration site increased by 287 m<sup>2</sup> and decreased by 56 m<sup>2</sup> between 2005 and 2007, a decrease of 12% in 2007. The reference site for Hamm Creek, North Winds Weir, and Kenco Marine has shown a slight decrease of approximately 11% in total area of marsh vegetation patches from 2002 to 2007.

**Table 3. Total area of marsh vegetation patches (Lyngby's sedge and bulrush) at the restoration and reference sites by survey year.**

<u>Site</u>	<b>Marsh vegetation patches in m<sup>2</sup></b>			
	<b>2002</b>	<b>2003</b>	<b>2005</b>	<b>2007</b>
Hamm Creek	1051	1014	1038	760
Hamm Cr., NWW, Kenco Marine reference	622	535	517	460
North Wind's Weir	-	182	469	413
Kenco Marine	-	-	-	16
Herring's House	279	395	587	723
Herring's House reference	65	109	46	-

#### *Species Composition (Criterion 2)*

The number of plant species present in vegetation transects at the sites is shown in **Table 4** and the percent cover of target and non-target species is shown in **Table 5**. The number of plant species at all of the restoration sites except for North Winds Weir was greater than at the reference site in 2007. This trend has been consistent since 2003.

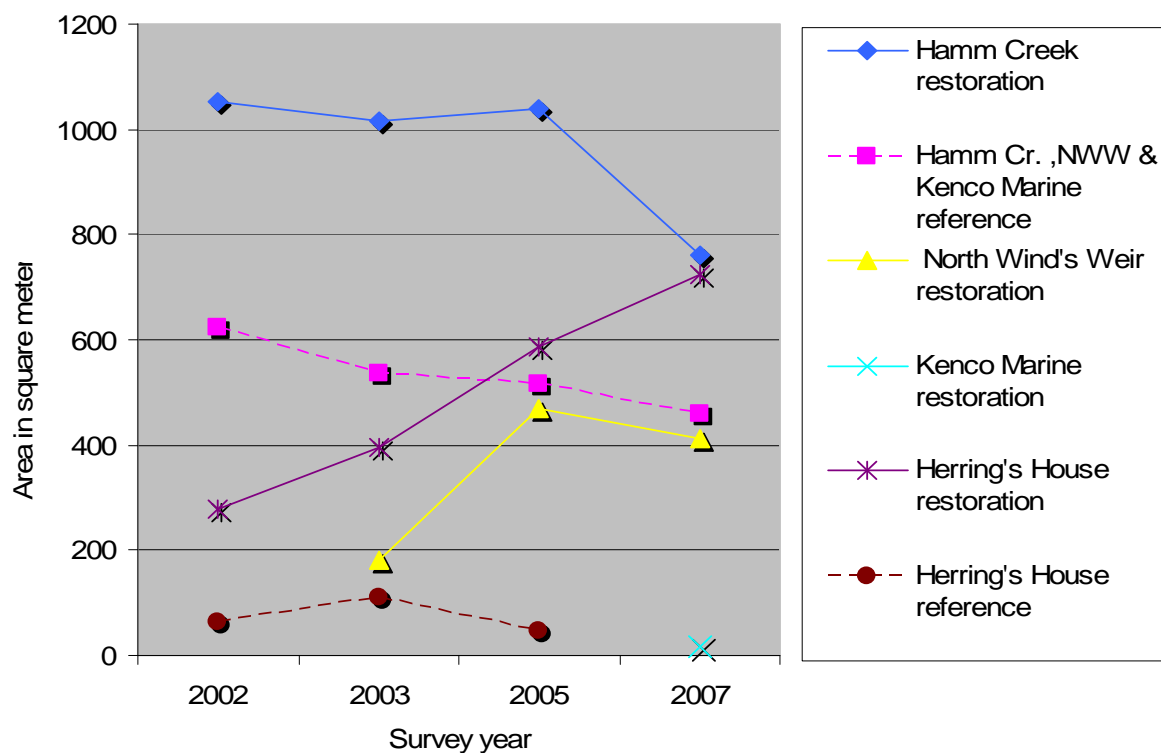
The percent cover of non-target species at Hamm Creek (11%) and its reference site (17%) were very similar in 2007. The estimated percent cover of target species at the Hamm Creek restoration site (51%) was less than at its reference site (72%). Percent cover of non-target species at the Hamm Creek site has decreased steadily since 2002, whereas the percent cover of target species at the site has increased steadily since 2003.

Data from the North Wind's Weir restoration site show that the number of species was the same as the values for the its reference site (same site as for Hamm Creek), and the estimated percent cover of non-target species was less than the reference. The estimated percent cover of target species at the North Wind's Weir restoration site increased by 56 percent since 2003 and was greater than the percent cover at the reference site.

The number of species increased slightly at the Herring's House restoration site. The estimated percent cover of non-target species at the Herring's House restoration site dropped between 2005 and 2007. The percent cover of target species at the Herring's House restoration site remained fairly consistent between 2005 and 2007.

None of the four species listed as invasive species of special concern in the EBD RP monitoring plan were found within transect plots at any of the restoration sites or the reference site. However, these, and other invasive species were noted when observed outside of the transect plots. Prevalence of these species is provided in the discussion section.





**Figure 11. Comparison of the total area of marsh vegetation patches (Lyngby's sedge and bulrush) at the restoration sites and their associated reference sites by survey year.**

**Table 4. Vegetation species present in marsh transects at the restoration sites and their associated reference sites (includes species of *Carex* and *Scirpus*).**

<u>Site</u>	<u>Number of Species</u>				
	<u>2001</u>	<u>2002</u>	<u>2003</u>	<u>2005</u>	<u>2007</u>
Hamm Creek	20	19	18	10	9
Hamm Creek & NWW Reference	5	7	5	5	6
North Wind's Weir	-	-	3	6	6
Kenco Marine	-	-	-	-	17
Herring's House	6	4	8	8	10
Herring's House Reference	6	10	7	7	-



### *Plant Vigor (Criterion 3)*

Mean shoot height of Lyngby's sedge (**Table 6**) was not significantly different between the Hamm Creek restoration site and the reference site ( $t = 0.3$ ,  $df = 85$ ,  $P \geq 0.05$ ). There were only 7 shoots of bulrush (**Table 7**) in the restoration site transect plots and none in the reference site transect plots in 2007, therefore comparisons could not be made.

Mean shoot height of Lyngby's sedge was significantly different ( $t = 5.0$ ,  $df = 79$ ,  $P < 0.05$ ) at the North Wind's Weir restoration site than at the reference site in 2007. The restoration site mean was greater than the reference mean. The mean shoot height of bulrush could not be calculated due to the absence of the bulrush in transect plots.

The Herrings House reference site was not sampled in 2007, so no comparisons could be made for this site.

Mean shoot height of Lyngby's sedge was significantly different ( $t = 0.01$ ,  $df = 32$ ,  $P < 0.05$ ) at the Kenco Marine restoration site than at the reference site in 2007. However, there were only four shoots present in transect plots at the restoration site so this would not be considered a valid comparison.

**Table 5. Estimated mean percent cover of target species, Lyngby's sedge (*Carex lyngbyei*) and bulrush (*Scirpus spp.*), and non-target species, including nonnative and invasive plants, at the restoration sites and their associated reference sites.**

Site	Estimated % cover of marsh vegetation <sup>1</sup>									
	Target species					Non-target species				
	<u>2001</u>	<u>2002</u>	<u>2003</u>	<u>2005</u>	<u>2007</u>	<u>2001</u>	<u>2002</u>	<u>2003</u>	<u>2005</u>	<u>2007</u>
Hamm Creek	17	28	21	45	51	47	51	41	16	11
Hamm Creek, NWW, Kenco Reference	78	82	70	74	72	26	16	3	11	17
North Wind's Weir	-	-	6	62	84	-	-	2	14	4
Kenco Marine	-	-	-	-	3	-	-	-	-	34
Herring's House	7	7	5	10	13	35	80	75	81	51
Herring's House Reference	31	19	7	31	-	52	55	32	57	-

<sup>1</sup>Each site's percent cover was estimated by averaging the percent cover values in each plot surveyed at the site.

**Table 6. Mean shoot heights of Lyngby's sedge and statistical analyses for the restoration sites and their reference sites by survey year. An asterisk indicates a statistically significant larger mean shoot height for the site (Mann-Whitney test,  $P < 0.05$ ).**

<b>Shoot Height for Lyngby's sedge</b>							
	<b>Year</b>	<b>Site</b>	<b>Mean (cm)</b>	<b>Min (cm)</b>	<b>Max (cm)</b>	<b>Std. dev.</b>	<b>n (shoots)</b>
Hamm Creek	2001	Restoration	96	45	177	38	18
		Reference	129*	48	190	40	30
	2002	Restoration	90	26	169	40	39
		Reference	143*	85	205	37	30
	2003	Restoration	85	12	155	35	43
		Reference	128*	65	194	36	29
	2005	Restoration	110	15	180	42	58
		Reference	119	49	180	40	30
North Wind's Weir	2007	Restoration	79	13	156	40	57
		Reference	90	16	171	50	30
	2003	Restoration	57	12	119	28	28
		Reference	128*	65	194	36	29
	2005	Restoration	139*	44	194	34	39
		Reference	119	49	180	40	30
	2007	Restoration	163*	100	204	21	51
		Reference	90	16	171	50	30
Herring's House	2001	Restoration	26	5	50	13	29
		Reference	76*	65	90	8	12
	2002	Restoration	No analysis performed ( <i>Carex</i> absent from plots)				
		Reference	87	45	104	17	12
	2003	Restoration	No analysis performed ( <i>Carex</i> absent from plots)				
		Reference	72	64	80	9	4
	2005	Restoration	No analysis performed ( <i>Carex</i> absent from plots)				
		Reference	67	25	110	36	7
Kenco Marine	2007	Restoration	16	9	27	8	4
		Reference	90*	16	171	50	30

In 2007, median shoot densities of Lyngby's sedge (**Table 8**) were significantly greater ( $U = 177$ ,  $CV = 166$ ,  $P < 0.05$ ) at the Hamm Creek reference site than at the restoration site. Median shoot densities remained stable at the restoration site and increased since 2005 in the reference site transect plots. Bulrush (**Table 9**) was not found in transect plots at the reference site in 2007, and only one shoot was found in transect plots at the restoration site so comparisons were not valid.

The median shoot densities of Lyngby's sedge was significantly greater ( $U = 151.5$ ,  $CV = 136$ ,  $P < 0.05$ ) at the North Wind's Weir reference site (same as Hamm Creek) than at the restoration site in 2007. Bulrush was not present in any transect plots at North Wind's Weir restoration or reference site; therefore, no comparison could be made.

**Table 7. Mean shoot heights of bulrush and statistical analyses for the restoration sites and their reference sites by survey year. An asterisk indicates a statistically significant larger mean shoot height for the site (Mann-Whitney test,  $P < 0.05$ ).**

			<b>Shoot height for Bulrush</b>				
	<b>Year</b>	<b>Site</b>	<b>Mean (cm)</b>	<b>Min (cm)</b>	<b>Max (cm)</b>	<b>Std. dev.</b>	<b>n (shoots)</b>
Hamm Creek	2001	Restoration	72	20	118	30	18
		Reference	148*	56	200	47	8
	2002	Restoration	64	49	87	10	11
		Reference	185*	152	215	27	6
	2003	Restoration	80	28	118	27	9
		Reference	164*	132	200	27	9
	2005	Restoration	120	91	162	31	7
		Reference	No analysis performed ( <i>Scirpus</i> absent from plots)				
North Wind's Weir	2007	Restoration	126	91	162	32	7
		Reference					
	2003	Restoration	No analysis performed ( <i>Scirpus</i> absent from plots)				
		Reference					
	2005	Restoration	No analysis performed ( <i>Scirpus</i> absent from plots)				
		Reference					
Herring's House	2007	Restoration	No analysis performed ( <i>Scirpus</i> absent from plots)				
		Reference					
	2001	Restoration	61	55	65	6	3
		Reference	143*	70	215	50	14
	2002	Restoration	48	20	113	24	27
		Reference	153*	111	193	28	15
	2003	Restoration	48	17	66	10	25
		Reference	142*	117	169	16	12
	2005	Restoration	78	30	152	31	24
		Reference	151*	111	179	21	15
Kenco Marine	2007	Restoration	90	47	154	16	16
		Reference	No analysis performed, reference site removed from sampling				
		Reference					

In 2007, median shoot densities of Lyngby's sedge were significantly greater ( $U = 198$ ,  $CV = 151$ ,  $P < 0.05$ ) at the Kenco Marine reference site than at the restoration site. There was no bulrush found in any of the plots at the reference site so a valid test could not be run.

The median shoot density comparisons for the Herring's House restoration site could not be conducted, as the reference site was not sampled. Lyngby's sedge was present in the restoration site transect plots for the first time since 2002. Lyngby's sedge was present in three of 20 plots with 39 shoots present in one plot.

**Table 8. Median shoot densities of Lyngby's sedge and statistical analyses for the restoration sites and their reference sites by survey year. An asterisk indicates a statistically significant larger mean shoot density at the site (Mann-Whitney test,  $P < 0.05$ ).**

	Year	Site	<u>Shoot Density for Lyngby's sedge</u> <sup>1</sup>			<u>N</u>	
			Median	Min	Max	Shoots	Plots
Hamm Creek	2001	Restoration	5	0	39	130	24
		Reference	14*	0	30	155	11
	2002	Restoration	9	0	57	218	24
		Reference	23*	0	42	251	11
	2003	Restoration	11	0	51	267	24
		Reference	26*	0	56	281	11
	2005	Restoration	14	0	39	317	23
		Reference	27*	0	51	298	11
	2007	Restoration	14	0	58	375	21
		Reference	38*	0	71	398	11
North Wind's Weir	2003	Restoration	2	0	7	38	17
		Reference	26*	0	56	281	11
	2005	Restoration	16	0	32	272	17
		Reference	27*	0	51	298	11
	2007	Restoration	13	6	26	236	17
		Reference	38*	0	71	398	11
Herring's House	2001	Restoration	4	0	19	70	20
		Reference	6	0	17	57	10
	2002	Restoration	0	0	0	0	20
		Reference	6*	0	51	61	10
	2003	Restoration	0	0	0	0	20
		Reference	1	0	11	12	10
	2005	Restoration	0	0	0	0	20
		Reference	3	0	22	28	10
	2007	Restoration	0	0	39	44	19
		Reference	Reference site not sampled due to enhancement actions				
Kenco Marine	2007	Restoration	0	0	2	4	19
		Reference	38*	0	71	398	11

<sup>1</sup>Number of shoots/0.25m<sup>2</sup>

## Discussion

### *Areal Extent (Criterion 1)*

The areal extent of marsh vegetation at Kenco Marine restoration site was 0.06 acre. This marsh was initially planted in 2006 and re-planted in the spring of 2007. It was noted during monitoring that the goose excluder fences were not completely successful. Waterfowl were observed swimming over the outer fence at high tide and foraging within the restoration site (**Figure 12**).

The total area of marsh vegetation patches (Lyngby's sedge and bulrush) was measured for the restoration sites and remaining reference site (**Table 3**). Data observers were the same in 2003 and 2005, but new observers collected the data in 2007. Since the measurement technique using a measuring tape can be subjective from one observer to another, some differences in values recorded may be attributable to differences in observation and random error.

**Table 9. Median shoot densities of bulrush and statistical analyses for the restoration sites and their reference sites by survey year. An asterisk indicates a statistically significant larger mean shoot density at the site (Mann-Whitney test,  $P < 0.05$ ).**

	Year	Site	Shoot Density for Bulrush <sup>1</sup>			N	
			Median	Min	Max	Shoots	Plots
Hamm Creek	2001	Restoration	1	0	10	28	24
		Reference	2	0	18	23	11
	2002	Restoration	1	0	11	29	24
		Reference	2	0	15	27	11
	2003	Restoration	2	0	30	51	24
		Reference	5	0	19	39	11
	2005	Restoration	2	0	40	45	23
		Reference	0	0	0	0	11
North Wind's Weir	2007	Restoration	0	0	1	1	21
		Reference	0	0	0	0	11
	2003	Restoration	0	0	0	0	17
		Reference	5	0	19	39	11
	2005	Restoration	0	0	0	0	17
		Reference	0	0	0	0	11
	2007	Restoration	0	0	0	0	17
		Reference	0	0	0	0	11
Herring's House	2001	Restoration	0.4	0	7	7	20
		Reference	6*	0	17	56	10
	2002	Restoration	4	0	25	70	20
		Reference	5	0	12	46	10
	2003	Restoration	3	0	22	52	20
		Reference	5	0	20	52	10
	2005	Restoration	6	0	29	113	20
		Reference	10	0	25	97	10
Kenco Marine	2007	Restoration	5	0	32	90	19
		Reference	Reference site not sampled due to enhancement actions				
	2007	Restoration	0	0	6	20	19
		Reference	0	0	0	0	11

<sup>1</sup>Number of shoots/0.25m<sup>2</sup>

At the reference site for Hamm Creek, North Wind's Weir, and Kenco Marine, the area for the target species Lyngby's sedge and bulrush area has steadily declined each year (**Table 3** and **Figure 11**). The declines from the previous sampling years were 87 m<sup>2</sup> (14 %) in 2003, 18 m<sup>2</sup> (3%) in 2005, and 57 m<sup>2</sup> (11 %) in 2007, for a total decrease of 27 percent since 2002. Possible causes of this steady decline include: the erosion of soils, an increase in invasive species and public use, and random and measurement errors.

The total area of Lyngby's sedge and bulrush patches at the Hamm Creek restoration site decreased by 37 m<sup>2</sup> (4%) in 2003, increased by 24 m<sup>2</sup> (2%) in 2005, and decreased by 278 m<sup>2</sup> (27%) in 2007. The greater decrease noted in 2007 may have been partially due to physical changes to the site. Hamm Creek rerouted through the freshwater marsh and broke through the berm that previously separated the

freshwater and saltwater marshes. Some marsh was lost when this occurred. In addition, the measurement technique is somewhat subjective and changes in observers may account for some of the difference. From these observed changes, the Hamm Creek restoration site no longer meets Biological Success Criterion 1.



**Figure 12. Waterfowl feeding inside goose excluder fencing at Kenco Marine.**

At North Wind's Weir patches of Lyngby's sedge have increased by 231 m<sup>2</sup> since planting in 2003. Lyngby's sedge patches encompass most of the intertidal area above standing water in the basin. The total area of Lyngby's sedge patches increased by 158 percent in 2005 and decreased by 12 percent in 2007. Random error and measurement error likely account for a portion of the decrease noted between 2005 and 2007. The Lyngby's sedge marsh at the site still appears to encompass the entire suitable habitat at the site (**Figure 13**) and declined at a similar rate as the reference site. The overall increase in area of Lyngby's sedge patches since construction, and the similar decrease in patch size between 2005 and 2007 at both the restoration and reference sites, indicates that the marsh vegetation at North Wind's Weir restoration site is comparably similar and meets Biological Success Criterion 1.





**Figure 13. Lyngby's sedge marsh at North Wind's Weir.**

The size of Lyngby's sedge and bulrush patches at Herring's House restoration site increased from 2005 to 2007. The total area of Lyngby's sedge and bulrush patches was 723 m<sup>2</sup> in 2007. This is an 83 percent increase from 2003 and a 159 percent increase since 2002. The patches have continued to increase without the goose exclusion fencing that was removed in 2003. As noted in the 2005 report, the reference site for Herring's House has been altered with the addition of enhancement plantings and construction of a goose exclusion fence (**Figure 14**). Therefore, monitoring this reference site for marsh vegetation was discontinued and comparisons are no longer possible for this site. However, with the continual increase in size of Lyngby's sedge and bulrush patches at Herring's House, this site continues to meet Biological Success Criterion 1.

The Kenco Marine site had 16 m<sup>2</sup> of bulrush patches in 2007. As this site was planted in the spring of 2006 and re-planted in 2007, it is too early to determine whether or not it meets Biological Success Criterion 1.

#### *Species Composition (Criterion 2)*

The percent cover of target species at the Hamm Creek, Herring's House, and North Wind's Weir restoration sites and their reference site have either increased or remained stable over the entire monitoring period.

At the reference site, the number of species and target species percent cover remained relatively stable from 2003 to 2007. Despite heavy grazing by geese at the southern end of the reference site, impacts

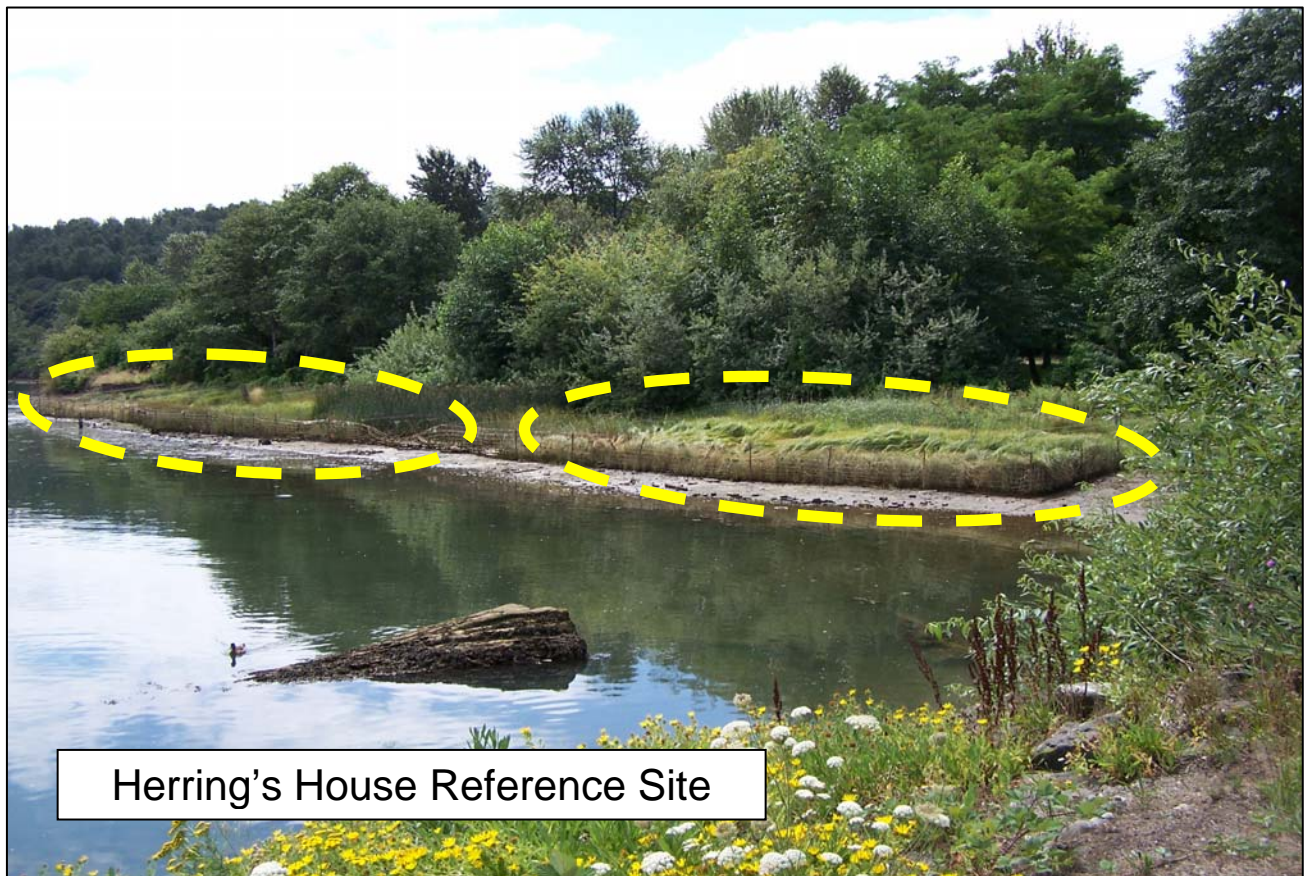


on percent cover and density measurements were not readily apparent. Therefore, species composition and percent cover at this reference site are expected to remain relatively stable overtime (**Figure 15**).

For the Hamm Creek restoration site, the number of understory species and percent cover of non-target species sampled from 2002 to 2007 declined while the target species increased.

At the North Wind's Weir restoration site, the number of species and percent cover of non-target species increased between 2003 and 2005, and decreased between 2005 and 2007. Target species percent cover at this site have increased since 2003 exceeding that of the reference site. The decrease in number of species at North Winds Weir is likely due to the health of the *Carex* marsh (one of the target species) and its ability to outcompete other vegetation. This is considered a sign of a healthy marsh even though the site has less cover by non-target species than the reference site. The increase in percent cover for target species at the North Wind's Weir site may have been partially attributed to site conditions. In six of the transect plots the Lyngby's sedge had already fallen over, beginning the decomposition process. This may have influenced the ability to accurately assess percent cover for the target species Lyngby's sedge.

Overall, these restoration sites appear to be moving closer to comparable species composition and percent cover of species as the reference sites, and therefore we believe North Wind's Weir and the Hamm Creek restoration sites meet Biological Success Criterion 2.



**Figure 14.** Marsh plantings and goose excluder fencing at Herring's House reference site looking south from Herring's House.

The number of species and percent cover of non-target species at the Kenco Marine site is markedly higher than at the North Wind's Weir and Hamm Creek restoration sites and at the reference site. One possible explanation may be that transect 1 at the Kenco Marine site was placed at a slightly higher elevation than at these other sites. It should also be noted that this is a new site recently constructed and still being colonized with regards to vegetation composition. As such, conditions are not expected to be similar to the reference site and therefore Kenco Marine does not yet meet Biological Success Criterion 2.

The number of species at the Herring's House restoration site increased slightly in 2007. The percent cover of non-target species at the site has fluctuated, with a 37% decrease since 2005. It should be noted that 20% of this cover is from the nonnative brassbuttons (*Cotula coronopifolia*). Target species continue to increase but since the marsh reference site for Herring's House is no longer viable, comparisons are no longer possible to determine if the Herring's House restoration site meets Biological Criteria 2.



Figure 15. Marsh reference site across from North Wind's Weir looking southwest.





**Figure 16. Common reed in the upper marsh of Hamm Creek.**

In 2005, reed canarygrass (*Phalaris arundinacea*) was found in a transect plot at Hamm Creek. Of the four species listed in the EBD RP monitoring plan as invasive species of special concern, reed canarygrass is the only species of special concern found in marsh transects at the restoration and reference sites since 2001. In 2007, several species of special concern were noted at the Hamm Creek restoration site growing in areas not sampled by the transects. A clump of common reed (*Phragmites communis*) was noted in the upper marsh (**Figure 16**). A clump of reed canarygrass (*Phalaris arundinacea*) was growing near the start of transect 1, and several others were located at the upper edge of the marsh (**Figure 17**).

During a site reconnaissance visit in May 2007, it was noted that some invasive species removal had occurred. Numerous clumps of yellow flag iris (*Iris pseudacorus*) had been removed from the Hamm Creek marsh and were piled in various areas. Some clumps of iris had not been removed during the May visit and were flowering at the time of the marsh vegetation sampling in July including clumps adjacent to transect 3 (**Figure 18**). Linear leaved cattail was noted near the previously established end of transect 2 (since washed out) and above transect 4 (**Figure 19**). Single occurrences of perennial pepperweed (*Lepidium latifolium*), a state-listed species to be controlled, were found at several of the sites and removed when feasible.





**Figure 17. Reed canarygrass growing near Transect 1 of Hamm Creek.**



**Figure 18. Yellow flag iris growing adjacent to transect 3 in Hamm Creek.**





**Figure 19. Cattail near the end of transect 2 and above transect 4 in Hamm Creek.**

### *Plant Vigor (Criterion 3)*

At the Hamm Creek restoration site mean shoot density of Lyngby's sedge has continued to increase since 2001. It remains significantly different than shoot density at the reference site. The mean shoot height of Lyngby's sedge at Hamm Creek was not significantly different than the reference site and is greater than 80% of the reference site. Mean shoot height of bulrush at the restoration site has continued to increase since 2001; however, bulrush was not present in the transect plots at the reference site and comparisons to the restoration site could not be made. Plant vigor (shoot height and shoot density) at the Hamm Creek site is approaching, but does not fully meet Biological Success Criterion 3.

The North Wind's Weir restoration site had a significantly greater mean shoot height of Lyngby's sedge than the reference site but mean shoot density was significantly less than the restoration site. These differences may be attributed to heavy grazing by geese on the southern end of the reference site (**Figure 15**). Heavy grazing reduces shoot height and may increase the number of shoots present. The original plantings of Lyngby's sedge in 2003 have thrived and spread to cover most of the intertidal area above standing water in the basin. Although mean shoot height of target species exceeds the mean at the reference site, mean shoot density does not. Bulrush was absent from transect plots at both the restoration and reference site. Plant vigor at North Wind's Weir is approaching, but does not fully meet Biological Success Criterion 3.

The Kenco Marine site was planted in 2006 and re-planted in the spring of 2007. Target vegetation was not well established yet to compare to the reference site. The Kenco Marine site does not meet Biological Success Criterion 3.

Lyngby's sedge was present in plots at the Herring's House restoration site for the first time since 2001; however, only 8 shoots were counted. Mean shoot height of bulrush remained relatively stable between 2005 and 2007. Monitoring the Herring's House reference site has been discontinued, so no comparisons could be made.

### **Riparian Vegetation (Biological Success Criteria 4 and 5)**

*The areal extent of vegetation should be stable or increasing over time, and cover not less than 90% of the upland vegetated area of each project site at the end of 10 years, and invasive plant coverage should be minimal (Criterion 4). Survival of riparian plantings in each cover class (herb, shrub, and tree) should be at least 75% at the end of 3 years (Criterion 5) (EBDRP 2000).*

#### Methods

##### *Areal Extent/Percent Cover/Invasives (Criterion 4)*

To estimate the areal extent of upland riparian vegetation, the perimeters of riparian vegetation at each site were mapped using the Trimble GeoExplorer 3 GPS in the same manner as for areal extent of marsh vegetation. The areal extent was estimated using ArcView 3.1. During construction of the restoration sites, most of the area upslope of the marsh was planted with riparian vegetation (shrubs and trees) in a somewhat uniform fashion, with herbaceous plants colonizing the disturbed areas between the plantings. The riparian and marsh vegetation zones occasionally overlapped. For purposes of the estimate, the riparian vegetation zone included all upland plantings and patches of riparian vegetation that extended below the +12-foot MLLW level into the marsh vegetation zone.

To assess the percent cover of herbaceous, shrub, and tree layers, surveys were conducted in the riparian vegetation zone along transects established in 2001 for Hamm Creek and Herring's House restoration sites. Vegetation transects at the North Wind's Weir site were established in 2003. Vegetation transects at the Kenco Marine site were established in 2007. The first sample plot of each transect was located at a random distance (1-9 meters) from the starting point and subsequent plots were placed along that transect using that determined interval. The herbaceous layer was sampled using a 0.25 m<sup>2</sup> quadrat and the shrub and tree layers were sampled using a 3-meter radius circular plot. Percent cover was visually estimated to the nearest 5 percent for each layer. For each site, mean percent cover values were calculated for all layers. Because each layer's estimate was independent of the other vegetation layers and the size of herbaceous sample plots was smaller than the other layers, percent cover can not be summed across layers.

Nonnative invasive species were sampled as a layer using a 3-meter radius circular plot. Percent cover was visually estimated to the nearest 5 percent for each layer and means were calculated as with the other vegetation layers. The monitoring plan (EBDRP 2000) identified three nonnative species of special concern as target species: Himalayan blackberry (*Rubus discolor*), Scot's broom (*Cytisus scoparius*), and Japanese knotweed (*Polygonum cuspidatum*). Two of these species (Himalayan blackberry and Scot's broom) were encountered at the sites. Other nonnative species were present and were included in the all nonnative percent cover estimates in each plot.

### *Survival (Criterion 5)*

The monitoring plan (EBDRP 2000) calls for collecting shrub and tree survival data in years 1 to 3; therefore, survival data was not collected for Hamm Creek, Herring's House, and North Wind's Weir after 2003. However, Kenco Marine, being a relatively new site planted in 2006 and re-planted in 2007, should be considered for collection of this data in 2010 at the end of year 4.

### Results

#### *Areal Extent/Percent Cover/Invasives (Criterion 4)*

The total areal extent of riparian vegetation at each restoration site was estimated and is provided in **Table 10**. The areal extent of riparian vegetation decreased at all three restoration sites when compared to 2005 data. Hamm Creek had a decrease of 759 m<sup>2</sup> (23.4 percent), North Wind's Weir decreased 85 m<sup>2</sup> (6.7 percent), and Herring's House decreased 227 m<sup>2</sup> (2.5 percent). The new site, Kenco Marine, was planted in the spring of 2006 and was re-planted in 2007.

Because of routine maintenance and invasive and nonnative species control at the restoration sites, interpretation of vegetation coverage data must be considered carefully. Other entities (e.g., King County Parks, Seattle City Parks, and People for Puget Sound) have spent much effort controlling nonnative plants, removing dead trees and shrubs, and planting new vegetation in the riparian areas. These actions are beneficial and necessary to the long-term health of the site. However, it is important to consider these actions when interpreting our results. The results show the status of the restoration sites at a single point in time and are not a measure of natural succession over time.

**Table 10. Estimates of riparian areal extent at restoration sites by survey year.**

Site Name	Riparian areal extent in m <sup>2</sup> (acres)				
	2001	2002	2003	2005	2007
Hamm Creek	2,104 (0.5)	2,648 (0.7)	3,049 (0.8)	3,237 (0.8)	2,478 (0.61)
North Wind's Weir	-	-	1,285 (0.3)	1,261 (0.3)	1,176 (0.29)
Herring's House	9,598 (2.4)	8,706 (2.2)	9,705 (2.4)	8,912 (2.2)	8,685 (2.15)
Kenco Marine	-	-	-	-	854 (0.21)

At Hamm Creek, percent cover increased for all three layers (herbaceous, shrub and tree) from 2005 to 2007. At North Wind's Weir, percent cover increased at the shrub layer but decreased at the herbaceous and tree layers. At Herring's House, percent cover increased at the herbaceous and tree layers but decreased at the shrub layer. Riparian vegetation species observed at Hamm Creek, North Wind's Weir, and Herring's House restoration sites from 2001 to 2005 are included in Appendix 3.

Himalayan blackberry and Scot's broom were observed in the transect plots and are two of the three nonnative invasive plant species designated as target species. To date, none of the known knotweed species has been observed at any of the restoration sites. Other nonnative plant species were also



observed in the transect plots. The percent cover of target species was estimated separately and also combined with other non-target species for an estimate of all nonnative species in each plot. Percent cover of the non-native target species doubled at Hamm Creek, increased by about 50 percent at North Wind's Weir, and decreased by about 38 percent at Herring's House. All restoration sites had a decrease in the percent cover of all nonnative species from 2005 to 2007 (**Table 11**).

**Table 11. Independent estimates of percent cover for herbaceous, shrub, tree, and nonnative riparian vegetation layers at restoration sites by survey year.**

Site	Year	Percent Cover of Riparian Vegetation Layers				
		Herbaceous (0.25m <sup>2</sup> quadrat)	Shrub (3m radius plot)	Tree (3m radius plot)	Nonnative	
					Target spp (3m radius plot)	All species (3m radius plot)
Hamm Creek	2001	28	7	11	1.5	4
	2002	71	15	25	6	18
	2003	76	8	30	5	21
	2005	63	20	26	5	14
	2007	71	85	47	10	12
North Wind's Weir	2003	36	30	38	3	21
	2005	55	14	78	2	16
	2007	36	35	73	3	8
Herring's House	2001	44	27	26	2	5
	2002	50	16	35	4	17
	2003	56	16	57	3	18
	2005	51	11	35	8	17
	2007	75	7	54	5	6
Kenco Marine	2007	82	7	19	2	7

## Discussion

### *Areal Extent/Percent Cover/Invasives (Criterion 4)*

As previously noted, the areal extent of riparian vegetation decreased at all restoration sites. The extensive decrease of areal extent at Hamm Creek (759 m<sup>2</sup>) was caused by the cut of a new channel by the creek through the berm, which eroded the area at the end of transect 2 (**Figure 8**). Areal extent of riparian vegetation is expected to continue fluctuating over time as riparian and marsh vegetation becomes more interwoven.

Vegetation coverage goals for Year 5 are given in the monitoring plan (EBDRP 2000). The herbaceous layer goal is for not more than 10 percent bare ground. The shrub layer is expected to be greater than 50 percent and the tree layer greater than 40 percent. The herbaceous vegetation has successfully established and survived at the restoration sites. The herbaceous layers at Hamm Creek and Herring's House meet Biological Success Criterion 4. However, this criteria has not been met at North Wind's Weir. The shrub layer at Hamm Creek and North Wind's Weir meet Criterion 4, but has not been met at Herring's House.

The projected goal for the tree layer is 40 percent coverage by Year 5 and 25 percent by Year 3. The percent cover of trees increased by 80 percent at Hamm Creek and by 54 percent at Herring's House. Tree layer coverage at Hamm Creek (47 percent), Herring's House (54 percent) and North Wind's Weir (73 percent) meets Biological Success Criterion 4.

Two of the three nonnative invasive species identified as target species, Himalayan blackberry and Scot's broom, were present at the sites. The percent coverage of these target species at the sites ranged from 3 to 10 percent. Many other nonnative species are also present at the sites. When all nonnative species in the surveys are included, the estimated percent cover of nonnative species at the restoration sites ranges between 6 and 12 percent. This is probably due to the important and extensive work done by other entities to remove nonnative and invasive species at the sites. The extensive work to control nonnative species provides evidence that continued maintenance of the sites is important to preserve and provide the best habitat possible. All three restoration sites, excluding the new Kenco Marine site, meet the Biological Success Criterion 4 goal of less than 20 percent nonnative species by Year 5 and less than 10 percent by Year 3.

#### **Bird Use (Biological Success Criterion 6)**

*Use of the restoration sites and the area within 50 meters of the site by indigenous/native bird species should be comparable to that of the appropriate reference sites (EBDRP 2000).*

With the approval of the EBDRP Panel, none of the sites were monitored for bird use in 2007. However, from the data collected in previous years, the number of bird species observed at the restoration sites appeared to be more comparable to numbers seen at the reference sites with each successive year. Therefore, the restoration sites meet Biological Success Criterion 6.

#### **Fish Presence/Access (Biological Success Criterion 7)**

*Estuarine fishes will access the project sites. Juvenile salmonid presence within the project sites should be comparable to that of appropriate reference sites at the end of ten years (EBDRP 2000).*

With the approval of the EBDRP Panel, none of the sites were monitored for fish presence/access in 2007. The capture of salmonids and non-salmonids in all years indicates that the restoration sites are accessible to these fishes and juvenile salmonid presence is comparable to the appropriate reference sites. Therefore, the restoration sites meet Biological Success Criterion 7.

#### **Invertebrate Prey Resource Production (Biological Success Criteria 8)**

*Production of invertebrate prey taxa known to be important to juvenile salmonids should be comparable to that of appropriate reference sites at the end of ten years (EBDRP 2000).*

#### **Background**

This part of the monitoring project is part of an ongoing research effort to understand how invertebrate prey resources colonize and use restored wetland habitats in the Duwamish River estuary. In collaboration with the USFWS and the EBDRP, researchers at the University of Washington have monitored invertebrate populations at the restoration sites three times since their construction. The Kenco Marine site was added in 2007 totaling 4 restoration sites and 2 reference sites on the Duwamish to be sampled once per month from April through June. Specific tasks performed were as

follows: (1) deploy and collect five fallout insect traps (tubs and platforms) in the estuary at each restoration site and respective reference site; (2) collect core samples in the estuaries at all restoration sites and their respective reference sites; and (3) identify invertebrates from the samples. Taxa known to be important to juvenile salmonids are identified to species and enumerated with the remainder identified to order level.

**Table 12. Invertebrate samples by site for 2007.**

<b>Sample Type</b>	<b>Herring's House</b>	<b>Herring's House Ref.</b>	<b>Hamm Creek Estuary</b>	<b>Kenco</b>	<b>North Wind's Weir</b>	<b>NWW Ref.</b>	<b>Total</b>
Fallout insect traps/event	5	5	5	5	5	5	30
Total (all 3 events)	15	15	15	15	15	15	90
Core Samples/event							
Vegetated macrofauna	10	10	10	10	10	10	60
Mudflat macrofauna	10	10	-	10	10	10	50
Mudflat meiofauna	10	10	-	10	10	10	50
Total (all 3 events)	90	90	30	90	90	90	480
Total invertebrate samples	105	105	45	105	105	105	570

### Methods

Sampling for fallout insects from riparian areas and benthic invertebrates from intertidal areas, collectively described as invertebrate prey resources produced, was conducted using the protocols described by Cordell *et al.* (1994, 1999). Invertebrate sampling occurred once a month in March, April, May, and June. Two types of invertebrate samples were collected: (1) fallout insect traps for terrestrial insects, and (2) core samples for aquatic invertebrates. The numbers of traps deployed varied by site and habitat strata present at each site.

Fallout insects were sampled using floating plastic tubs distributed throughout a project site and left out for four days (e.g. placed on Monday, retrieved on Thursday). Benthic invertebrates were sampled with cores taken to a depth of 10 cm with a minimum of 10 replicates in each stratum; including areas of mud, sand flats and areas of marsh vegetation.

At the Hamm Creek restoration and reference sites, monthly invertebrate sampling included placement of five fallout insect traps in the restoration site and five in the reference site. Ten core samples for macroinvertebrates were taken in the intertidal area at the site, but the samples were not stratified in vegetated and unvegetated areas. At the Hamm Creek site, the creek runs through the lower intertidal area, significantly affecting the estuarine invertebrate community of the mudflat. With the freshwater creek flowing over this area during low tide, the invertebrate community is substantially different from the brackish community of the reference area. For this reason, no samples were taken in the mudflat stratum of Hamm Creek restoration and reference sites. At the Herring's House and North Wind's Weir restoration and reference sites, five fallout insect traps were placed in the estuary at each site. In addition to the fallout insect traps, 10 invertebrate core samples were taken from each of the following

habitats: (1) macrofauna in the vegetated region of the higher intertidal zone, (2) macrofauna in the mudflat area of the lower intertidal zone, and (3) meiofauna in the mudflat area of the lower intertidal zone.

### Results

The 2007 monthly invertebrate sampling and analysis task was contracted to Jeff Cordell of the University of Washington School of Aquatic and Fisheries Sciences and results are expected to be available by the end of December of 2008.

#### *Fallout Insects*

For the 2005 monitoring season, Cordell *et al.* (2006) reported that taxa richness for fallout insects was similar among the restored and reference sites with the exception of the upper freshwater channel at Hamm Creek where there was 20 more taxa present than any other site.

#### *Benthic Meiofauna*

Cordell *et al.* (2006) also reported that the taxa richness for meiofauna was similar between restored and reference sites, and was slightly higher at the reference sites. Herring's House had higher taxa richness with about 10 more taxa than the North Wind's Weir site. However, there were no records of the harpacticoid *Cletocamptus* sp., which was reported in previous years.

#### *Benthic Macrofauna*

In 2005, taxa richness for macrofauna was found to be highest at the Herring's House sites as compared to the other two restoration sites. Taxa richness was slightly higher at all reference sites, except for the mudflat location at North Wind's Weir where restored and reference sites were equal (Cordell *et al.* 2006).

Biological Success Criteria 8 states that the production of invertebrate prey taxa known to be important to juvenile salmonids should be comparable to that of appropriate reference sites at the end of ten years (EBDRP 2000). The 2005 data report reflects monitoring year five for Hamm Creek and Herring's House, and year three for North Wind's Weir, with data from Kenco Marine not yet reported. Therefore, making a determination for Biological Success Criteria 8 will be possible for Hamm Creek and Herring's House in 2010.

## SUMMARY

The status of restoration sites in meeting the Physical and Biological Success Criteria are summarized by criterion and the status by survey year is shown in **Table 13** and **Table 14**. The monitoring plan, EBDP (2000), allows for adaptive management of monitoring at the sites as outlined in the following statements: “Elimination of Monitoring Tasks. It is possible that in the future, the Elliot Bay / Duwamish Restoration Program Panel might reach consensus that specific success criteria have been met, and that associated monitoring tasks could cease. Similarly, it could be determined that a monitoring task was not returning useful information, and therefore not worth the expense of continuation.” Monitoring tasks and results were evaluated based on these statements, and options are given for adapting monitoring activities to reflect the current status of the sites.

## PHYSICAL CHARACTERISTICS

### **Intertidal Area (Physical Success Criterion 1)**

*Total restored area between an elevation of +12.0 ft Mean Low Low Water (MLLW) and -2.0 ft MLLW will be at least 90% of the target intertidal elevation for each site. Target intertidal area for the Hamm Creek is 4,047 m<sup>2</sup> (1.0 acre), Herring’s House is 8,094 m<sup>2</sup> (2.0 acres), and North Wind’s Weir is 4,047 m<sup>2</sup> (1.0 acre) (EBDP 2000).*

With the approval of the EBDP Panel, the Hamm Creek and Herring’s House restoration sites were not monitored for intertidal area in 2007. Previously collected data indicated that these sites have been stable since construction (USFWS 2006). Previously collected data also indicated that the North Winds Weir site was stable. This site was monitored in 2007 and will be monitored again in 2010 so there are consistent years of data for the sites. Baseline data was collected for the Kenco Marine site in 2007.

Since construction of the restoration sites, intertidal area estimates varied by  $\pm 0.1$  acre indicating the restoration sites have remained stable over time. Herring’s House exceeds the target intertidal area. Hamm Creek and North Wind’s Weir do not meet the target intertidal area of Physical Criterion 1 because they were not constructed as planned but have remained stable over time.

### **Tidal Regime (Physical Success Criterion 2)**

*Tidal amplitude, as determined by both timing and elevation of high and low tide events, is equivalent inside and outside of the project area (EBDP 2000).*

With the approval of the EBDP Panel, none of the sites were monitored for tidal regime in 2007. Previously collected data indicated that tidal exchange between the restoration sites and Duwamish River estuary was unimpeded (USFWS 2004).

### **Slope Erosion (Physical Success Criterion 3)**

*No evidence of erosion that threatens property, infrastructure, or is otherwise unacceptable, is observed after a period of initial site stabilization (EBDP 2000).*

**Table 13. Success of Hamm Creek and Herring's House restoration sites to meet physical and biological criteria targets by monitoring task and survey year.**

Task	Target	Hamm Creek					Herring's House					
		2001	2002	2003	2005	2007	2001	2002	2003	2005	2007	
Physical Criteria (1-3)												
1	Intertidal area	numerical target	N	N	N	N	.	Y	Y	Y	Y	.
2	Tidal Regime	site equivalent with river	Y	Y	.	.	.	Y	Y	.	.	.
	(years 1 & 5 only)											
3	Slope Erosion	minimal erosion	N <sup>1</sup>	N	N	N	N	N <sup>1</sup>	Y	Y	Y	Y
Biological Criteria (1-8)												
Marsh												
1	areal extent	stable or increasing size	.	N <sup>1</sup>	N	Y	.	.	N <sup>1</sup>	Y	Y	.
1	patch size	stable or increasing size	.	N <sup>1</sup>	Y	Y	N	.	N <sup>1</sup>	Y	Y	Y
2	species composition	compare to reference site	N	N	N <sup>2</sup>	N <sup>2</sup>	Y	N	N	N <sup>2</sup>	N <sup>2</sup>	N <sup>2</sup>
3	plant vigor / shoot height	compare to reference site	N	N	N <sup>2</sup>	N <sup>2</sup>	N	N	N	N <sup>2</sup>	N <sup>2</sup>	N <sup>2</sup>
3	plant vigor / shoot density	compare to reference site	N	N	N <sup>2</sup>	N <sup>2</sup>	N	N	N	N <sup>2</sup>	N <sup>2</sup>	N <sup>2</sup>
Riparian												
4	areal extent	stable or increasing size	Y	Y	Y	Y	N	Y	Y	Y	Y	Y
4	% cover by layer	numerical target / layer	N <sup>1</sup>	N	N	N	Y	N <sup>1</sup>	N	N	N	Y <sup>3</sup>
5	survival (yrs 1-3 only)	> 75% survival	Y	Y	Y	.	.	Y	Y	Y	.	.
Birds												
6	presence/absence	compare to reference site	Y	Y	Y	Y	.	Y	Y	Y	Y	.
Fish												
7	presence/absence	compare to reference site	Y	Y	Y	Y	.	Y	Y	Y	Y	.
Inverts												
8	presence/absence	compare to reference site	.	.	.	.	.	.	.	.	.	.

N<sup>1</sup> first year of data; no comparison possible

N<sup>2</sup> reference site was compromised by disturbance

Y<sup>3</sup> Yes for herbaceous and tree (No for shrub layer)

Y<sup>4</sup> Yes for shrub and tree (No for herbaceous layer)

Extreme erosion occurred at the Hamm Creek restoration site during the winter of 2006/2007. The Hamm Creek site does not meet Physical Success Criterion 3. Herring's House and North Wind's Weir have met Physical Success Criterion 3. The Kenco Marine was assessed for slope erosion in 2007 and none was noted.



**Table 14. Success of North Wind's Weir and Kenco Marine restoration sites to meet physical and biological criteria targets by monitoring task and survey year.**

		North Wind's Weir					Kenco Marine				
Task	Target	2001	2002	2003	2005	2007	2001	2002	2003	2005	2007
Physical Criteria (1-3)											
1	<b>Intertidal area</b>	numerical target	.	.	N	N	.	.	.	.	N
2	<b>Tidal Regime</b>	site equivalent with river	.	.	Y	.	.	.	.	.	.
(years 1 & 5 only)											
3	<b>Slope Erosion</b>	minimal erosion	.	.	N <sup>1</sup>	Y	Y	.	.	.	Y
Biological Criteria (1-8)											
<b>Marsh</b>											
1	areal extent	stable or increasing size	.	.	N <sup>1</sup>	Y	N	.	.	.	N <sup>1</sup>
1	patch size	stable or increasing size	.	.	N <sup>1</sup>	Y	Y	.	.	.	N <sup>1</sup>
2	species composition	compare to reference site	.	.	N <sup>2</sup>	N <sup>2</sup>	Y	.	.	.	N <sup>1</sup>
3	plant vigor / shoot height	compare to reference site	.	.	N <sup>2</sup>	N <sup>2</sup>	N	.	.	.	N <sup>1</sup>
3	plant vigor / shoot density	compare to reference site	.	.	N <sup>2</sup>	N <sup>2</sup>	N	.	.	.	N <sup>1</sup>
<b>Riparian</b>											
4	areal extent	stable or increasing size	.	.	Y	Y	N	.	.	.	N <sup>1</sup>
4	% cover by layer	numerical target / layer	.	.	N <sup>1</sup>	N	Y <sup>4</sup>	.	.	.	N <sup>1</sup>
5	survival (yrs 1-3 only)	> 75% survival	.	.	Y	.	.	.	.	.	N <sup>1</sup>
<b>Birds</b>											
6	presence/absence	compare to reference site	.	.	Y	Y	.	.	.	.	.
<b>Fish</b>											
7	presence/absence	compare to reference site	.	.	Y	Y	.	.	.	.	.
<b>Inverts</b>											
8	presence/absence	compare to reference site	.	.	.	.	.	.	.	.	.

N<sup>1</sup> first year of data; no comparison possible

N<sup>2</sup> reference site was compromised by disturbance

Y<sup>3</sup> Yes for herbaceous and tree (No for shrub layer)

Y<sup>4</sup> Yes for shrub and tree (No for herbaceous layer)

#### **Sediment Structure (Physical Success Criterion 4)**

*Over time, sites will accumulate fine-grained material and organic matter. This would be evidenced by a decrease in mean grain size, and an increase in organic carbon in surface sediments (EBDRP 2000).*

With the approval of the EBD RP Panel the restoration sites were not monitored for sediment structure in 2007. In 2005, it was determined that without threshold values, it would be too difficult to ascertain statistically whether the restoration projects have or will successfully meet Physical Success Criterion 4 as listed in the monitoring plan (EBDRP 2000).

#### **Sediment Quality (Physical Success Criterion 5)**

*No evidence of contamination due to sediment transport or on-site migration of upland contaminants to groundwater or aquatic areas (Herring's House only) (EBDRP 2000).*

Originally, the monitoring plan allocated funds for the installation of three groundwater monitoring wells at the Herring's House site to evaluate the success of Physical Success Criterion 5. Following discussions with their cooperators in 2003, the EBD RP Panel decided not to install monitoring wells at the Herring's House site; therefore, this criterion was not implemented.

### **BIOLOGICAL CHARACTERISTICS**

#### **Marsh Vegetation Establishment (Biological Success Criteria 1-3)**

*The areal extent of vegetation should be stable or increasing (Criterion 1), species composition of native wetland plants should be comparable to appropriate reference sites (Criterion 2) and plant vigor should be comparable to appropriate reference sites (Criterion 3) (EBDRP 2000).*

##### Areal Extent – (Criterion 1)

This criterion had been met for the Hamm Creek, Herring's House, and North Winds Weir sites in 2005. With the approval of the EBD RP Panel, only areal extent of marsh vegetation was collected for the Kenco Marine site. Total area of marsh vegetation patches has varied over the years of sampling. Due to the methodology, some of this variation is likely due to changes in observers and random error. Erosion at the Hamm Creek site in 2007 reduced the extent of marsh vegetation.

##### Species Composition – (Criterion 2)

Species composition of non-target marsh vegetation at restoration sites was comparable to their appropriate reference sites, with the exception of Kenco Marine which was planted in 2007. However, only North Wind's Weir had a percent cover of target species (Lyngby's sedge and bulrush) that was comparable to its reference site.

A clump of reed canarygrass detected in 2005 at Hamm Creek was the only occurrence (within a transect) of an invasive species of special concern at the restoration and reference sites since monitoring began. Additional invasive species of concern were noted at the sites. Yellow flag iris and *Phragmites* remain a concern at the Hamm Creek restoration site. Yellow flag iris is a Class C noxious weed. It likely will not be a problem at other sites due to the absence of freshwater inputs. *Phragmites* forms monotypic stands if allowed to establish at a site. Perennial pepperweed was found at low levels at all of the sites. This species is a Class B noxious weed and greater efforts should be made to keep it from setting seed. Percent cover of nonnative or invasive plant species at the restoration sites was comparable to their associated reference sites.

Biological Success Criteria 2 regarding species composition could be considered to have been met for all the sites with the exception of Kenco Marine. The percent cover of nonnative species portion of

this criterion could be considered to have been met if only transect data is utilized. However, other observances of nonnative species would indicate that this criterion has not yet been met.

#### Plant Vigor – (Criterion 3)

Plant vigor of the target species (Lyngby's sedge and bulrush), was generally better at the reference site than at the restoration sites; however, plant vigor at the restoration sites has been increasing over time. Shoot density at North Winds Weir and Hamm Creek was significantly less than reference. North Wind's Weir restoration site had a significantly larger mean shoot height for Lyngby's sedge than its associated reference site. Shoot height at the Hamm Creek restoration site was greater than 80% of the reference. These two restoration sites partially meet Biological Success Criteria 3.

#### **Riparian Vegetation (Biological Success Criteria 4 and 5)**

*The areal extent of vegetation should be stable or increasing over time, and cover not less than 90% of the upland vegetated area of each project site at the end of 10 years, and invasive plant coverage should be minimal (Criterion 4). Survival of riparian plantings in each cover class (herb, shrub, and tree) should be at least 75% at the end of 3 years (Criterion 5) (EBDRP 2000).*

#### Areal Extent/Percent Cover/Invasives – (Criterion 4)

The total areal extent of riparian vegetation at the restoration sites decreased in 2007, but the entire upland area remains covered and has not more than 20 percent cover of nonnative species. All restoration sites have less than 10 percent bare ground in the herbaceous layer. None of the restoration sites have greater than 50 percent shrub cover and only North Wind's Weir has greater than 40 percent tree cover. Because of the removal of nonnative species and the addition of supplemental plantings by other entities, the value of our sampling data to monitor the natural succession at the sites is limited. The data show the current condition of the site after an unknown amount of riparian vegetation manipulation at the site.

The restoration sites in 2007 met Biological Success Criterion 4 only in part since percent cover at two of the three sites met only a portion of the three cover classes and total areal extent of riparian vegetation decreased overall. Percent cover of vegetation layers can no longer be accurately assessed due to undocumented plant maintenance work at some of the sites. Biological Success Criterion 4 no longer appears to be returning useful information on the natural succession at the sites and it is unknown if meeting this criterion is ultimately obtainable under the current circumstances. If an estimate of current conditions of the sites undergoing vegetation maintenance is still desired, then continued monitoring may provide some useful information.

#### Survival – (Criterion 5)

Riparian plant survival surveys were scheduled for Years 1-3 only. Monitoring during the first 3 years indicated all restoration sites had at least 75 percent survival plantings in each cover class (herb, shrub, trees). Biological Success Criteria 5 has been met and monitoring tasks ceased after Year 3 for all sites with the exception of the newly planted Kenco Marine site which will be monitored for survival in the next monitoring period.

#### **Bird Use (Biological Success Criterion 6)**

*Use of the restoration sites and the area within 50 meters of the site by indigenous/native bird species should be comparable to that of the appropriate reference sites (EBDRP 2000).*

Numbers of bird species were comparable between the Hamm Creek, Herring's House, and North Wind's Weir restoration sites and their respective reference sites in 2005. With the approval of the EBD RP Panel, it was agreed that biological Success Criterion 6 for bird use had been met and bird use monitoring was concluded following the 2005 monitoring.

#### **Fish Presence/Access (Biological Success Criterion 7)**

*Estuarine fishes will access the project sites. Juvenile salmonid presence within the project sites should be comparable to that of appropriate reference sites at the end of ten years (EBDRP 2000).*

Biological Success Criterion 7 for fish access / presence was determined to have been met following the 2005 monitoring season, and with the approval of the EBD RP Panel fish access/presence monitoring was concluded following the 2005 monitoring season.

#### **Invertebrate Prey Resource Production (Biological Success Criteria 8)**

*Production of invertebrate prey taxa known to be important to juvenile salmonids should be comparable to that of appropriate reference sites at the end of ten years (EBDRP 2000).*

The 2005 invertebrate report by Jeff Cordell of the University of Washington was submitted in 2006 and the 2007 invertebrate report will be available by the end of December of 2008. Making a determination for Biological Success Criteria 8 will be possible by 2010 for both Hamm Creek and Herring's House sites.

### **RECOMMENDATIONS**

#### **Coordination**

Other activities including: monitoring and research efforts, vegetation management, restoration and construction activities on or near the four restoration sites and their associated reference sites continue to compromise, at least in part, the ability of this monitoring effort to generate the intended information originally set forth by the EBD RP Panel in 2000. For example, well-intentioned restoration and vegetation management activities on the current restoration and reference sites typically are not coordinated with this monitoring effort or considered prior to their implementation. As noted in previous years, effective coordination using a primary contact was recommended as one option for information exchange and to decrease the potential for overlap of effort or conflicting activities at these sites. The EBD RP Panel should consider from this point forward the usefulness of the data currently collected by this monitoring program and make the necessary changes to best utilize this effort for 2010 and beyond. We believe the time to begin these discussions is well in advance of the next monitoring period and with the Panel's approval, we will provide a more detailed set of recommendations on how to best collect the most meaningful information with regard to the four restoration sites.

#### **Site Stewardship**

Success of the restoration sites in partially meeting vegetation goals continues to be attributed to, at least in part, the removal of nonnative and invasive species by other entities and volunteers. A significant effort has been applied to controlling invasive species, planting additional vegetation, replacing dead

plants, removing trash and debris, and constructing erosion control measures. Continued site stewardship remains a vital part of maintaining valuable restored habitats at these sites. However, with many different entities working on site maintenance, it is difficult to quantify the effort and resources expended. Quantifying the effort devoted to the sites by maintenance crews, volunteer organizations, and others would help in assessing the level of effort being placed towards the success of the restoration sites. We continue to support the development of a process that improves coordination between monitoring and site stewardship activities enabling increased complementary efforts and overall site success. The capacity of the land management entity and volunteer groups to support continued site stewardship needs to be evaluated and any gaps resolved.

Unallocated and/or additional funds should be directed towards supporting site stewardship activities with a specific focus on controlling invasives. Hamm Creek for example, should be evaluated for its extent of invasives such as the common water reed (*Phragmites communis*), and yellow flag iris (*Iris pseudacorus*) while populations of these species are still relatively small and manageable. Common water reed was listed in the EBD RP monitoring plan as an invasive species of special concern.

As mentioned in the report, other invasive species were noted during the 2007 monitoring event besides the four invasive plant species of special concern listed in the EBD RP monitoring plan. These species included yellow flag iris and perennial pepperweed (*Lepidium latifolium*). Yellow flag iris is listed as a Class C noxious weed and perennial pepperweed is listed as a Class B weed in Washington State. It will be critical for future success of these sites to control occurrences of these invasives while they are relatively small in number and while control methods have a negligible impact on site restoration efforts.

### **Monitoring Changes**

The monitoring plan states that one goal of the program is to provide “a useful tool to others interested in estimating habitat restoration project monitoring costs” (EBDRP 2000). The original design of the monitoring plan (EBDRP 2000) was not sufficient to provide adequate sample sizes to effectively evaluate success of monitoring criteria and the plan underestimated the costs associated with many of the monitoring tasks in this project. Large standard errors were detected after analysis of the data from the first few years of the project. We noted in our previous reports that increasing sample sizes could lower the standard error but recognized large increases in sample sizes would not be within the budget framework originally conceived for this effort. Therefore, by concentrating funds on fewer criteria to monitor with more intensity during 2007, we have established a better prospect of reaching more reliable conclusions with better statistical evaluation when appropriate.

In addition, we believe the time period in which to collect the data with regards to vegetation should be re-evaluated. Collecting data for riparian vegetation at the same time as marsh vegetation may not take into account the differences in growing season for each vegetation type and therefore may not be returning the best result for the data collected. We are currently evaluating this with regard to Biological Success Criteria 5 for riparian plant survival for the newly constructed Kenco Marine site.

We also advocate the use of aerial photography for each site and believe this information would contribute in a more meaningful way in the overall determination of how well the sites have done from year to year both in physical attributes as well as biological. Photographic comparisons are often useful in determining larger scale alterations or successional progressions over time.

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## **APPENDICES**

**Appendix 1.** Riparian plant species observed at the restoration sites and their reference sites in 2001-2005. An asterisk(\*) denotes species included in nonnative percent cover estimates.

Scientific name	Common name	Scientific name	Common name
<i>Abies grandis</i>	Grand fir	<i>Lonicera involucrata</i>	Black twinberry
<i>Acer circinatum</i>	Vine maple	<i>Lotus corniculatus</i>	Birds-foot trefoil*
<i>Acer macrophyllum</i>	Big Leaf Maple	<i>Mahonia sp.</i>	Oregon-grape
<i>Agrostis sp.</i>	Bentgrass*	<i>Malus fusca</i>	Pacific crabapple
<i>Alnus rubra</i>	Red alder	<i>Medicago hispida</i>	Bur clover*
<i>Amelanchier alnifolia</i>	Serviceberry	<i>Melilotus alba</i>	White sweet clover*
<i>Ammophila arenaria</i>	Beach grass*	<i>Oemleria cerasiformis</i>	Indian-plum
<i>Anaphalis margarita</i>	Pearly everlasting	<i>Oxalis sp.</i>	Oxalis
<i>Anthemis cotula</i>	Dog Fennel*	<i>Phalaris arundinacea</i>	Reed canary grass*
<i>Anthoxanthum odoratum</i>	Sweet vernal grass*	<i>Philadelphus lewisii</i>	Mock orange
<i>Arbutus menziesii</i>	Pacific madrona	<i>Physocarpus capitatus</i>	Pacific ninebark
<i>Arctostaphylos uva-ursi</i>	Kinnikinnick	<i>Picea sitchensis</i>	Sitka spruce
<i>Asclepias sp.</i>	Milkweed*	<i>Pinus contorta</i>	Lodgepole pine
<i>Aster subspicatus</i>	Douglas aster	<i>Plantago sp.</i>	Plantain
<i>Atriplex patula</i>	Orache	<i>Poa sp.</i>	Poa (grass)
<i>Atropa belladonna</i>	Nightshade*	<i>Polygonum sp.</i>	Knotweed*
<i>Betula sp.</i>	Birch	<i>Polystichum munitum</i>	Sword fern
<i>Buddleja sp.</i>	Butterfly bush*	<i>Populus balsamifera</i>	Black cottonwood
<i>Callitriche sp.</i>	Water star-wort	<i>Potentilla anserina</i>	Pacific silverweed
<i>Carex lyngbyei</i>	Lyngby's sedge	<i>Pseudotsuga menziesii</i>	Douglas fir
<i>Chenopodium album</i>	Lambs-quarters*	<i>Quercus sp.</i>	Oak
<i>Cirsium arvense</i>	Canada thistle*	<i>Rabinia sp.</i>	Black locust
<i>Cirsium vulgare</i>	Bull thistle*	<i>Ranunculus repens</i>	Creeping buttercup*
<i>Conium maculatum</i>	Poison hemlock*	<i>Rhamnus purshiana</i>	Cascara
<i>Convolvulus arvensis</i>	Morning glory*	<i>Ribes sanguineum</i>	Red-flowering currant
<i>Cornus nuttallii</i>	Pacific flowering dogwood	<i>Rosa nutkana</i>	Nootka Rose
<i>Cornus stolonifera</i>	Red-osier dogwood	<i>Rubus discolor</i>	Himalayan blackberry*
<i>Cotula coronopifolia</i>	Brass buttons	<i>Rubus laciniatus</i>	Evergreen blackberry*
<i>Crataegus douglasii</i>	Black Hawthorne	<i>Rubus parviflorus</i>	Thimbleberry
<i>Cytisus scoparius</i>	Scot's Broom*	<i>Rumex crispus</i>	Curled Dock*
<i>Distichlis spicata</i>	Saltgrass	<i>Salicornia pacifica</i>	Pickleweed
<i>Eleocharis palustris</i>	Creeping spikerush	<i>Salix hookeriana</i>	Hooker's willow
<i>Eleocharis parvula</i>	Small spike rush	<i>Salix lucida</i>	Pacific willow
<i>Elyptigia repens</i>	Quackgrass	<i>Salix sitchensis</i>	Sitka willow
<i>Epilobium angustifolium</i>	Fireweed	<i>Scirpus acutus</i>	Hard-stemmed bulrush
<i>Epilobium sp.</i>	Willowherb	<i>Scirpus americanus</i>	American bulrush
<i>Equisetum sp.</i>	Horsetail	<i>Scirpus maritimus</i>	Seacoast bulrush
<i>Festuca arundinacea</i>	Tall fescue*	<i>Scirpus validus</i>	Soft stemmed bulrush
<i>Festuca rubra</i>	Red fescue	<i>Senecio vulgaris</i>	Common groundsel*
<i>Glaux maritima</i>	Sea milkwort*	<i>Sonchus sp.</i>	Sow-thistle*
<i>Hedera sp.</i>	English ivy*	<i>Spergularia canadensis</i>	Canadian sandspurry
<i>Holcus lanatus</i>	Common velvetgrass*	<i>Spiraea douglasii</i>	Hardhack
<i>Holodiscus discolor</i>	Ocean spray	<i>Symphoricarpos albus</i>	Common snowberry
<i>Hypericum sp.</i>	St. Johns wort*	<i>Tanacetum vulgare</i>	Common tansy*
<i>Hypochaeris radicata</i>	Hairy cat's-ear*	<i>Thuja plicata</i>	Red cedar
<i>Juncus bufonius</i>	Toad rush*	<i>Trifolium pratense</i>	Red clover*
<i>Juncus uncialis</i>	Inch-high	<i>Trifolium repens</i>	White clover*
<i>Lactuca serriola</i>	Prickly lettuce*	<i>Triglochin maritima</i>	Seaside arrowgrass
<i>Lilaeopsis occidentalis</i>	Western lilaeopsis	<i>Verbascum thapsus</i>	Great mullein
<i>Lolium perenne</i>	Rye grass*	<i>Vicia sp.</i>	Vetch

