

2016 WEDA Environmental Excellence Award Nomination

Boeing's Plant 2 Sediment Remediation and Urban Waterway Restoration

Duwamish Waterway
Seattle, Washington

From a camouflaged bomber plant that helped win World War II



To an invaluable natural habitat.



The Boeing Company



Summary

Boeing recently completed a major, multi-faceted environmental restoration of a one-mile portion of the Duwamish Waterway, removing contaminated sediments and creating acres of new aquatic habitat critical for endangered salmon migration. The innovative remediation dredging methods (RDM's) developed for the project successfully demonstrated that contaminated sediment can be removed efficiently without adverse release of chemicals to the water and without leaving a residual layer of contaminated sediment on the bed of the waterway after dredging.

The birthplace of the Boeing Company and the B-17 Flying Fortress bomber that was critical to national defense during World War II (photos 1 & 2) is now home to salmon habitat and the start of big changes for Seattle's Duwamish Waterway.

The project addressed more than a century of impacts from industrialization along the waterway and throughout the entire watershed. This restoration effort is highlighted by making significant strides in creating and restoring wildlife habitat in the form of vegetated marsh and riparian areas where industrial activities previously occurred.

Rather than work through traditional environmental restoration and remediation programs one at a time, Boeing engaged multiple agencies and stakeholders to combine shoreline restoration and environmental dredging into a single project to achieve environmental benefits sooner and with less community disruption. In doing so, Boeing was awarded an Excellence in Restoration award from the National Oceanic and Atmospheric Administration (NOAA) for completing the largest single restoration project on the Duwamish Waterway.

The integration of cleanup with habitat restoration, which included creation of off-channel habitat and intertidal wetlands, allowed the overall project to be completed in a shorter timeframe, thereby reducing its impact on local residents and other waterway users during the construction phase and allowing the positive environmental benefits to occur sooner.

In addition to NOAA, the project has been recognized by major stakeholders—including local residents and tribes, and the US EPA—for its collaborative efforts to improve the environment on the Duwamish Waterway.

Project team members

Owner	The Boeing Company (Nominating Entity)	
Engineers	Amec Foster Wheeler: Investigation, Shoreline and Habitat Construction Design and Oversight (WEDA member)	
	Dalton, Olmsted & Fuglevand, Inc. (DOF): <ul style="list-style-type: none"> Sediment Remediation Design and Construction Management/Oversight (WEDA member) 	
Contractors	Prime contractor: Envirocon, Inc. (WEDA member)	
	Subcontractors: Quigg Bros., Inc.; Ballard Diving & Salvage; Waste Management	
Stakeholders	South Park Community	US Environmental Protection Agency
	Muckleshoot Indian Tribe	National Marine Fisheries Service
	Suquamish Tribe	US Fish and Wildlife Service
	Cities of Tukwila and Seattle	US Army Corps of Engineers
	Port of Seattle	Washington Department of Ecology
	NOAA Restoration Office	Washington Department of Fish and Wildlife

Environmental benefits

Boeing's Plant 2 project is a showcase of urban waterway restoration, employing dredging to restore and enhance the Duwamish Waterway's ecological health while improving the overall waterfront area. This has resulted in numerous socio-economic benefits for two neighboring residential communities and other waterway users, including tribal and recreational fishers that rely on the waterway and its historic salmon run.

The project's environmental benefits for generations to come can be seen in the way the work was performed and in the dramatic transformation of a nearly one-mile stretch of the Duwamish Waterway. ([photos 3 and 4](#))

"The National Oceanic and Atmospheric Administration's Restoration Center, the branch of NOAA dedicated to restoring vital habitat, on Friday will present Boeing with an 'excellence in restoration' award for completing the largest single restoration project thus far on the Duwamish Waterway."

Will Stelle, Administrator of the West Coast Region of NOAA Fisheries, June 18, 2015

Project metrics

- **Dredged 163,000 cubic yards** of contaminated sediment from the waterway using project-developed enhanced dredging approaches. ([photo 5](#))
- **Eliminated release, resuspension, residuals (3Rs)** normally associated with remediation dredging through newly developed remediation dredging methods (see Innovation).
- **Removed historic over-water buildings** as well as 700 creosote treated pilings, converting an industrial-debris covered and darkened shoreline to valuable intertidal habitat.
- **Excavated 50,000 cubic yards** of intertidal and shoreline sediment, soil and debris using precision excavation equipment.
- **Placed 190,000 cubic yards** of sand and gravel to reshape the shoreline and waterway bed following dredging and excavation to establish environmentally valuable intertidal and subtidal habitat. ([photos 6 & 7](#))
- **Implemented a green infrastructure using enhanced passive stormwater management** to significantly upgrade water discharged into the waterway from Boeing's 100-acre facility, to protect the waterway from sediment recontamination from our facility.
- **Created or restored five acres of habitat** for fish, birds, and other wildlife along this vital salmon migration corridor. ([photo 8](#))
- **Planted 170,000 native plants** and installed 13 woody debris mounds as shoreline refuge for juvenile salmon and steelhead throughout the new and improved aquatic habitat. ([photo 9](#))

Unique challenges

Not spreading contamination in the waterway during dredging. The US EPA, concerned about potential contaminant releases in the waterway during dredging (3Rs), asked Boeing to construct a massive wall around the dredging project. Because of its significant adverse consequences—including obstruction to navigation, flow constriction, bed scour outside the wall spreading contaminants downstream, and its hindrance to efficient dredging operations and barge movement—Boeing proposed an alternative solution: using 10 specific remediation dredging methods (RDM) developed to reduce and eliminate potential adverse consequences from dredging without the negative environmental consequences of the wall. Following intensive review by the US EPA, the US Army Corps of Engineers, and the local citizen technical advisory group, the RDMs were adopted and implemented (see Innovations)—resulting in no measurable release of contamination to the waterway during the project.

- **Protecting salmon and tribal fishing.** Salmon—including Puget Sound Chinook salmon, which are protected by the US Endangered Species Act—are a critical part of the environment and cultural history of the Pacific Northwest. Limiting the impact on salmon during construction was an important goal. Therefore, dredging was suspended each year from March through August, which is a critical time for out-migrating juvenile salmon. Boeing also worked with the Muckleshoot Indian Tribe to support their fishing during the project by coordinating the daily movement of multiple sediment barges with their activities. ([photo 10 – tugboat and nets](#))

- **Respecting residential neighbors.** On the waterway’s west bank is the residential neighborhood of South Park. To reduce the project’s impact on residents there, the US EPA initially restricted in-water work to daylight hours. However, discussions between Boeing and its longtime neighbors revealed that they were concerned about extending the project’s duration if work were limited to daytime. Boeing proposed a pilot 24/7 workweek in combination with strict best-management practices for noise and light control. The pilot was successful and the US EPA and the neighbors agreed to allow day and night work for three seasons. Over the course of the project, there were only two issues with neighbors, both quickly resolved.
- **Creating a habitat with limited available urban land.** Creation of the industrial waterway in the early 1900s resulted in the loss of about 95 percent of the estuary’s natural habitat. Existing waterfront land available to create and restore ecologic habitat was scarce; so, to create the necessary land, Boeing combined an aggressive program of demolition, remediation, and restoration, converting nearly a mile of hardened shoreline into critical aquatic habitat. Based on the project’s success, Boeing received the “Excellence in Restoration” award from NOAA for setting a high standard for urban waterway restoration.
- **Coordination with active bridge construction and two other remedial projects.** Additional project coordination and navigational challenges arose when King County began construction of a new bridge bisecting Boeing’s project and when two neighboring businesses began their own remedial actions on adjacent sites. *(photo 11)*

Mitigation measures to provide environmental benefits

- The Duwamish Valley has the highest-ranked air pollution in Seattle. To mitigate emissions that would be generated by shipping thousands of truckloads of dredged material to landfills, Boeing developed barge and rail transportation capabilities to move the material with reduced air emissions.
- To address the potential of future waterway recontamination from our stormwater discharges, multiple state-of-the-art treatment systems were constructed along the waterway to improve the quality of the more than 250 million gallons of stormwater entering the Duwamish from Boeing sites each year. In addition, outfalls from the systems were buried below the intertidal shoreline and discharged 150 feet off shore to avoid erosion of the restored habitat.
- To mitigate the resuspension and release of contaminants during dredging, as well as the formation of a post-dredging contaminated sediment layer (residuals), the project team developed and implemented RDMs that successfully reduced and eliminated measurable resuspension, release, and residuals as evidenced by excellent water quality monitoring results throughout the project.

Working with nature

Because of the project’s intertidal location on an urban waterway, a number of “engineering with nature” principles were incorporated into the design and construction.

- Native vegetation was extensively used, including pre-vegetated mats to stabilize the shoreline and provide improved environmental benefits, as opposed to typical hardened stabilization measures. *(photo 12)*

Rather than fighting nature by building a sheet pile wall around the site to limit resuspension and release of contaminants downstream during dredging, the project developed RDMs to be able to work in a naturally flowing waterway while specifically reducing and eliminating the release and resuspension normally associated with dredging.

- The site’s 14-foot tidal range was used to optimize the dredging program. Deeper water areas were often dredged during low tide to reduce the distance to the waterway bed and improve dredging cycle times. Shallow areas were dredged during high tides to provide necessary draft for equipment.
- Passive stormwater management was implemented using enhanced bio-filtration prior to discharge through extended outfalls, thereby protecting the shoreline habitat, sediment, and water quality. *(photo 13)*

Innovations

Two attitudes influenced the innovations that contributed to the successful restoration of a major portion of one of the most heavily polluted waterways in Washington: “Do it right the first time” and “Dredging residuals don’t have to happen.”

Leadership

The project demonstrated leadership by taking steps beyond “traditional” environmental dredging that led to a number of successful outcomes.

- Rather than work through traditional environmental restoration and remediation processes, Boeing engaged multiple agencies and stakeholders to combine shoreline restoration and environmental dredging into a single project to achieve environmental benefits sooner and with less community disruption.
- Advancing the state-of-the-art of precision dredging technology—using electronic-sensor equipped excavators to remove targeted contaminated sediment while virtually eliminating the overdredging of underlying clean material—significantly reduced overall project volume.
- Instead of pursuing the “lowest construction cost” approach, Boeing chose to incorporate new dredging technologies to not only remove the target material, but to do so with new methods that had the potential to significantly reduce the adverse impacts from dredging. Implementation of the RDMs resulted in virtual elimination of measurable releases of contaminants and formation of post-dredging contaminated sediment layers.
- Boeing partnered with the Muckleshoot Indian Tribe, which has usual and accustomed rights to fish on the waterway, to improve their operations by installing new attachments for their fish nets.
- The project team actively reached out to and worked with individuals in the community. By developing personal relationships, Boeing was able to understand and accommodate their needs while gaining their support for the project.

Breaking new ground with methods/technologies

The project used a number of new approaches to address the environmental challenges.

- The use of typical chemical flocculants was made impracticable by the Washington water quality authority, so—for the first time on a dredging project—a state-of-the-art treatment system was developed for 44 million gallons of dredge return water using electro-coagulation.
- Throughout the project, an on-board dredge engineer—sitting beside the dredge operator—was used. *(photos 14 and 15)* The engineer, who was knowledgeable about the project design and objectives, worked with the operator to implement the RDMs, freeing the operator to focus on dredging precision and productivity. The engineer-operator team was a key factor in the success of the RDMs and elimination of releases. Also, it was credited with improving dredging productivity over what could be achieved by the operator working alone.
- Rather than traditional unit price or lump-sum contracting, a cost-plus form of agreement was used with the dredging contractor, allowing for refinement of operations during the project as necessary. This provided the appropriate balance between productivity, precision, and environmental protectiveness. The procurement process also emphasized the importance of selecting a contractor with both the required environmental dredging skills and a proven ability to work as part of a team with common objectives.

Economic benefits

Cost-effective methods

Cost effectiveness was measured in terms of achieving the restoration and remediation goals in an environmentally protective manner that minimized disruption to the community.

- **RDMs.** The RDMs were developed specifically to allow dredging of the targeted contaminated sediment, eliminating the need and associated cost for a massive wall. Dredging proceeded in an efficient, cost-effective manner that resulted in no measurable downstream releases of polychlorinated biphenyls (PCB) and reduced project duration and impact on the community while maintaining environmental quality.

Remediation Dredging Methods (RDMS)

- Complete a detailed delineation of the target sediment as a 3D geospatial digital terrain model (DTM) before dredging
- Dredge target sediment using an electronically instrumented precision excavator (+/- 4-inch accuracy) with DTM electronic display of target sediment.
- Dredge using an enclosed double-arc closing environmental bucket to limit sediment remolding.
- Dredge to design DTM and immediately place a sand cover
- Dredge target sediment in layers to avoid over-steepened slopes and bank failures
- Collect free water from dredge bucket and barge and remove contaminants before discharge back to the waterway
- Employ a two person team of engineer and operator in the dredge cab to implement the RDMS, improve environmental outcomes and increase dredge productivity.

- **On-board dredge engineer.** Teaming a full-time, on-board dredge engineer with the dredge operator resulted in a cleaner, faster, and lower-cost project, when compared to more conventional methods that would have resulted in greater residuals, releases, dredge volumes and disposal costs. Having the engineer monitor implementation of the RDMS, the dredge plan, stair-step dredge cuts, and barge loading and status—as well as coordinate upcoming stepping and moving of the dredge—allowed the dredge operator to focus solely on optimizing dredge operation. As a result, the precision of the dredging improved, overdredging below the target elevation was reduced or eliminated, and cycle time, bucket fill factor, and effective working time all improved.

Socio-economic aspects

Plant 2 is located near two residential neighborhoods on the Duwamish—South Park and Georgetown—that provide homes and local jobs for thousands of people. The project has provided local citizens with obvious and measurable socio-economic benefits related to the removal of industrial buildings, improved views from adjacent residential areas, improved use of the waterway, decreased noise, and improved fishing opportunities for both recreational and tribal fishermen.

- **Building demolition.** The old, multi-story industrial buildings that overhung the intertidal area imposed on the waterway. Their demolition improved views and provided more light for adjacent residents and enhanced the overall atmosphere of the waterway.
- **Habitat restoration.** Reshaping the area from an industrial-armored shoreline to a more natural habitat by planting more than 170,000 plants and trees has provided a better habitat for birds and other wildlife and helped reduce noise and improve views for waterfront residents. In addition, restoration of this vital tribal fishing area—along with the installation of seven net attachment pilings—has provided considerable economic benefits to the hundreds of local tribal members who depend on the waterway for seasonal jobs.

Contribution to the economy

In addition to the obvious short-term economic benefits, the restored habitat and reuse of vital upland industrial property within this important manufacturing and industrial corridor of Seattle has improved conditions for local residents that will provide a variety of economic benefits for decades to come.

The multiple years of construction—as well as the previous decades of studies—have provided jobs at levels ranging from temporary construction labor to highly trained professionals.

While completion of the project results in a loss of these temporary jobs, it paves the way for future employment opportunities and support of local community businesses as a result of the usable industrial space now available for Boeing's future growth.

Better views and an improved waterway atmosphere should also result in long-term economic benefits for local residents through higher land values.

Transferability

The Plant 2 project produced many lessons that will benefit future sediment remediation and habitat restoration projects.

- **Integrated remediation and restoration.** Demonstrated that environmental remediation and restoration liabilities can be effectively addressed simultaneously, improving efficiencies and thereby producing positive results in a shorter timeframe.
- **RDMs— dredging without residuals.** Demonstrated that RDMs can be applied to a dredging project in a manner that reduces the 3Rs while maintaining dredge productivity without the need for a massive wall.
- **On-board dredge engineer.** Demonstrated that employing an on-board dredge engineer can improve dredge quality, improve efficiency, and virtually eliminate overdredging and residuals.
- **Public outreach.** Demonstrated that active one-on-one engagement with project stakeholders builds trust and results in projects that address community needs while completing dredging in a cost-effective and protective manner. ([photo 16](#))
- **Dredge return-water treatment.** Demonstrated that electro-coagulation technology is a viable alternative to the use of chemical flocculants to remove solids from dredge return water.

Outreach and education

Boeing took multiple, ongoing steps to reach out and engage the local community, thereby educating the public about the project and, just as importantly, educating Boeing employees about the true concerns of citizens. ([photo 17 – Local child looking at project poster](#))

Many of the neighboring 38,000 residents live in close proximity to the waterway, requiring work to be performed practically in their backyards, day and night. To prevent issues, Boeing made considerable effort to coordinate the project with them.

In 2011, two years before construction began, Boeing’s remediation project manager began to personally engage with Boeing’s neighbors at monthly Neighborhood Association meetings. Continued attendance during construction kept neighbors informed of the project’s progress and upcoming activities so they knew what to expect (no one likes surprise construction in their backyard at 2 a.m.).

More than 2,000 mailers were sent to residents who were likely to be affected by the project. The mailers explained what was being done and provided contact information. In addition, a hotline was established so issues and concerns raised by residents during construction—such as nighttime lights and noise—could be promptly addressed.

“Boeing really listened to what the community wanted and actually implemented a more stringent cleanup than possibly could have been required. We’re excited that the cleanup was done with a lot of care and integrity.”

Bill Pease, community resident

Working with tribal fishermen

Significant effort was taken to coordinate the cleanup and habitat restoration with more than 100 Muckleshoot Indian Tribe fishers who have fishing rights along the waterway. ([photo 18](#))

Years were spent working with tribal representatives to figure out how dredging and net fishing could take place simultaneously. Once dredging began, there was daily communication with the tribe during the fishing season to ensure successful coexistence of dredging and fishing.

In addition to developing ways that dredging could go on without risking damage to the fishing nets, convenient attachments were provided so tribal fishermen could anchor their nets without disturbing the newly replanted habitat. Thanks to the numerous meetings and extensive planning, fishing went on seamlessly during the three years of dredging, and the project resulted in improved tribal fishing for future generations.

Acting as an ambassador

Because of the project’s success, Boeing received NOAA’s “Excellence in Restoration” award and was asked by NOAA to act as an ambassador for the promotion of other efforts to restore urban estuaries in the Pacific Northwest. As a first step, in November 2015, Boeing shared its restoration expertise and lessons learned at a daylong NOAA workshop that brought together restoration practitioners working along the Duwamish Waterway.



Photo 1 – A 26-acre make-believe village was constructed on top of Plant 2 to provide wartime cover. The Army Corps of Engineers dismantled the canvas cottages, wire mesh trees, and burlap lawns in 1946.



Photo 2 – On April 9, 1945, the 6,981st and last B-17 Flying Fortress built for World War II at Plant 2 rolled off the assembly line.



Photo 3 – North Habitat Area



Photo 4 – South Habitat Area



Photo 5 – Dredging of the waterway to remove contaminated sediment and restore intertidal habitat.

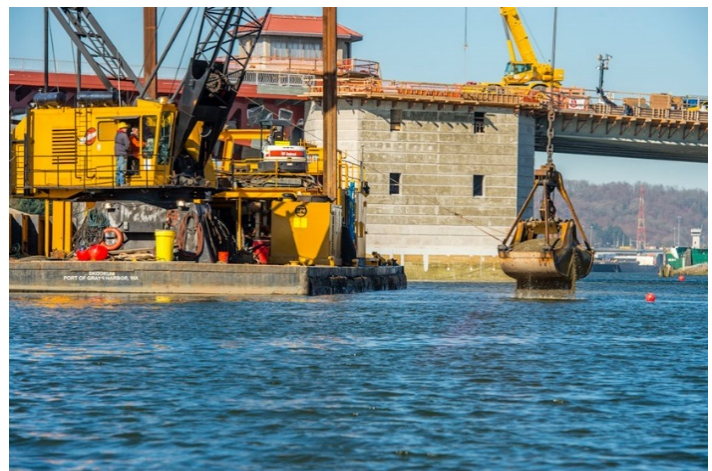


Photo 6 – Placing backfill to restore habitat after dredging to remove impacted sediments.

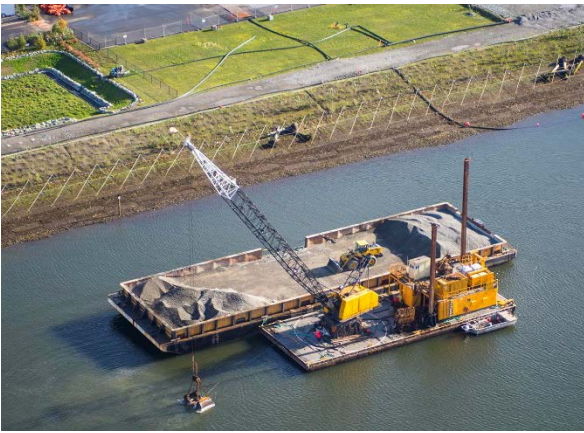


Photo 7 – Placing clean sand to restore intertidal habitat.



Photo 8 – North Habitat Area.



Photo 9 – Installing Native Plants using pre-vegetated mats



Photo 10 – Tug navigating tribal fishing nets marked by buoys to perform work without impacting Tribal fishing.

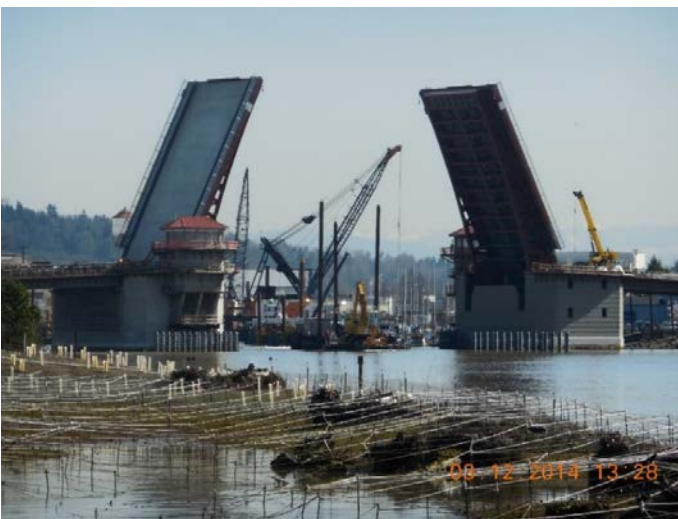


Photo 11 – Construction of a new bridge bisecting the project created challenges for access.



Photo 12 – Installation of pre-vegetated mats in habitat area.

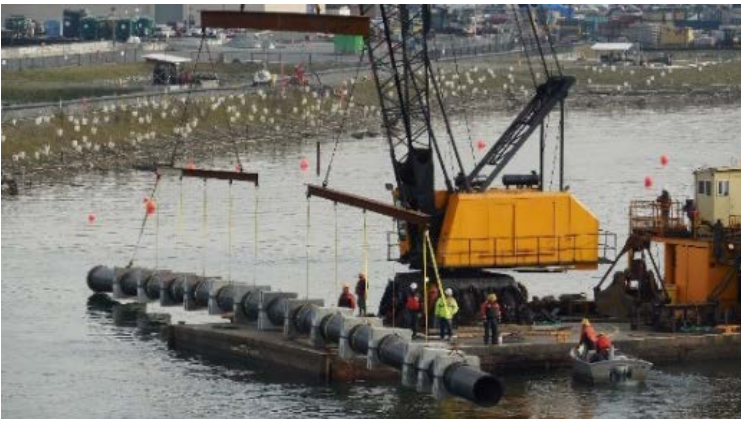


Photo 13 – Floating cranes position 110' long outfall pipe for installation as part of improved stormwater system.



Photo 14 – Engineer in cab working with operator provides efficient, focused operation.



Photo 15 – Precision instrumented fixed arm excavator dredge provides needed accuracy.



Photo 16 – Working in the “backyard” of local residents 24 hours per day required committed coordination.



Photo 17 – Boeing keeps the community informed of its cleanup and restoration efforts by participating in the Duwamish River Festival, neighborhood association meetings, and boat tours.



Photo 18 – The Duwamish Waterway is an important active fishery for the Muckleshoot Tribe.