The WRIA 9 Marine Shoreline Monitoring and Compliance Project
Phase 2 Final Report

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King County

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King County
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EXECUTIVE SUMMARY

Salmon recovery organizations have been restoring marine shorelines of King County since Chinook salmon were listed as threatened under the Endangered Species Act (ESA) two decades ago. This report explores an urgent question: "Is the progress restoring marine shorelines being offset by new actions that degrade habitat, and if so, were those actions permitted?"

Why was this study done?

A primary strategy to recover Chinook in the marine environment is to reduce existing shoreline armoring (e.g. bulkheads) and limit new armoring. ESA-listed Puget Sound Southern Resident Orcas feed mostly on Chinook salmon, including fish from central Puget Sound rivers. Consequently, one of the three primary actions recommended by the Southern Resident Orca Task Force is to recover Chinook salmon through habitat restoration and protection. To support these salmon recovery efforts, King County studied changes in shoreline armoring and other shoreline infrastructure in two phases. The first phase, or pilot study, concluded in 2014 and led to improved community awareness and permit compliance. A variety of outreach actions occurred on Vashon and Maury Islands to raise awareness of ecological issues associated with shoreline armoring and the need for permits for various shoreline actions. The second phase of the study began in 2016 and concluded in 2018.

What did we expect to find?

We hypothesized the type and number of shoreline changes would be similar to what was documented in phase one of the study, with most of the changes related to repairs to existing infrastructure. The basis for this was that over 60 percent of the shoreline within King County is armored so the potential for new armoring is relatively low.

Given what was seen in the pilot study, we expected that about a third of shoreline modifications would be categorized as not having obvious long-term effects. Furthermore, we hypothesized that the total amount of shoreline armoring would decline from 2014 to 2018. Our reasoning was that three bulkhead removal projects had occurred since 2014 and that with improved compliance, new armoring would be minimal.

We hypothesized outreach efforts to shoreline landowners would increase compliance with environmental regulations in unincorporated King County, where the outreach efforts were focused.

The phase two study evaluated compliance with state and local permits, which was defined as a landowner getting a permit prior to undertaking work that required a permit. We hypothesized compliance rates would be similar for both permit types based on the

assumption that staff from each agency would make applicants aware of the need for permits from the other.

What did we observe?

The phase two project undertook surveys in 2016 and 2018, and found a total of **284 changes in shoreline condition over the five-year period since the last phase one survey**. These shoreline modifications were similar in type and proportion of those documented in the pilot study. All modifications associated with shoreline armoring accounted for almost 50 percent (136) of the changes. Of that 50 percent, 30 percent of the changes were major repairs to or the replacement of existing shoreline armoring, while minor repairs to existing shoreline armoring were roughly 15 percent of the total changes. Changes associated with clearing of vegetation, stairs, retaining walls, and houses each accounted for approximately 10 percent of the total. The rest of the changes were composed of alterations such as docks, accessory buildings, and boat ramps.

Approximately 40 percent of all the changes noted were considered to have no obvious physical or ecological effects associated with the change. In general, the most negatively impactful changes were associated with repairs to bulkheads that expanded their footprint waterward of the existing structure and new shoreline armoring.

There has been a **net increase of 364 feet of new shoreline armoring**. Two restoration projects removed 382 feet of armor, excluding Seahurst Park, but nine new bulkheads totaling 746 feet of armor were installed between June of 2013 and May of 2018.

From 2013 to 2018, compliance with local permits across jurisdictions was 42 percent. Compliance was highest in Seattle, Burien, and Normandy Park, each with a rate of 67 percent. Compliance was lowest in unincorporated King County with a rate of 28 percent. The compliance rate for unincorporated King County varied over the course of the two studies and it appears that outreach efforts that occurred before phase two did not effectively improve compliance.

Did shoreline modifications comply with environmental regulations?

- In 2016, 70 of the 148 changes (47 percent) identified in the 2016 survey, were permitted by local governments prior to the work being done. The estimated compliance ranged from 32 percent to 77 percent between jurisdictions, as determined through consultations with local jurisdictions, though compliance was not field-verified. Compliance with Washington Department of Fish and Wildlife (WDFW) Hydraulic Project Approval permits (HPAs) was lower than the local government permit compliance rate, with only 37 (25 percent changes being permitted by WDFW prior to work being done.
- In 2018, 48 of the 136 changes (35 percent) were permitted by local governments. Compliance rates within each jurisdiction ranged from 24 percent to 67 percent.

The state compliance rate was also lower in 2018, with 21 (15 percent) of changes having an HPA.

- Compliance for minor repairs of shoreline armoring increased from 18 percent in 2012 to 35 percent in 2018.

Local compliance rates were highest (60 percent) for major modifications to bulkheads and houses and lowest for stairs, docks, and vegetation removal. This pattern was observed in both phases of the study. **Major repairs to or replacement of shoreline armoring had the highest HPA compliance rate** of all types of changes with 45 percent and 58 percent compliance in 2016 and 2018, respectively.

What factors affected permit compliance?

Permit compliance was similar for both time periods. There was a slight increase in the overall compliance rate for unincorporated King County between studies, but the increase was small and resembled increases in other jurisdictions. Therefore, it appears that the outreach activities did not effectively improve compliance.

This study did not identify root causes for why people modified or armored shorelines without permits, or why compliance rates differ among jurisdictions. **Understanding why landowners infrequently sought permits would help inform approaches to improving compliance rates**. In turn, this could lead to improved shoreline conditions and promote salmon habitat recovery in WRIA 9. This knowledge gap could be addressed with a future study.

What could this mean for salmon and orcas?

Beach habitats are still being degraded, with many of the most harmful modifications being unpermitted and therefore not mitigated for**.** The most harmful changes were associated with new shoreline armoring, especially ones that occurred on previously unarmored feeder bluffs and ones that displaced potential forage fish spawning habitat. Also, a large proportion of the repairs to existing bulkheads built further out into the intertidal zone as part of the repair, having a negative impact on beach habitat quantity and quality, but not the extent of new shoreline armor. Even so, approximately 40 percent of all the changes were likely to cause none to relatively minor impacts to shoreline habitat conditions.

Summary

Given so many shoreline modifications are occurring without permits, and are likely impacting the physical and ecological condition of the marine shorelines, targeted outreach or enforcement actions may be needed across all WRIA 9 jurisdictions to prevent these types of damaging impacts continuing. Though not evaluated by this study, existing outreach efforts should likely be improved and expanded to increase their effectiveness. The following actions are recommended:

- A separate study should be undertaken to understand why landowners are getting permits at such low rates, especially for minor repair work.
- Using similar methods as this project, the Puget Sound Partnership or WDFW should undertake a comprehensive assessment of compliance rates across Puget Sound in order to better estimate the net change in shoreline armoring and to understand if observed low levels of compliance are representative of Puget Sound, in general.
- Local jurisdictions should consider using this study as a launching point to undertake a specific evaluation of whether permitted actions are meeting the standard of no net loss of ecological function within their Shoreline Master Plans.
- Local jurisdictions should start to require the inclusion of an HPA permit number with the submittal for local permits and vice versa for WDFW. This recommendation was made by Barnhart et al. in 2015 and would likely improve compliance rates to some degree.

1.0 INTRODUCTION

The WRIA 9 marine shoreline is 92 miles long and has six different local governments with jurisdiction over the shoreline (Table 1 and Figure 1). King County's jurisdiction (Vashon and Maury Islands) accounts for slightly over half of the study area. The islands are zoned rural while the mainland portion of the WRIA is under urban zoning by one city or another and generally has denser residential zoning than on the islands.

The marine shorelines of Puget Sound provide critically important habitat for many different species. Forage fish, like sand lance and surf smelt, directly spawn on the upper beaches throughout Puget Sound. Forage fish, as the name implies, are eaten by many other species, including salmon, birds, and marine mammals. Chinook salmon, which are listed as threatened under the Endangered Species Act (ESA), feed and reside in these habitats as juveniles for several months before going out to the ocean. Adult Chinook salmon are the primary food source for Southern Resident Puget Sound Orcas, which are also listed as threatened under the ESA. These shoreline habitats have been degraded by past development but are protected from new impacts through regulations at the local, state, and federal level. Those protections are only successful if landowners follow the regulations.

The phase two project (The WRIA 9 Marine Shoreline Monitoring and Compliance Project Phase 2 Final Report) follows up on two previous studies: the WRIA 9 Status and Trends Monitoring Report 2005–2010 (WRIA 9 Implementation Technical Committee 2012) and The WRIA 9 Marine Shoreline Monitoring and Compliance Pilot Project (King County 2014) both of which examined shoreline modifications across the 92 miles of the WRIA, including unincorporated King County. Those previous efforts found that many unpermitted changes had occurred to existing marine shoreline features throughout the WRIA (Figure 1), including on Vashon and Maury Islands. Since the pilot project was completed, King County took action to bring the unpermitted modifications found in the pilot project into compliance. It was hypothesized that the pilot project and King County's follow-up compliance efforts created greater community awareness about the need to protect natural shorelines from new development impacts and that most development actions, including repairs to existing infrastructure, near the shoreline require permits.

There are regional and local goals to reduce the total amount of shoreline armoring because of its negative impacts fish and wildlife habitats along the shoreline (Green/Duwamish and Central Puget Sound Watershed Water Resource Inventory Area 9 (WRIA 9) Steering Committee 2005, Puget Sound Partnership 2016). One of the paramount impacts is the negative effect armoring has on the delivery of sediment to the beach through bank and bluff erosion. This erosion is critically important to the beach ecosystem because its ability to function as fish and wildlife habitat is highly dependent on the type and amount of sediment that is on the beach. In Puget Sound, the majority of material that makes up a beach originates from bluffs along Puget Sound (Keuler 1988). Depending on oceanographic conditions and shoreline configuration, the sediment on a beach typically

moves slowly along the shore in the direction of dominant wind and waves via a process called alongshore sediment transport. Without continued sediment input from bluffs, beaches can become starved of sediment over time if the sediment that is transported away is not replaced by new bluff sediment. Shoreline armoring greatly reduces the amount of sediment reaching beaches. The WRIA 9 shoreline is approximately 65 percent armored.

Shoreline armoring structures are generally broken into hard armor structures, typically a rock, concrete, or wood bulkhead, and techniques colloquially called soft shoreline armoring that utilize an array of methods that attempt to allow some flexibility in how the beach responds to wave energy. Soft shoreline armoring is typically believed to be less negatively impactful than hard structures, but there are still impacts associated with it. Soft shoreline armoring is generally considered an improvement in overall ecological condition if a hard structure is replaced with soft shoreline armoring. Soft shoreline armoring projects have been the subject of much discussion regionally as the Puget Sound area attempts to track broader restoration efforts using indicators like the amount of shoreline armoring. It is not recommended to classify soft shoreline armoring as complete removal as there are still impacts associated with soft armoring methods that are not present with complete removal (Shipman 2017).

This report documents changes seen between the end of the pilot project in the June of 2013 and May of 2018. Specifically, it includes analyses of the types of changes, where changes in shoreline condition were encountered, and the likelihood of the changes having an ecological impact. It also documents if the changes were permitted or not at the local and state level.

The phase two project's primary goals were to:

- Document changes in shoreline conditions in 2016 and 2018 via boat surveys;
- Document if shoreline changes were accompanied by permits from local jurisdictions and Washington Department of Fish and Wildlife;
- Evaluate if compliance rates for 2016 and 2018 changed relative to rates seen in the pilot project in 2012/2013;
- Conduct outreach on project methods to other jurisdictions and salmon recovery entities across the Puget Sound region in order to expand where this type of assessment is being done;
- Raise the general awareness of the shoreline-owning public about the importance of marine shoreline areas for Puget Sound and Chinook salmon recovery efforts; and
- Evaluate if separate restoration actions to reduce the total amount of shoreline armoring within WRIA 9 are keeping pace with new shoreline armoring.

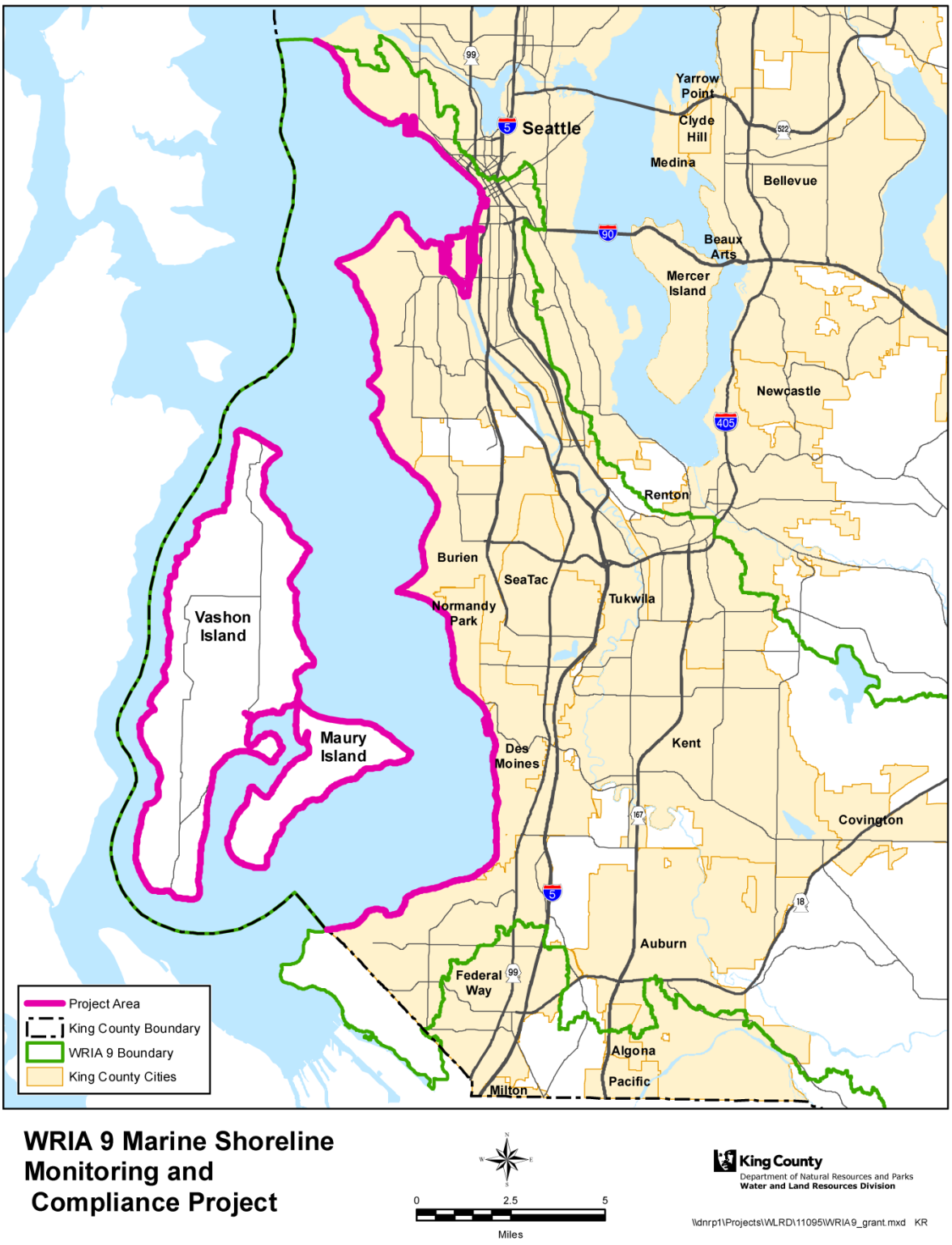

Figure 1. WRIA 9 project area

2.0 METHODS

2.1 Data collection and verification

The methods for this project closely follow the methods documented in The WRIA 9 Marine Shoreline Monitoring and Compliance Pilot Project (King County 2014). For a more detailed description of methods, see The WRIA 9 Marine Shoreline Monitoring and Compliance Pilot Project, https://www.kingcounty.gov/services/environment/watersheds/central-puget-sound/nearshore-environments/shoreline-monitoring.aspx (King County 2014).

Shoreline conditions were documented by surveys from a boat. The surveys assessed changes to a subset of the 2004 baseline data (marine shoreline armoring, vegetation condition, boat ramps, overwater structures, breakwaters, and groins). The surveys also recorded other new infrastructure or issues not previously documented in 2004 that were assessed in the pilot project including: houses, buildings (structures other than houses), mid-slope retaining walls, stairs to the beach, decks located near the water, and landslides. Potential changes in shoreline condition were mapped in GIS on a mobile computer and documented with a camera.

The type of change and the status (new, major repair, and minor repair) or extent of change was recorded. The status was initially established in the field, but later verified through analysis of photographs. A *new* status indicated that there was no data showing that there was functioning shoreline infrastructure in that location previously. A visual approximation of 25 percent change or greater from baseline condition was used to differentiate between the *minor* repair and *major* repairs.

Several changes occurred in field data collection methods from the 2014 pilot effort. The pilot project used a relatively small-screened Trimble GPS unit to collect new data and a GIS-capable laptop to view baseline data. For the phase two project an iPad with ArcCollector was loaded with a GIS project to facilitate data collection. The iPad allowed both needs to be integrated into one device that could be easily carried around by the surveyor. The increased ease of interpreting baseline data may have improved change detection slightly, but it mostly improved convenience for the surveyor and reduced the amount of time spent at any site. Using ArcCollector also allowed for quick access to much more of the County's basic spatial GIS data while on the boat, including the added ability to change background aerial photographs.

In the office, data collected from the field was evaluated to see if the potential change noted was an actual change in condition. Changes were verified by comparing field photographs collected on the boat to a combination of aerial and oblique photographs from 2017, 2015, 2013, and earlier. Oblique photographs from the Washington Department of Ecology from 2016 were also used.

2.2 Data analysis

An assessment was undertaken to quantify the potential effects of the observed changes on shoreline ecological condition. The evaluation of potential effects to shoreline processes primarily follows the format used by King County to analyze shoreline conditions in the characterization of marine shorelines for its Shoreline Master Plan update (King County 2007). The approach evaluates if the change in condition affected sediment transport or delivery processes, changes in how light energy reaches the water, changes in organic material accumulation in the shoreline, and any changes to how wave energy interacts with the shoreline. In addition, to those metrics, the change in shoreline condition was also evaluated to determine if the change impacted forage fish habitat, or created a potential public safety hazard related to navigation or slope stability. It should be noted that the term effect is neutral, and both positive and negative effects were documented. This approach relies on a logic model that describes the likely effects of an action, multiple actions or infrastructure on a physical process that can create corollary changes in how the physical and ecological environments are expressed. Where appropriate, descriptions of changes and analyses used for previously mapped shoretypes (Johannessen et al. 2005) are used to provide context about the potential effects of the changes.

Defining the potential ecological effects of the physical changes in shoreline condition can be very challenging in any circumstance, but especially so after the change has occurred. Given that this assessment was done after most of the changes occurred, it is generally impossible to know what construction techniques or best management practices (BMPs) were used as part of construction and if those methods had impacts. Therefore, impacts associated with construction techniques were not evaluated. New docks, bulkheads, or other infrastructure were easier to describe the type of effects that they typically have because the extent of change from the baseline condition is usually greater than the changes associated with repairing existing infrastructure. In the case of repairs to existing infrastructure, the effects described are associated with the repair only. They do not include the original effects associated with the initial construction of the original feature. Given all the caveats noted above, it is likely that this methodology underrepresents the actual impacts of the changes noted and overestimates the number of modifications that had no obvious effect.

Once verifications of changes were completed, the pertinent data and field photographs were shared with staff from each jurisdiction that participated in the survey or other permit staff. Permit staff from each jurisdiction[1] were asked to determine if they had permitted the change in shoreline condition and to provide the permit number associated with the change in condition. If the change in condition was permitted at the time the condition changed, it was considered to be in compliance. If the change was currently in or had already gone through a code enforcement process, the change in condition was considered to be out of compliance. This study also evaluated whether changes noted

[1] Ben Perkowski from Seattle, David Johanson from Burien, David Nemens from Normandy Park, Holly Keeton from Des Moines, Doc Hansen from Federal Way, and Laura Casey from King County.

received a permit from Washington Department of Fish and Wildlife by evaluating permit data in WDFW's databases.

Compliance is defined, as it was in the pilot project, as an action that has gone through the applicable local government or state government agency permit process to undertake the change in condition that was observed during the surveys. Each jurisdiction was provided with a compilation of information about changes in shoreline condition that occurred within their jurisdiction. Each jurisdiction provided data on if the changes noted in the field had an associated permit. It should be noted that changes that are described as 'not permitted' have not been field verified by the specific local government permitting staff and the permit status was generally based on database searches. It is possible that once permitting staff visit the site, they may decide that an individual change did not need a permit. Thus, the compliance rates described below should be considered non-field verified.

Along with the evaluation of local permits, an evaluation was undertaken to see if changes along the shoreline had an associated Hydraulic Permit Approval (HPA) permit from Department of Fish and Wildlife. With WDFW training and assistance, King County staff queried WDFW's permit databases to evaluate if changes had permits. Each change was searched for in WDFW's databases using multiple queries (e.g. by Township/Range, address, and landowner name). While every change was evaluated to see if it had an HPA, several of the documented types of changes may not need an HPA. Chapter 77.55 of the Revised Code of Washington (RCW) notes that an HPA is needed for "the construction or performance of work that will use, divert, obstruct, or change the natural flow or bed of any of the salt or freshwaters of the state." Any modifications to bulkheads, docks, boat ramps, and stair landings would typically need to get an HPA because of their location on the shoreline. Based on the RCW, changes or modifications to houses, accessory buildings, tree clearing, and retaining walls may or may not need an HPA, but are at a minimum less likely to need an HPA. For comparison purposes, evaluating the HPAs was done by looking at both *all* observed changes as well as only the changes *most likely* to need an HPA.

3.0 RESULTS

Throughout this section, results from the phase two surveys are evaluated and compared with the results from the pilot surveys of 2012 and 2013. The first survey of the phase two project started in late 2016 with a 3.3-year gap in time between the last pilot project survey and the 2016 survey. The field surveys started later in the year than originally desired, but were done in fall in order to provide the greatest length of time possible between the two planned surveys. Undertaking surveys this late in the year meant the sun was at a low angle to the south throughout surveys. This created reduced visibility in some parts of the study area, especially north facing shorelines where the sun glare reduced visibility and sun angle cast strong shadows over the shoreline reducing ability to differentiate shoreline conditions. This condition was most prevalent throughout Federal Way and portions of Vashon and Maury Islands. The second survey occurred in May of 2018, with a 1.4-year gap between the two surveys and did not have the same issue with reduced visibility.

The 2016 survey for the mainland portion of WRIA 9, covering the cities of Seattle, Burien, Normandy Park, Des Moines, and Federal Way occurred on December 6, 2016. The following staff participated in the mainland surveys: Jerry Suder, Seth Amrhein, Megan Mueller, and Ben Perkowski from the City of Seattle, Jason Wykie from the City of Des Moines, Brian Davis and David Van De Weghe from City of Federal Way, Phill Dionne from WDFW, David Pater from Washington Department of Ecology (WDOE), Doug Osterman (WRIA 9), and Kollin Higgins (King County). The survey of the Vashon and Maury Islands shoreline occurred on December 7, 2016. The following staff participated in the island surveys: Pat Pressentin (City of Normandy Park Planning Commission), Michael Schwinn (WDFW), Misty Blair (WDOE), and Kate O'Laughlin, Dave White, Alexis Kleinbeck, and Kollin Higgins from King County.

In 2016, the initial field collected data had compiled 139 potential changes in shoreline condition. The QA/QC process of the data found that 40 of those changes were not changes in condition or were previously noted in the pilot project. The QA/QC process also noted 49 more changes that were either missed in the field or where a change spanned multiple parcels and the specific issue was broken into more than one data point in order to track actions across multiple properties. Also, several of the changes noted were not necessarily human induced changes, like recent landslides and were not evaluated further. After the QA/QC process was completed, a total of 148 changes from 139 parcels were evaluated for impacts and permit compliance (Table 1 and Figure 2).

The 2018 surveys occurred on May 9 and 10. The following staff participated in the May 10 mainland survey: Maggie Glowacki and Ben Perkowski from the City of Seattle, Holly Keeton and Tyler Beekley from the City of Des Moines, David Van De Weghe from the City of Federal Way, Mark Hoppen from the City of Normandy Park, Debbie Meisenger from the King Conservation District, Julie Watson from WDFW, Maria Sandercock and Misty Blair from WDOE, Libby Gier and Kristen Feifel from Washington Department of Natural

Resources (WDNR), and Kollin Higgins from King County. The survey of the Vashon and Maury Islands shoreline occurred on May 9, 2018. The following staff participated in the island survey: Hannah Faulkner and Allison Cook from WDFW, Jamie Kilgo from WDNR, Michael Jenkins, Laura Casey, Janne Kaje, Harkeerat Kang, and Kollin Higgins from King County.

In 2018, the initial field collected data compiled 153 potential changes in shoreline condition. While going through the verification and QA/QC process of the data a variety of potential changes were deleted from the data because they have been previously noted in other surveys or were not an actual change in condition. Additionally, the location of floats and other overwater mooring structures were initially recorded in the field. However, given that these structures were not previously recorded in other surveys and occur in deep water that cannot be directly tied to a specific upland parcel, they were removed from further consideration for analysis. After the QA/QC process was completed, a total of 136 changes from 119 parcels were evaluated for impacts and permit compliance (Table 1 and Figure 3).

Table 1. Results of shoreline change analysis in WRIA 9, from 2012 to 2018. Number indicates the quantity or percent of changes observed for each survey year. (Pilot project data from 2004-2013 included for context.)

		Burien	Normandy Park	Des Moines	Federal Way	Seattle	County	Total
2004 to 2012	#	3	1	2	5	9	65	85
	%	2%	1%	2%	6%	11%	77%	100%
	#/mile	0.6	0.2	0.4	1.4	0.4	1.3	0.9
	#/year	0.4	0.1	0.3	0.6	1.1	8.1	10.6*
2012 to 2013	#	11	4	9	3	5	28	60
	%	18%	7%	15%	5%	8%	47%	100%
	#/mile	2.2	0.7	1.9	0.9	0.2	0.5	0.7
	#/year	13.8	5.0	11.3	3.8	6.3	35.0	75.0
2013 to 2016	#	22	6	8	7	24	81	148
	%	15%	4%	5%	5%	16%	55%	100%
	#/mile	4.4	1.0	1.7	2.0	1.1	1.6	1.6
	#/year	6.7	1.8	2.4	2.1	7.3	24.5	44.8
2016 to 2018	#	7	3	4	14	21	87	136
	%	5%	2%	3%	10%	15%	64%	100%
	#/mile	1.4	0.5	0.9	4.0	1.0	1.7	1.5
	#/year	5.0	2.1	2.9	10.0	15.0	62.1	97.1

3.1 Summary of changes over time

The time between the surveys has varied. The 2012 survey had approximately eight years between the baseline surveys and 85 changes in condition were found, or about 10 changes per year (Table 1). The time period between the 2012 and 2013 surveys was less than one year (0.8) and equated to 75 changes per year but encountered almost as many changes as in the prior eight year period. The 2016 survey took place about 3.3 years after the 2013 surveys and encountered 148 changes in condition since the 2013 survey, or about 45 changes per year. The 2018 survey took place 1.4 years after the 2016 survey, or almost 100 changes per year. Given the limited data the cause is uncertain for the large number of changes per year found in 2013 and 2018. It is possible that the variability is due to factors like development pressures or economic factors. However, we see a strong relationship between the rate of change per year and the number of changes observed between surveys. We believe it is likely that older changes are harder to recognize in the field, especially if they are relatively minor or small in size. The relatively short time between surveys before the 2013 and 2018 surveys likely improved the ability to detect changes. Thus the 2012 and 2016 surveys which had longer time intervals between surveys likely undercounted the number of actual changes. Given the eight year period between the 2004 baseline surveys and the 2012 survey, the results of the 2012 survey are likely the least accurate and should be treated with caution. The results of the 2013 and 2018 surveys are likely more representative of the actual rate of change in condition that is occurring.

3.2 Summary of changes by jurisdiction

The majority of changes in 2016 occurred in unincorporated King County and Seattle, accounting for 55 percent and 16 percent of the changes, respectively (Table 1). This was anticipated given the relatively larger amount of shoreline in those jurisdictions. However, the city of Burien had 15 percent of the changes, a much larger proportion of changes in shoreline condition given the City's relatively smaller proportion (5 percent) of shoreline length within the study area. When the number of changes encountered was compared to miles of shoreline, Burien's rate of 4.4 changes per mile was much higher than all other jurisdictions and higher than the rate seen in previous years. It is unclear what the cause was for this increase in activity within Burien. There was also a doubling in the rate of changes per mile over the whole study are between 2013 and 2016.

The majority of changes in 2018 occurred in unincorporated King County and Seattle, accounting for 64 percent and 15 percent of the changes, respectively (Table 1). Again, this was anticipated given the relatively larger amount of shoreline in those jurisdictions. Of the other jurisdictions, the city of Federal Way had a larger than typical proportion of changes (10 percent) occur within the city, with a rate of four per mile. It is unclear why the rate of change was so much higher in Federal Way for 2018. As was seen in the 2016 survey data, the 2018 data of the entire study area saw a similar higher rate of change per mile than the pilot survey data.

3.3 Summary by type of change

The majority of the changes in shoreline condition from the 2016 survey were composed of changes associated with shoreline armoring (55 percent), stairs (11 percent), houses and buildings (7 percent), and the clearing of vegetation (10 percent) (Table 2). The remaining 17 percent of changes were from of a broad grouping of miscellaneous activities.

The 2018 survey results were relatively similar in which activities amounted for the most changes, with 40 percent of changes associated with shoreline armoring, 17 percent associated with houses and buildings, 11 percent associated with clearing of vegetation, and 10 percent associated with retaining walls. The remaining 22 percent of changes in 2018 were made up of a variety of alterations of shoreline features (Table 2).

While there were more changes overall in each of the phase two surveys compared to the pilot project surveys, the relative proportion of changes within the primary categories of types of changes were similar to what was encountered in 2012 and 2013 (Table 2). Major repairs and minor repairs to bulkheads accounted for the most changes in each survey year. The number of new bulkheads, representing 1 to 5 percent of the changes in each year, was relatively small, especially when compared to other actions associated with shoreline armoring. Of the seven new bulkheads encountered during the 2016 survey, five of them were located in unincorporated King County, one was located in the city of Federal Way, and one was located in the city of Des Moines. Both of the two new bulkheads encountered during the 2018 survey were located in unincorporated King County. Changes associated with houses and buildings, clearing of vegetation, docks, and stairs each made up about 10 percent of changes in any survey (Table 2).

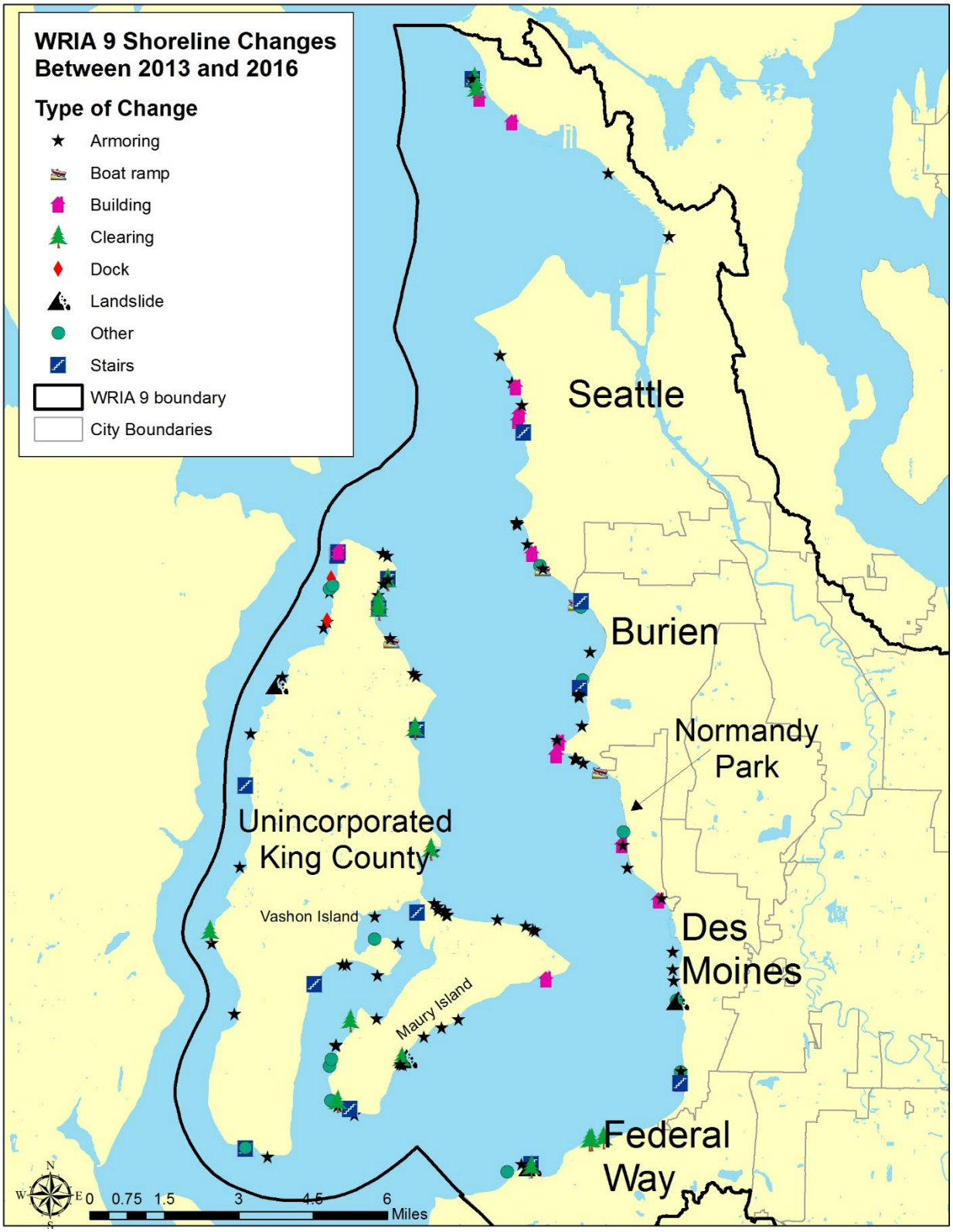

Figure 2. Locations of changes in shoreline condition for WRIA 9 jurisdictions in 2016.

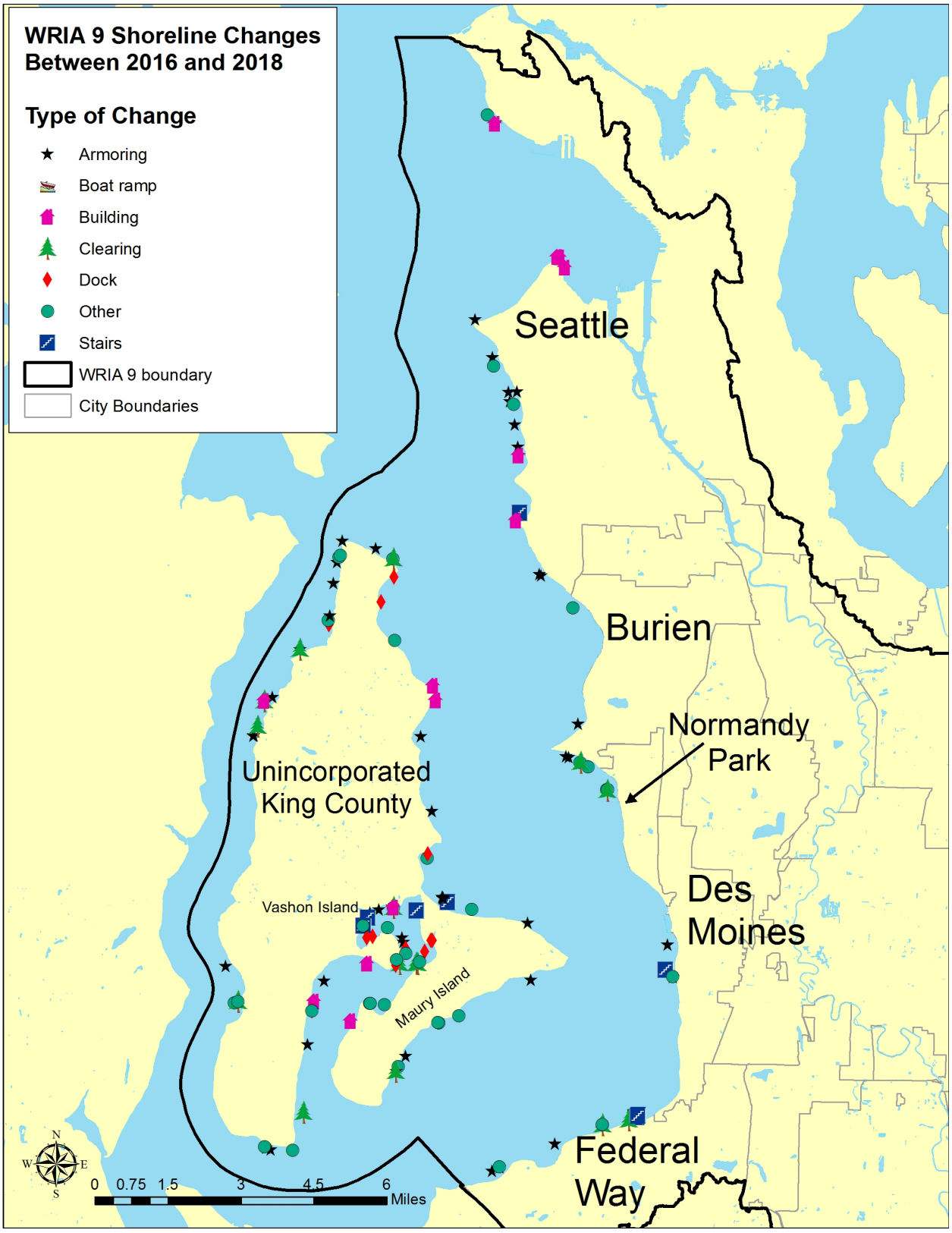

Figure 3. Locations of changes in shoreline condition for WRIA 9 jurisdictions in 2018

Table 2. Primary categories of types of changes observed in 2012, 2013, 2016, and 2018.

		2012		2013		2016		2018	
Type	Status	#	%	#	%	#	%	#	%
Armoring	removal	0	0%	0	0%	2	1%	0	0%
Armoring	new	5	6%	2	3%	7	5%	2	1%
Armoring	major repair	26	31%	10	17%	55	37%	31	23%
Armoring	minor repair	22	26%	8	13%	18	12%	21	15%
Stairs	all	7	8%	9	15%	16	11%	10	7%
Docks	all	10	12%	5	8%	2	1%	9	7%
Clearing	all	8	9%	7	12%	15	10%	15	11%
Houses	all	3	4%	7	12%	10	7%	15	11%
Retaining wall	all	0	0%	7	12%	8	5%	14	10%
Ramps	all	2	2%	2	3%	4	3%	1	1%
Other	all	2	2%	3	5%	11	7%	18	13%
	total	85	100%	60	100%	148	100%	136	100%

3.4 Summary of ecological and physical effects of shoreline changes

3.4.1 No obvious effects

All of the changes were evaluated against a potential range of physical and ecological effects. It should be noted that this evaluation was done separately from whether an action was permitted or not and many actions that were permitted (see compliance rates section below) were found to have negative physical and ecological effects (Appendix). For the 2016 and 2018 surveys, 34 percent and 43 percent of the changes, respectively, did not appear to have any obvious effects (positive or negative) compared to the previous shoreline conditions (Table 3 and Appendix). The percentage of actions not having an obvious effect in 2016 and 2018 were relatively similar to rates observed in the 2012 and 2013 surveys. For shoreline armoring across all four survey years, a much higher percentage of minor repairs (67 percent) was classified as not having an effect than major repairs (50 percent), which is not surprising given the much smaller extent of alterations that occur for minor repairs. All new shoreline armoring and clearing actions were considered as having a negative effect.

In 2016, there were seven changes that resulted in ecologically positive changes in condition (Appendix). This typically occurred with major bulkhead repairs where the bulkhead location was relocated higher up on the beach which is likely to have improved intertidal habitats, at least incrementally. There were three other changes that had both impacts and improvements in condition where some aspect of the structure was set back, while at the same time a new impact occurred. In 2018, there were three changes that resulted in an improvement in condition. Two of these were associated with repairs to

existing shoreline armoring where it was setback slightly from its original location and the third was associated with a restoration project where a dock was moved and the shoreline edge was regraded and revegetated.

Table 3. Results of ecological and physical effects analysis in WRIA 9 from 2012 to 2018.

Type	2012				2013				2016				2018			
	Total Changes encountered		Changes with no obvious effect		Total Changes encountered		Changes with no obvious effect		Total Changes encountered		Changes with no obvious effect		Total Changes encountered		Changes with no obvious effect	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Armoring-Major repair	26	31%	14	54%	10	17%	6	60%	55	37%	23	42%	31	22%	14	45%
Armoring-Minor repair	22	26%	19	86%	8	13%	6	75%	18	12%	7	39%	21	15%	14	67%
Armoring-New	5	6%	0	0%	2	3%	0	0%	7	5%	0	0%	2	1%	0	0%
Docks	10	12%	0	0%	5	8%	1	20%	2	1%	0	0%	9	7%	2	22%
Clearing	8	9%	0	0%	7	12%	0	0%	15	10%	0	0%	15	11%	0	0%
Stairs	7	8%	0	0%	9	15%	3	33%	16	11%	4	25%	10	7%	5	50%
Other	7	8%	1	7%	19	32%	10	53%	35	24%	16	46%	48	35%	23	48%
total	85	60%	34	40%	60	57%	26	43%	148	66%	50	34%	136	57%	58	43%

3.4.2 Bulkheads/Armoring

Shoreline armoring generally has many ecological effects, with most of the effects described below associated with sediment delivery and transport, how waves interact with the beach and displacement of the upper beach for forage fish habitat and organic material storage. The current results indicate that the general trend of increasing shoreline armoring is continuing within the WRIA 9 area, with most of the new armoring occurring on Vashon and Maury Islands. Between 2013 and 2018 there were three restoration projects that removed shoreline armoring, but only two of them were counted as removal of shoreline armoring for this study (Table 4).

- The Dockton Heights project occurred on Maury Island and removed approximately 300 feet of shoreline armoring and was counted as the removal of shoreline armoring.
- The Maury Island Natural Area restoration project removed 82 feet of armoring associated with an old cement dock structure left over from gravel mining operations and was considered a removal.
- The second phase of the Seahurst Park restoration project was not included in calculations for the amount of shoreline armoring removed. As noted earlier, soft shoreline armoring projects like this one have been challenging to describe and regional guidance is that they should not be counted as removed armor. While the project improved the physical and ecological conditions of approximately 1,500 feet of shoreline after restoration, the site still has an extensively modified condition with a road running along the backshore. Due to the heavily modified condition of the site after restoration, which greatly limits the connectivity of the feeder bluffs to the beach and that there is a hard structure still in place behind the beach nourishment, it was classified as a major repair versus complete removal for the analyses in this report.

A total of nine new bulkheads were encountered during this project where there was no armoring previously or the previously existing armor had become ineffective many years prior and erosion was actively occurring (Table 4). The nine new bulkheads accounted for 746 feet of new shoreline armoring between 2013 and 2018. During this same time period 382 feet of shoreline armor was removed through two restoration projects noted above.

This analysis is very sensitive to the exclusion or inclusion of the Seahurst Park project.

- Excluding the Seahurst Park project from armor removal category would mean there has been an increase in shoreline armoring of 364 feet between June of 2013 and May of 2018 (Table 4). The pilot project found that there had been an increase in the overall amount of shoreline armoring of 70 feet from 2004 to 2013 (King County 2014), meaning there has been an overall increase of 434 feet of shoreline armoring since 2004.
- Including Seahurst Park project as shoreline armor removal, would mean that there has been a decrease of 1,136 feet of armor between 2013 and 2018 and an overall reduction of 1,066 feet of shoreline armoring since 2004 versus an increase.

Most of the new bulkheads were encountered in 2016. In 2016, there were seven new bulkheads (Table 4), four of which will likely have a negative impact on the amount of sediment reaching the beach over the short-term as well as in the longer term. The four bulkheads are assumed to have both short-term and long-term negative effects because the new bulkheads were installed on relatively active sources of sediment known as feeder bluffs (Table 4 and Figure 4). In 2018, there were two new bulkheads, one of which will likely have a negative impact on the amount of sediment reaching the beach over the short-term as well as in the longer term (Table 4) due to being constructed in front of a feeder bluff. Of these five most impactful new bulkheads over the two survey years, three of these were located in unincorporated King County, one was located in Federal Way, and the last one was in the city of Des Moines. Three of these five new bulkheads were built on known forage fish spawning beaches.

Table 4. Changes by jurisdiction observed in 2016 and 2018 where the shoretype changed, (FBE=Exceptional Feeder Bluff, FB=Feeder Bluff, M=modified/armored, TZ= Transport Zone, AS=Accretion shoreform)

Survey year	Jurisdiction	Original shoretype	Current shoretype	Status of change	Permitted locally?	Permitted by WDFW?	Length of change
2016	Des Moines	FBE	M	New	no	no	116
2016	Federal Way	FB	M	New	yes	no	50
2016	King County	FB	M	New	no	no	110
2016	King County	FB	M	New	no	no	25
2016	King County	TZ	M	New	Partial	Yes	140
2016	King County	TZ	M	New	no	no	30
2016	King County	AS	M	New	no	no	100
2018	King County	FB	M	New	no	no	50
2018	King County	AS	M	New	no	no	125
2016	King County	M	FB	Removed	yes	yes	82
2016	King County	M	AS	Removed	yes	yes	300
						total new armor	746
						total armor removed	382
						total (new armor minus restoration)	-364

Figure 4. Vegetation clearing and two different bulkheads in the process of construction, arrows indicate one at the toe of slope and the other made of sandbags built in upper intertidal.

Two of the other new bulkheads will likely affect the amount of sediment reaching the beach over the long term, but not necessarily in the short term. This assumption is based

on the fact that these bulkheads were installed in front of transition zone shoreforms in unincorporated King County (Table 4 and Figure 5). Transition zone shoreforms are characterized as relatively stable bluffs that appear to be in equilibrium with the beach environment and do not currently contribute much sediment to the beach system (Johannessen et al. 2005). With the predicted rates of sea level rise in Central Puget Sound (Miller et al. 2018), it is expected that transition zone shoreforms will eventually become active feeder bluffs, thus the new bulkheads would likely affect the long-term sediment contributions to the beach. There was no documented forage fish spawning habitat on the beaches at these two locations, though as is typical in many parts of King County, forage fish spawner surveys have not been comprehensive and have been relatively sporadic in time and space over the last 30 years.

Figure 5. A new small rock filled gabion basket bulkhead associated with stairs in front of a transition zone shoreform indicated by the arrow.

The remaining two new bulkheads were built on accretion shoreforms. These are generally areas where beach sediment is accumulating (Table 4 and Figure 6). Neither of these two locations were known to have forage fish spawning occurring on the beach, though as previously noted, spawner surveys have not been comprehensive within King County.

Changes were also evaluated for their impacts to alongshore sediment transport processes, which is where beach sediment slowly moves along the shoreline in a specific direction. Structures that jut out into the shoreline can intercept the sediment and stop it from moving down the beach. The baseline conditions for sediment transport throughout the study area are fairly degraded with 151 groins, over two hundred overwater structures, as well as 51 percent of the 92 miles of the shoreline having bulkheads that are physically

located below the Ordinary High Water (OHW) line (Anchor Environmental 2004). Throughout the study area in 2016, 21 of the 148 changes likely had a negative impact on sediment transport. In 2018, 11 of the 136 changes likely had an impact on sediment transport (Appendix). These 32 changes were composed mostly of major repairs to shoreline armoring where the repair work extended out into the intertidal such that it likely intercepts some alongshore sediment transport in the upper beach. No new groins were encountered in either survey.

Figure 6. Aerial photographs of 2015 condition on the left and on the right new shoreline armoring in construction in the foreground (indicated by lowest arrow) on an accretion shoreform and vegetation clearing in 2017 right, indicated by the two upper arrows.

The majority of the bulkhead repairs observed did not affect the delivery of sediment since the original bulkhead was already in place impacting that physical process before the repair was made. While the bulkhead repairs did not generally change the rate of sediment supplied to the beach, many of them were associated with other impacts to the upper beach. A frequent component of repairs observed involved building further out onto the beach, impacting how wave energy interacts with the upper beach, reducing the area available for the accumulation of organic matter, and displacing forage fish spawning habitat. In 2016, excluding changes associated with new armor, the displacement of forage fish spawning habitat and reduced organic matter storage area was noted for 29 of the 141 changes (Appendix). In 2018, excluding changes associated with new armor the displacement of potential forage fish spawning habitat and reduced organic matter storage area was noted for 18 of the 136 changes (Appendix). Most of these changes that impacted potential forage fish spawning habitat from 2013 to 2018 were associated with major repairs to existing armor, or modifications associated with landings for stairs.

3.4.3 Clearing

The clearing of vegetation along beaches and bluffs, as described below, has three primary types of effects. It can increase the rate of sediment delivery by destabilizing steep slopes. The clearing of shoreline vegetation also reduces the amount of organic material locally accumulating on the beach (Dethier et al. 2016 and Heerhartz et al. 2014.) and changes how light energy reaches the beach at night and during the day (Figure 7). Most instances of clearing of vegetation were associated with other changes in shoreline condition. In 2016, there were a total of 35 instances of clearing of vegetation noted, with the majority of instances having occurred in unincorporated King County (Table 5). The individual instances of clearing of vegetation were generally small, with the average size being 0.07 acres or 3,000 ft^2 in size. A sum total of 2.4 acres or 105,000 ft^2 of shoreline vegetation were impacted. In 2018, there were a total of 33 instances of clearing of vegetation noted, with the majority of instances having occurred in unincorporated King County (Table 5). The individual instances of clearing of vegetation were generally small, with the average size being 0.08 acres or 3,400 ft^2 in size. A sum total of 2.7 acres or 117,000 ft^2 of shoreline vegetation were impacted.

Table 5. The number and acres of changes by jurisdiction associated with the clearing of vegetation.

Jurisdiction	2016		2018	
	Vegetation cleared		Vegetation cleared	
	#	acres	#	acres
Burien	0	0.00	3	0.03
Normandy Park	1	0.04	1	0.02
Des Moines	1	0.03	0	0.00
Federal Way	5	0.93	2	0.92
Seattle	6	0.19	1	0.02
King County	22	1.25	26	1.69
total	35	2.44	33	2.68
avg size		0.07		0.08

Figure 7. Clearing that took place in a King County road right of way, indicated by arrow.

3.4.4 Docks/overwater structures

Docks and overwater structures primarily affect changes in light transmission and wave energy, but can have many of the same effects of bulkheads if they are not already associated with existing shoreline armoring. In 2016, there were two changes associated with overwater structures and both were encountered in unincorporated King County and were relatively small in size (Table 2). The changes were very minor modifications that barely extended out into the intertidal zone, so that they are unlikely to have a large negative ecological effect. In both cases, structures appeared to have been created on top of derelict pilings that had not had an overwater structure present for a long time. In 2018, there was an increase in the number of changes associated with overwater structures, with nine changes encountered (Table 2), all on Vashon and Maury Islands. The changes were a mixture of relatively minor repairs or reconfigurations of the docks along with several small new overwater structures (Figure 8).

Figure 8. Largest change in docks during the study period. On the left is the 2015 condition with the docks traced in purple. On the right is the modified condition in the 2017 with the purple tracing showing the location of the docks in 2015.

3.4.5 Other effects

The changes in shoreline condition were also qualitatively evaluated for potential water quality impacts and if they could potentially create a hazard to public safety. There was one major repair to armoring that clearly replaced creosote pilings with rock. This was considered an improvement to water quality conditions (Appendix). It is likely that there were more similar improvements as other wooden bulkheads were replaced with rock bulkheads, but it was not clear from aerial photographs if the original wood was treated with creosote.

Public safety issues were classified as changes that might affect the human safety of someone other than the landowner where the change occurred. This was typically limited to issues like hazards to navigation and specific slope stability issues that might propagate off site where someone other than the landowner might be affected, like increasing the risks of a land slide. Four safety issues where noted over the course of the project (Appendix). Three were associated with increased landslide risks and one was a potential hazard to navigation. One instance of tree clearing occurred on several adjoining parcels that are located mid-slope above two private residences (Figure 7). Approximately 15 trees were cut down from a quarter of an acre area in unincorporated King County identified as a steep slope hazard area. In another case a new building was constructed roughly 10 feet from the top of bluff above Dockton Road, a relatively busy county road that connects Maury Island to Vashon Island. The bluff in this location has experienced multiple slides over the past 10 years and the specific parcel was noted in the pilot project for clearing of vegetation along the top of bluff. Adding a small structure near the edge of the bluff will not improve slope stability issues and may increase the risks to land sliding onto the road. The third instance was the clearing of trees on a steep slope where there is a house at both the top and bottom of the steep slope. The slope stability issues could affect both houses.

The potential hazard to navigation was associated with the replacement of a dock where the dock now extends an additional 70 feet offshore into Puget Sound. While this could potentially create a hazard to navigation, the location of the dock in relatively shallow water and in the shadow of a sand spit makes it unlikely to create much of a hazard to navigation. The other two issues involve steep slopes.

3.5 Compliance rates

All changes observed were evaluated to see if the appropriate permits were received by the landowner prior the change occurring. Table 6 and Table 7 show the changes that were permitted in 2016 and 2018, respectively, by jurisdiction and by primary type of change. For all summary information, if a change in condition went through code enforcement in order to come into compliance, it was still considered not in compliance for the purposes of this report. This is because the change in condition was not originally permitted or in compliance when the original work was begun. There were seven instances in 2016 and two in 2018 where a change was in or had gone through a code enforcement process. Some changes in 2016 were described by King County as partially permitted and were counted as permitted for the purposes of this report. This occurred when a project proponent was given emergency authorization through the shoreline exemption process to undertake an action initially and would need to apply for building or clearing and grading permits after the work was complete. The four partially permitted projects were approved for an exemption and undertook the work, but had not completed the permit process at the time this report was finalized.

The overall rate of compliance at the local level for all jurisdictions combined over the four different surveys ranged from a low of 22 percent in the 2012 survey to a high of 47 percent in the 2016 survey (Table 8). While the overall compliance rate seemed to be following an upward trend over the different surveys, it dropped back down in the 2018 survey leaving no clear pattern. When comparing compliance across jurisdictions the cities of Seattle and Burien had the highest compliance rates, both averaging above 65 percent for all four surveys, while the City of Federal Way and King County had the lowest compliance rates, both being below 30 percent.

HPA compliance was not evaluated for the pilot project effort, thus data is only available for the phase two surveys. When all changes were evaluated for HPA compliance, the relatively low rate of 25 percent and 15 percent was observed for 2016 and 2018, respectively (Table 9). When the HPA evaluation considered only the subset of the types of changes that were most likely to need an HPA, the overall HPA compliance rate improved slightly to 32 percent and 27 percent for 2016 and 2018, respectively (Tables 6, 7, and 9), but was still well below the local government compliance rates. It is not clear why the HPA compliance rate was lower than the local government compliance rates. Interestingly, compliance rates were better in 2016 than in 2018 for both local permits as well as at the state level (Tables 8 and 9).

Table 6. Summary of changes in compliance in 2016 (shaded boxes indicates types of changes that were less likely to need a WDFW permit).

Jurisdiction	Type	Status	#	Local Government Permits					WDFW Permit	
				Permitted	Partially Permitted	NOT Permitted	Closed code enforcement	Open code Enforcement	Permitted	NOT Permitted
Burien	Armoring	Major repair	9	8		1			3	6
		Minor repair	4	2		2			1	3
	Stairs	New	1	1					1	
		Major repair	1			1				1
	House	New	3	3						3
	Retaining wall	New	1	1					1	
	Other	New	1	1						1
	Ramp	Major repair	2	1		1			1	1
Normandy Park	Armoring	Major repair	3	3					1	2
	House	Minor repair	1			1				1
	Retaining wall	New	1	1						1
	Building	New	1			1				1
Des Moines	Armoring	New	1			1				1
		Major repair	2	2					1	1
		Minor repair	1			1				1
	Retaining wall	New	2	1		1				2
	Stairs	New	1			1				1
	Building	New	1			1			1	
Federal Way	Armoring	new	1	1						1
	Other	Major repair	1			1				1
	Clearing	Recent	4	3		1			1	3
	Stairs	New	1			1				1
Seattle	Armoring	Major repair	9	8		1			4	5
		Minor repair	3	2		1			2	1
	Stairs	New	2			2				2
	Boat Ramp	New	1			1				1
	House	New	5	4	1					5
		Major repair	1	1						1
	Clearing	Recent	2			1	1			2
	Other	New	1			1				1
County	Armoring	Removal	2	2					2	
		New	5		1	4			1	4
		Major repair	32	18	2	12			16	16
		Minor repair	10	1		8		1		10
	Clearing	Recent	9			8		1		9
	Dock	New	1			1				1
		Major repair	1			1				1
	Stairs	New	4		1	3				4
		Major repair	5			5				5
		Minor repair	1			1				1
	Building	New	2			1	1			2
	Retaining wall	New	2			2				2
		Major repair	2	1		1			1	1
	Ramp	Major repair	1					1		1
	Other	Misc	4			2	1	1		4
		Total	148	65	5	71	3	4	37	111
		%		43.92%	3.38%	47.97%	2.03%	2.70%	25.00%	75.00%

Table 7. Summary of changes in compliance in 2018 (shaded boxes indicates types of changes that were less likely to need a WDFW permit).

Jurisdiction	Type	Status	#	Local Government Permits				WDFW Permit	
				Permitted	NOT permitted	Closed code enforcement	Open code Enforcement	Permitted	NOT permitted
Burien	Armoring	Major repair	2	1	1				2
		Minor repair	1	1					1
	House	all	1	1					1
	Building	all	1	1					1
	Retaining wall	New	1		1				1
	Clearing	Recent	1		1				1
Normandy Park	Clearing	Recent	1	1					1
	Retaining wall	New	1		1				1
	House	New	1	1					1
Des Moines	Armoring	Major repair	1	1				1	
		Minor repair	1		1				1
	Stairs	New	1		1				1
	Other	New	1	1				1	
Federal Way	Armoring	Major repair	1	1					1
		Minor repair	3	2	1				3
	Retaining wall	new	2	1	1				2
	Clearing	Recent	2		2				2
	House	all	1	1					1
	Building	all	1		1				1
	Stairs	Major repair	2		2				2
		Minor repair	1		1				1
		New	1		1				1
Seattle	Armoring	Major repair	5	2	3			2	3
		Minor repair	6	5	1			1	5
	Stairs	New	1		1				1
	House	New	3	3					3
		Major repair	3	3					3
	Building	all	1		1				1
	Other	Misc	2	1	1				2
County	Armoring	New	2		1	1			2
		Major repair	22	15	7			15	7
		Minor repair	10	1	9				10
	Clearing	Recent	11	1	9	1			11
	Dock	New	5		5				5
		Major repair	1		1				1
		Minor repair	3		3			1	2
	Stairs	New	2		2				2
		Major repair	1		1				1
		Minor repair	1		1				1
	House	New	2	2					2
		Minor repair	4		4				4
	Building	all	5	1	4				5
	Retaining wall	New	9		9				9
		Minor repair	1		1				1
	Ramp	Major repair	1		1				1
	Other	Misc	7	1	6				7
		Total	136	48	86	2	0	21	115
		%		35.29%	63.24%	1.47%	0.00%	15.44%	84.56%

Table 8. Estimated local government compliance rates over the course of the pilot project surveys (2012 and 2013) and the most recent surveys (2016 and 2018).

Jurisdiction	2012	2013	2016	2018	Avg
Burien	100%	73%	77%	57%	77%
Normandy Park	0%	25%	67%	67%	40%
Des Moines	0%	56%	38%	50%	36%
Federal Way	20%	0%	57%	36%	28%
Seattle	71%	60%	67%	67%	66%
County	14%	29%	32%	24%	25%
all jurisdictions combined	22%	42%	47%	35%	37%

Table 9. WDFW HPA compliance rates for this study by jurisdiction, all changes compared to changes most likely required to get an HPA.

Jurisdiction	2016		2018	
	All changes	Changes most likely to need an HPA	All changes	Changes most likely to need an HPA
Burien	32%	35%	0%	0%
Normany Park	17%	33%	0%	none
Des Moines	25%	20%	50%	33%
Federal Way	14%	0%	0%	0%
Seattle	25%	40%	14%	25%
King County	25%	31%	18%	33%
all jursidictions combined	25%	32%	15%	27%

Table 10. Local permit compliance rates compared to HPA compliance rate for all changes noted in the phase 2 surveys.

Jurisdiction	Local permit rate 2016	HPA permit rate 2016	Local permit rate 2018	HPA permit rate 2018
Burien	77%	32%	57%	0%
Normandy Park	67%	17%	67%	0%
Des Moines	38%	25%	50%	50%
Federal Way	57%	14%	36%	0%
Seattle	67%	25%	67%	14%
County	32%	25%	24%	18%
all jurisdictions combined	47%	25%	35%	15%

When evaluating compliance by primary project type, restoration projects that removed shoreline armoring were few, but had 100 percent compliance for both local and state permits (Table 11). Changes associated with houses and major repairs to or replacements of bulkheads were the types of changes that had the next highest rate of permitting at the local level in both studies, averaging over 60 percent compliance in each case (Table 11).

Major repairs to shoreline armoring also had the highest HPA compliance rate with an average compliance between both surveys around 50 percent. Changes associated with houses did not receive any HPAs, which given the ambiguity in the WAC is not surprising. Changes associated with stairs, docks, and clearing of shoreline vegetation had relatively low rates of compliance in both studies, for both local and state permits (Table 11). Interestingly, the local government compliance rate for minor repairs of shoreline armoring increased over the course of both studies, starting out in 2012 at 18 percent and increased to 43 percent in 2018. The reason for the increase is unclear.

We assumed that if a landowner worked with local government permit staff they would be aware of the need to get state permits and vice versa if a landowner worked with the state. Therefore, we hypothesized that any specific permitted change in condition would likely have both local and state permits. For the two years of comparable data, compliance rates were always higher for local government permits compared to HPAs (Tables 6, 7, and 10) indicating that overall this hypothesis does not appear to be true. However, the one notable exception is that local permit compliance associated with shoreline armoring in unincorporated King County very closely matched compliance with state permits.

As the pilot project was being completed in 2014, a variety of outreach activities occurred in unincorporated King County that did not occur in the other jurisdictions. We hypothesized that the outreach activities would raise community awareness about the sensitive nature and ecological importance of marine shorelines. Activities included:

- two articles and two editorials about the project and its findings in the local paper,
- a workshop for landowners, several presentations to community groups on the islands, and
- one to two letters from the County to each landowner requesting they work with the County to come into compliance.

Given the outreach done in 2014 within unincorporated King County and relatively little to no outreach for the other jurisdictions, we hypothesized that the compliance rate might increase substantially for unincorporated King County. However, the increase in compliance in 2016 was relatively small and in 2018 it dropped to lower than the rate seen in 2013 and 2016. Therefore, it does not appear that the outreach activities that occurred impacted compliance rates.

Table 11. Local and state permit compliance by primary type of change observed.

Type	Status	% permitted at local level				% permitted by state/HPA	
		2012	2013	2016	2018	2016	2018
Armoring	major repair	38%	70%	75%	65%	45%	58%
Armoring	minor repair	18%	38%	28%	43%	17%	5%
Armoring	new	40%	100%	29%	0%	14%	0%
Armoring	remove	n/a	n/a	100%	n/a	100%	0%
Stairs	all	0%	11%	13%	0%	6%	0%
Docks	all	20%	40%	0%	0%	0%	11%
Houses	all	0%	86%	90%	73%	0%	0%
Buildings	all	n/a	n/a	0%	25%	25%	0%
Clearing	all	13%	14%	20%	13%	7%	0%
Retaining wall	all	none	43%	50%	7%	25%	0%
Ramps	all	0%	0%	25%	0%	25%	0%
Other	all	0%	0%	14%	30%	0%	10%
	total	22%	42%	47%	35%	25%	18%

4.0 SUMMARY

Most changes were shoreline armoring repairs or replacements

A total of 284 changes in shoreline condition were found during surveys in 2016 and 2018. The results of the surveys show similar types and proportions of shoreline modifications that were documented in the pilot effort. Changes associated with shoreline armoring accounted for almost 50 percent of the changes noted. The largest percentage of changes, 30 percent, consisted of major repairs to or the replacement of existing shoreline armoring. Minor repairs to existing shoreline armoring made up roughly 15 percent of the total changes. These findings are similar to recent findings from the Puget Sound Partnership's (PSP) review of permitted shoreline armor projects. They found that 73 percent of shoreline armor by length was for replacement of existing armor (PSP 2018). Changes associated with clearing of vegetation, stairs, retaining walls, and houses each accounted for approximately 10 percent of the total. The rest of the changes were composed of a variety of alterations such as docks, accessory buildings, and boat ramps.

The rate of shoreline change may be biased by the length of time between surveys

While the proportion of changes seen were similar, the actual number of changes observed in this study was almost double of what was seen in the pilot effort. While the exact reason for this increase is uncertain, one possibility is that the increase observed in the 2016 survey was in response to damages created by the December 2012 high winds and highest tide on record. While the 2013 survey occurred after that storm, it was likely too soon after the storm such that landowners had not had enough time to undertake repairs until after the 2013 survey occurred. Another possible explanation for the increase is that there was reduced time between surveys for 2016 and 2018. Combining all four surveys from both reports, less time between surveys led to a higher number of changes observed per year. This is likely due to the methods used to document changes that rely on being able to visually notice the repair due to newer materials being used in the repair. The longer the time between the surveys, the more the materials weather and become less noticeable.

- Given the visibility and weathering issues, it is recommended that any similar monitoring and compliance efforts attempt to undertake surveys roughly every two years. Longer time periods between repeat surveys will likely under represent the true number of changes that have occurred.

Many changes appear to have had negligible ecological effects

As with the pilot project, approximately 40 percent of all the changes noted were considered to have no obvious physical or ecological effects associated with the change. This mostly applied to minor and major repairs to existing bulkheads where the repair noted did not change the existing footprint of the structure. Similarly, most of the changes associated with replacement of the existing houses or buildings in the same location were found to have few new negative effects. In general, the most negatively impactful changes were associated with repairs to bulkheads that expanded their footprint waterward of the

existing structure and new shoreline armoring, especially bulkheads that occurred on previously unarmored feeder bluffs, and ones that displaced potential forage fish spawning habitat. Changes associated with intertidal landings for staircases and clearing of vegetation had mostly negative effects.

There was a net increase in shoreline armoring

The pilot project found that between 2004 and 2013 an additional 70 feet of shoreline armoring had been installed beyond what had been removed through restoration. The 2016 and 2018 surveys observed two restoration projects that removed 382 feet of armor. Even though the habitat quality was improved, the phase 2 of the Seahurst Park restoration project did not count towards the goal of removing shoreline armoring because the hard armor was replaced with soft shoreline armoring. Over the same period, nine new bulkheads totaling 746 feet of armor were constructed. This resulted in a net total of 364 feet of new shoreline armoring demonstrating a continued slow increase in the total amount of armored shoreline within WRIA 9 similar to what was seen in the pilot project.

While 78 percent of new armoring occurred in unincorporated King County, none of the new armor was located within the Maury Island Aquatic Marine Reserve, which has been a focus of the county's shoreline restoration efforts. Furthermore, since the 2018 survey was undertaken, King County removed four bulkheads within the reserve amounting to about 700 feet of armor. While it is possible to add these new restoration projects to the total amount of removed shoreline armoring observed in this study, it is unknown if new armor was installed during the same time period that would offset the new restoration projects.

The Puget Sound Partnership (2018) recently released a 2017 update on the amount of shoreline armoring through its vital sign indictor update. The PSP has a 2020 recovery target that, "From 2011 to 2020, the total length of armor removed should be greater than the total length of new armor in Puget Sound. This is referred to as Cumulative Net from 2011." Due to limited compliance data for all of Puget Sound, WDFW HPA data associated with permitted shoreline armoring is used as a proxy for all armor. Their findings indicate that the amount of new armor permitted has been more than off-set by the amount of armor being removed through restoration in three of the last four years. Furthermore, the cumulative total of new armor installed over the last 7 years has almost been offset by restoration actions in the same time period. However, if the compliance rates seen in the WRIA 9 phase 1 and 2 studies are applicable to the rest of Puget Sound, the PSP approach of using permitted armor as a proxy does not accurately represent the net change in shoreline armoring and underestimates the amount of new armoring going in throughout Puget Sound. As this report shows, quantifying unpermitted armor rates is extremely important to accurately describe the net change in shoreline armoring.

- It is recommended that PSP or WDFW undertake a more comprehensive assessment of compliance rates across Puget Sound in order to better estimate the actual net change in shoreline armoring.

Jurisdictions are not likely meeting the "no net loss of ecological function" standard

Guidance from WDOE to local governments indicates that each jurisdiction's Shoreline Master Plan, that locally implements the Shoreline Management Act, should meet the standard of "no net loss" of ecological function. This guidance is geared towards actions that are permitted by each local government. While analyses in this report were not intended to answer if jurisdictions are meeting the no net loss standard, the evaluation clearly showed that some permitted actions have had negative impacts on the physical processes and ecological conditions along marine shorelines. It is possible that mitigation actions were undertaken to offset the impacts noted, but this report did not evaluate if mitigation actions were required or implemented. It also appears that for some jurisdictions, unpermitted actions are occurring at rates that are offsetting improvements occurring through restoration.

- We recommended that jurisdictions consider using this study as a launching point to undertake a specific evaluation of if permitted actions are meeting the standard of no net loss of ecological function.

Compliance rates were highest in Burien and Seattle

In both studies, the cities of Burien and Seattle had the highest rates of compliance averaging 66 percent and 77 percent, respectively. King County and Federal Way had the lowest compliance rates for all four years, averaging 25 percent and 28 percent, respectively. The shorelines of unincorporated King County and Federal Way have the lowest percentage of armored shoreline within the study area with both about 50 percent armored. However, they had some of the highest number of changes per year and lowest compliance rates. This means both jurisdictions have substantial marine shoreline habitat at risk of degradation from new unpermitted development actions.

Compliance with local government regulations is higher than with WDFW HPAs

The local government permit compliance rates seen in the phase two project are similar to what was seen in the pilot project. There was a slight increase in the overall compliance rates between studies for all jurisdictions starting with the pilot project rate of 30 percent and increasing to 42 percent in the phase two study. The results showed that permit compliance for HPAs is lower than for local government permits. It was assumed that if a landowner worked with local government permit staff they would be made aware of the need to get state permits and vice versa if a landowner worked with the state. Therefore, it was expected that any specific permitted change in condition would likely have both local and state permits. This only occurred in unincorporated King County with major repairs to armoring.

- We recommend that a separate study be conducted to survey local government and WDFW permit staff to find out if there are differences in how they coordinate with other permitting agencies and if those differences are responsible for the variability seen in this study.
- Alternatively, following recommendations made by Barnhart et al. (2015), local jurisdictions could start to require the inclusion of an HPA permit number with the

submittal for local permits and vice versa for WDFW. Alternatively, local jurisdictions could require an HPA after SEPA determination and prior to permit issuance. Either approach would likely equalize local permits rates with HPA compliance rates.

Compliance rates were lower than documented in other studies in Puget Sound

There have been two other recent permit compliance studies done in other parts of Puget Sound, both of which found higher rates of compliance than the pilot effort or this study. In 2012, WDFW undertook an analysis of the 52 miles of Bainbridge Island shoreline to evaluate if activities were occurring without an HPA (Quinn 2012). They did not evaluate if activities should have gotten a permit from the City. They found that 80 percent of the activities they observed had an HPA for the work. That rate is much higher than the rates of HPA compliance evaluated in this study. The two armor removal projects both had HPAs, or 100 percent compliance. However, both projects were constructed by a government agency and not the general public and as such are not likely indicative of the broader compliance rate. Changes associated with new, major, and minor repairs to shoreline armoring accounted for 134 changes and are likely the most comparable between this study and the Bainbridge study. Even when only using shoreline armoring from this study, the highest HPA compliance rate was 45 percent and 58 percent for major repairs in 2016 and 2018, respectively. This is still well below the 80 percent HPA compliance seen in the Bainbridge Island study. The HPA compliance for this study of minor repairs was very low with between 5 percent and 17 percent, which is well below the compliance rate seen for Bainbridge Island.

The San Juan Initiative undertook surveys of 34 miles of the shorelines of the San Juan archipelago evaluating if changes to docks and armor projects had state or county permits (Key 2013). The initiative reported that 50 percent of the changes found did not have either a state or local permit, while some portion of the other 50 percent had one or both types of permits. The data is reported in an aggregated method and thus it is not 100 percent comparable to the WRIA 9 study. That said, at a minimum the San Juan compliance rates would be lower than 50 percent for both HPAs and local permits.

Anecdotal explanations for noncompliance: permits can be expensive and confusing

This study did not directly attempt to identify why people are not getting permits or why there were differences in compliance rates among jurisdictions within the study area. As noted earlier, as part of the pilot project, King County worked with unincorporated area landowners to bring them into compliance in 2014. As King County permit staff met with landowners, the primary reasons that they heard for the original noncompliance were (Personal Communication with Laura Casey, King County Department of Local Services, Permitting Division):

- High cost associated with permit fees
- Long processing timelines for permits when they had a sense of urgency to act quickly
- Confusion over if a permit was needed in the first place

- Confusion over which government agency needed to be contacted due to overlapping regulatory authorities
- Belief that they had a right to do an action, especially clearing to maintain views, irrespective of the regulations

Permit cost may be a stronger factor in noncompliance when project costs are low

The high cost of permits has frequently shown up as a possible reason for noncompliance in regional discussions about shoreline armoring. However it should be noted that there are significant cost differences between state and local permits, at least for residents in unincorporated King County. From 2016 to July of 2017 WDFW's HPA costs $150 dollars to obtain and afterward there was no permit fee whatsoever. Whereas permits to undertake the same bulkhead work in unincorporated King County costs several thousand dollars. If cost was a primary driver, one would expect that the compliance rate for HPAs would be much higher than the rate for permits from King County. However, the compliance rate in 2016 for major repairs was 63 percent for King County and only 50 percent for WDFW and in 2018 the compliance rates were both 50 percent. This suggests that costs may not be a primary driver for compliance rates associated with major repairs to shoreline armoring. Given the very low local and state permit compliance for minor repairs to shoreline armoring, costs may be a significant driver when the size of the action taken is relatively small.

- It is recommended that a separate study be undertaken to evaluate why landowners obtain permits at such low rates, especially for minor repair work and what changes to the regulatory structure might be undertaken to increase their willingness to get permits. Understanding why permits were frequently not obtained would be very useful to help create different approaches to improving permit compliance rates, which should lead to improved shoreline conditions in WRIA 9, which in turn should lead to improved survival of Chinook salmon and Orca.

Unpermitted shoreline modifications continue to work against efforts to achieve "no net loss" per the Shoreline Management Act

The permit process can provide landowner educational opportunities that help decrease the negative effects from construction techniques as well as provide an opportunity to work with the landowner to lessen the effects of existing infrastructure and possibly prevent future ecological degradation. However, based on the results of this report, it appears that many landowners are still doing work along the shoreline without permits. Roughly two-fifths of the work does not appear likely to have had long-term or obvious ecological effects, though this project did not try to assess short-term impacts that occurred during construction. The other three-fifths of the actions likely had at least some level of negative long-term effect and do not appear to be meeting the intent of the Shoreline Management Act standard of "no net loss of ecological function." Furthermore, many of these actions are degrading forage fish spawning habitat and juvenile Chinook salmon rearing habitat. If the region's efforts to change the current downward trajectory of the Southern Resident Puget Sound Orca population and Puget Sound Chinook salmon

populations are to be successful, the low rate of permit compliance and continued habitat degradation needs to improve.

To summarize, the following actions are recommended:

- A separate study be undertaken to evaluate why landowners are obtaining permits at such low rates, especially for minor repair work. Understanding why permits were frequently not obtained would be very useful to help create different approaches to improving permit compliance rates which should lead to improved shoreline conditions in WRIA 9, which in turn should lead to improved survival of Chinook salmon and Orca.
- PSP or WDFW should undertake a comprehensive assessment of compliance rates across Puget Sound in order to better estimate the actual net change in shoreline armoring and to understand if the overall low rates of compliance seen in this study are similar across Puget Sound.
- Local jurisdictions should consider using this study as a launching point to undertake a specific evaluation of if permitted actions are meeting the standard of no net loss of ecological function within their SMPs.
- Local jurisdictions should start requiring the inclusion of an HPA permit number prior to local permit issuance, and vice versa for WDFW. This recommendation was made by Barnhart et al. in 2015 and would likely moderately improve compliance rates.
- Given the visibility and weathering issue, it is recommended that any similar monitoring and compliance efforts attempt to undertake surveys roughly every two years. Longer time periods between repeat surveys will likely under represent the true number of changes that have occurred.

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6.0 APPENDIX

Physical and ecological effects for each change observed in 2016 and 2018.

- 'X' indicates a negative effect
- '+' indicates a positive effect
- An empty cell means there was no change associated with that function
- Grey shaded cells indicated no impacts noted for that specific change

Year	id #	Type	Status	Permitted Y or N?	Jursidiction	sediment delivery			Sediment transport	Light Energy			Organic Material		Wave Energy		Other Effects		
						↓ in sediment	↑ rate clearing	Shell hash	↓ rate of movement	↓ light transmission	↑ Light transmission day	↑ Light transmission night	↓ Input	↓ Storage	↓ wave energy	Change in interaction with shore	Potential WQ effects	Forage fish displacment	Hazard to public safety
2018	103	Armoring	Main - Major repair	N	Burien	X								X	X	X		X	
2016	39	Armoring	Main - Major repair	N	Burien														
2018	102	Armoring	Main - Major repair	Y	Burien									X		X			
2016	153	Armoring	Main - Major repair	Y	Burien				X					+	+	+			
2016	38	Armoring	Main - Major repair	Y	Burien											X			
2016	59	Armoring	Main - Major repair	Y	Burien											X			
2016	60	Armoring	Main - Major repair	Y	Burien											X			
2016	67	Armoring	Main - Major repair	Y	Burien											X			
2016	28	Armoring	Main - Major repair	Y	Burien														
2016	34	Armoring	Main - Major repair	Y	Burien														
2016	55	Armoring	Main - Major repair	Y	Burien														
2016	33	Armoring	Main - Minor repair	N	Burien											X			
2016	37	Armoring	Main - Minor repair	N	Burien											X			
2018	101	Armoring	Main - Minor repair	Y	Burien											X			
2016	32	Armoring	Main - Minor repair	Y	Burien											X			
2016	41	Armoring	Main - Minor repair	Y	Burien											X			
2016	24	Boat ramp	Main - New	Y	Burien														
2018	104	Clearing	Main - New	N	Burien								X						
2018	100	Other	Main - New	Y	Burien								X						
2016	25	Other	Main - New	Y	Burien		X												
2016	36	Other	Main - New	Y	Burien														
2018	104b	Other	Main - New	N	Burien	X													
2018	105	Other	Main - New	Y	Burien		X					X	X						
2016	29	Other	Main - New	Y	Burien								X			X			
2016	35	Other	Main - New	Y	Burien														
2016	58	Other	Main - New	Y	Burien														
2016	70	Ramp	Main - New	N	Burien				X					X	X			X	
2016	30	Stairs	Main - New	N	Burien														
2016	31	Stairs	Main - New	Y	Burien				X					+		X			
2018	109	Armoring	Main - New	Y	Des Moines														
2016	44	Armoring	Main - New	Y	Des Moines	X	X				X	X	X			X			
2016	45	Armoring	Main - New	Y	Des Moines														
2018	107	Armoring	Main - New	N	Des Moines									X	X	X		X	
2016	49	Armoring	Main - New	N	Des Moines														
2016	85	Armoring	Main - New	N	Des Moines	X			X					X		X		X	
2016	48	Other	Main - New	N	Des Moines														
2018	109b	other	Main - New	Y	Des Moines														
2016	87	Other	Main - New	N	Des Moines														

Year	id #	Type	Status	Permitted Y or N?	Jurisdiction	sediment delivery			Sediment transport	Light Energy			Organic Material		Wave Energy		Other Effects		
						↓ in sediment	↑ rate clearing	Shell hash	↓ rate of movement	↓ light transmission	↑ Light transmission day	↑ Light transmission night	↓ Input	↓ Storage	↓ wave energy	Change in interaction with shore	Potential WQ effects	Forage fish displacment	Hazard to public safety
2016	46	Other	Main - New	Y	Des Moines	X													
2018	108	Stairs	Main - New	N	Des Moines		X						X						
2016	89	Stairs	Main - New	N	Des Moines				X					X		X		X	
2018	117	Armoring	Main - New	Y	Federal Way														
2018	118	Armoring	Main - New	N	Federal Way										X	X			
2018	110	Armoring	Main - New	Y	Federal Way										X				
2018	119	Armoring	Main - New	Y	Federal Way														
2016	53	Armoring	Main - New	Y	Federal Way	X			X					X		X	X	X	
2018	116b	Clearing	Main - New	N	Federal Way								X						
2018	115	Clearing	Main - New	N	Federal Way		X					X	X						
2016	50	Clearing	Main - New	N	Federal Way	X						X	X						
2016	51	Clearing	Main - New	N	Federal Way		X					X	X						
2016	91	Clearing	Main - New	N	Federal Way		X					X	X						
2016	95	Clearing	Main - New	Y	Federal Way		X				X	X	X						
2018	112	Other	Main - New	N	Federal Way	X													
2018	116	Other	Main - New	Y	Federal Way							X							
2018	118b	Other	Main - New	N	Federal Way														
2016	54	Other	Main - New	N	Federal Way	X								X		X		X	
2018	116c	Other	Main - New	Y	Federal Way											X			
2016	52	Stairs	Main - New	N	Federal Way		X				X	X	X						
2018	113	Stairs	Main - New	N	Federal Way														
2018	114	Stairs	Main - New	N	Federal Way														
2018	110b	Stairs	Main - New	N	Federal Way									X					
2018	111	Stairs	Main - New	N	Federal Way								X	X	X	X		X	
2018	63	Armoring	Main - New	N	King County	X								X					
2018	34	Armoring	Main - New	N	King County							X	X	X		X		X	
2018	33	Armoring	Main - New	N	King County														
2018	59	Armoring	Main - New	N	King County														
2018	68	Armoring	Main - New	N	King County														
2018	81	Armoring	Main - New	N	King County														
2018	9	Armoring	Main - New	N	King County														
2016	74	Armoring	Main - New	N	King County	X								X					
2016	78	Armoring	Main - New	N	King County									X		X		X	
2016	105	Armoring	Main - New	N	King County											X			
2016	81	Armoring	Main - New	N	King County								X						
2016	118	Armoring	Main - New	N	King County														
2016	129	Armoring	Main - New	N	King County														
2016	130	Armoring	Main - New	N	King County														

Year	id #	Type	Status	Permitted Y or N?	Jursidiction	sediment delivery			Sediment transport	Light Energy			Organic Material		Wave Energy		Other Effects		
						↓ in sediment	↑ rate clearing	Shell hash	↓ rate of movement	↓ light transmission	↑ Light transmission day	↑ Light transmission night	↓ Input	↓ Storage	↓ wave energy	Change in interaction with shore	Potential WQ effects	Forage fish displacment	Hazard to public safety
2016	133	Armoring	Main - New	N	King County														
2016	68	Armoring	Main - New	N	King County														
2016	82	Armoring	Main - New	N	King County														
2016	90	Armoring	Main - New	N	King County														
2016	97	Armoring	Main - New	N	King County														
2016	138	Armoring	Main - New	Y	King County														
2016	73	Armoring	Main - New	Y	King County														
2018	11	Armoring	Main - New	y	King County	X			X		X		X	X		X		X	
2018	12	Armoring	Main - New	y	King County	X			X		X		X	X		X		X	
2018	13	Armoring	Main - New	Y	King County	X			X		X		X	X		X		X	
2018	14	Armoring	Main - New	Y	King County	X			X		X		X	X		X		X	
2018	15	Armoring	Main - New	Y	King County	X			X		X		X	X		X		X	
2018	16	Armoring	Main - New	Y	King County	X			X		X		X	X		X		X	
2018	43	Armoring	Main - New	Y	King County				X					X		X		X	
2018	18	Armoring	Main - New	Y	King County									+		+			
2018	61	Armoring	Main - New	Y	King County									X		X			
2018	47	Armoring	Main - New	y	King County									X		X		X	
2018	4	Armoring	Main - New	Y	King County														
2018	51	Armoring	Main - New	Y	King County														
2018	60	Armoring	Main - New	Y	King County														
2018	70	Armoring	Main - New	Y	King County														
2018	42	Armoring	Main - New	Y	King County											X		X	
2016	120	Armoring	Main - New	Y	King County	X			X		X	X	X	X		X		X	
2016	64	Armoring	Main - New	Y	King County	X					X	X	X	X		X		X	
2016	148	Armoring	Main - New	Y	King County		X		X		X	X	X	X		X		X	
2016	88	Armoring	Main - New	Y	King County									+		+	+		
2016	98	Armoring	Main - New	Y	King County				+					+					
2016	101	Armoring	Main - New	Y	King County				X					X		X		X	
2016	96	Armoring	Main - New	Y	King County				X					X		X		X	
2016	75	Armoring	Main - New	Y	King County									X		X		X	
2016	124	Armoring	Main - New	Y	King County						X	X	X						
2016	140	Armoring	Main - New	Y	King County						X	X	X						
2016	103	Armoring	Main - New	Y	King County														
2016	112	Armoring	Main - New	Y	King County														
2016	126	Armoring	Main - New	Y	King County														
2016	127	Armoring	Main - New	Y	King County														
2016	143	Armoring	Main - New	Y	King County														
2016	69	Armoring	Main - New	Y	King County														

Year	id #	Type	Status	Permitted Y or N?	Jursidiction	sediment delivery			Sediment transport	Light Energy			Organic Material		Wave Energy		Other Effects		
						↓ in sediment	↑ rate clearing	Shell hash	↓ rate of movement	↓ light transmission	↑ Light transmission day	↑ Light transmission night	↓ Input	↓ Storage	↓ wave energy	Change in interaction with shore	Potential WQ effects	Forage fish displacment	Hazard to public safety
2016	77	Armoring	Main - New	Y	King County						X	X	X					X	
2016	131	Armoring	Main - New	Y	King County													X	
2016	110	Armoring	Main - New	N	King County				X					X	X	X		X	
2018	72	Armoring	Main - New	N	King County	X													
2018	22	Armoring	Main - New	N	King County														
2018	24	Armoring	Main - New	N	King County														
2018	35	Armoring	Main - New	N	King County														
2018	38b	Armoring	Main - New	N	King County														
2018	54	Armoring	Main - New	N	King County														
2018	55	Armoring	Main - New	N	King County														
2018	69	Armoring	Main - New	N	King County														
2018	80	Armoring	Main - New	N	King County														
2016	57	Armoring	Main - New	N	King County	X													
2016	142	Armoring	Main - New	N	King County											X			
2016	93	Armoring	Main - New	N	King County											X			
2016	113	Armoring	Main - New	N	King County														
2016	114	Armoring	Main - New	N	King County														
2016	116	Armoring	Main - New	N	King County														
2016	139	Armoring	Main - New	N	King County														
2016	79	Armoring	Main - New	N	King County														
2018	39	Armoring	Main - New	Y	King County														
2016	76	Armoring	Main - New	Y	King County						X	X	X						
2018	64	Armoring	Main - New	N	King County	X			X					X	X	X		X	
2018	78	Armoring	Main - New	N	King County				X					X	X	X		X	
2016	123	Armoring	Main - New	N	King County	X								X	X	X		X	
2016	63	Armoring	Main - New	N	King County	X			X					X		X		X	
2016	121	Armoring	Main - New	N	King County	X								X		X		X	
2016	56	Armoring	Main - New	N	King County	X								X		X		X	
2016	111	Armoring	Main - New	Y	King County	X			X					X		X		X	
2016	154	Armoring	Main - New	Y	King County		+	+	+					+	+	+			
2016	144	Armoring	Main - New	Y	King County						+	+	+			+			
2018	32c	Clearing	Main - New	N	King County						X	X	X						
2016	106	Clearing	Main - New	N	King County						X	X	X						
2018	62	Clearing	Main - New	N	King County		X				X	X	X						
2016	72	Clearing	Main - New	N	King County	X	X				X	X	X			X			
2016	119	Clearing	Main - New	N	King County		X				X	X	X						
2016	122	Clearing	Main - New	N	King County		X				X	X	X						
2016	62	Clearing	Main - New	N	King County		X				X	X	X						

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2016	72	Clearing	Main - New	N	King County	X	X				X	X	X			X			
2016	119	Clearing	Main - New	N	King County		X				X	X	X						
2016	122	Clearing	Main - New	N	King County		X				X	X	X						
2016	62	Clearing	Main - New	N	King County		X				X	X	X						
2016	107	Clearing	Main - New	N	King County						X	X	X						
2018	25	Clearing	Main - New	N	King County						X	X	X						X
2018	28	Clearing	Main - New	N	King County		X				X	X	X						
2018	29	Clearing	Main - New	N	King County		X				X	X	X						
2018	52	Clearing	Main - New	N	King County		X				X	X	X						
2016	141	Clearing	Main - New	N	King County		X						X						
2016	151	Clearing	Main - New	N	King County		X				X	X	X						
2016	104	Clearing	Main - New	N	King County		X				X	X	X						x
2018	5b	Clearing	Main - New	N	King County		X				X	X	X						
2018	64b	Clearing	Main - New	N	King County		X				X	X	X						
2018	58	Clearing	Main - New	N	King County								X						
2018	78b	Clearing	Main - New	N	King County								X						
2018	45	Clearing	Main - New	y	King County		X				X	X	X						
2018	46	Dock	Main - New	N	King County			X		X					X	X			X
2016	132	Dock	Main - New	N	King County					X									
2018	21	Dock	Main - New	N	King County					+			+						
2018	44	Dock	Main - New	N	King County														
2018	65	Dock	Main - New	N	King County														
2018	30	Dock	Main - New	N	King County			X	X	X				X	X	X			
2018	77	Dock	Main - New	N	King County			X		+					X	X	X		
2018	41	Dock	Main - New	N	King County								X						
2018	50	Dock	Main - New	N	King County					X									
2016	135	Dock	Main - New	N	King County			X		X		X							
2018	20	Dock	Main - New	N	King County					X				X	X	X		X	
2016	109	Other	Main - New	N	King County	X					X	X	X						
2016	102	Other	Main - New	N	King County														
2018	23	Other	Main - New	y	King County														
2016	100	Other	Main - New	Y	King County	X													
2018	8	Other	Main - New	N	King County	X													
2018	36	Other	Main - New	N	King County														
2018	49	Other	Main - New	N	King County														
2018	50b	Other	Main - New	N	King County														
2018	56	Other	Main - New	N	King County														
2018	7	Other	Main - New	N	King County														

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2018	75	Other	Main - New	N	King County														
2016	134	Other	Main - New	N	King County			X						X	X	X			
2016	147	Other	Main - New	N	King County		+							+	+	+		X	
2016	65	Other	Main - New	N	King County									X		X		X	
2016	149	Other	Main - New	N	King County						X	X							
2018	19	Other	Main - New	N	King County	X					X	X	X						
2018	73	Other	Main - New	N	King County	X							X						
2018	32b	Other	Main - New	N	King County	X													
2018	40b	Other	Main - New	N	King County	X													
2018	5	Other	Main - New	N	King County	X													
2018	53	Other	Main - New	N	King County	X													
2018	58b	Other	Main - New	N	King County	X													
2018	6	Other	Main - New	N	King County	X													
2018	67	Other	Main - New	N	King County	X													
2018	57	Other	Main - New	N	King County									X		X		X	
2018	10	Other	Main - New	N	King County		X												X
2018	40	Other	Main - New	N	King County								X						
2018	27	Other	Main - New	N	King County					X									
2018	26	Other	Main - New	N	King County														
2018	74	Other	Main - New	N	King County														
2018	78c	Other	Main - New	N	King County														
2016	146	Other	Main - New	N	King County	X							X						
2016	99	Other	Main - New	N	King County	X													
2016	86	Other	Main - New	N	King County														
2018	76	Other	Main - New	Y	King County	X							X						
2018	32	Other	Main - New	Y	King County						X	X							
2018	79	Other	Main - New	Y	King County														
2018	120	Other	Main - New	N	King County						X	X	X						
2016	115	Ramp	Main - New	N	King County				X					X	X			X	
2018	48	Ramp	Main - New	N	King County														
2018	31	Stairs	Main - New	N	King County														
2016	125	Stairs	Main - New	N	King County									X	X	X		X	
2016	136	Stairs	Main - New	N	King County						X	X	X						
2016	108	Stairs	Main - New	N	King County														
2016	137	Stairs	Main - New	N	King County														
2016	150	Stairs	Main - New	N	King County														
2018	37	Stairs	Main - New	N	King County										X				
2016	117	Stairs	Main - New	N	King County					X									

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2018	17	Stairs	Main - New	N	King County	X			X	X	X	X	X	X	X	X		X	
2018	38	Stairs	Main - New	N	King County								X						
2016	61	Stairs	Main - New	N	King County				X					X		X		X	
2016	71	Stairs	Main - New	N	King County							X	X						
2016	145	Stairs	Main - New	Y	King County				X					X	X	X		X	
2016	66	Stairs	Main - New	N	King County		X							X		X		X	
2016	84	Armoring	Main - New	N	Normandy Park									X	X	X		X	
2016	83	Armoring	Main - New	N	Normandy Park									X		X		X	
2016	42	Armoring	Main - New	Y	Normandy Park				X					X		X		X	
2018	106b	Clearing	Main - New	y	Normandy Park								X						
2018	106c	Other	Main - New	N	Normandy Park	X													
2018	106	Other	Main - New	y	Normandy Park														
2016	43	Other	Main - New	N	Normandy Park														
2016	80	Other	Main - New	N	Normandy Park														
2016	40	Other	Main - New	Y	Normandy Park	X						X	X						
2018	3	Armoring	Main - New	N	Seattle									+	+	+			
2018	86	Armoring	Main - New	N	Seattle														
2018	92	Armoring	Main - New	N	Seattle														
2016	5	Armoring	Main - New	N	Seattle				+					X		X		X	
2016	3	Armoring	Main - New	N	Seattle														
2018	98	Armoring	Main - New	Y	Seattle									X		X		X	
2018	89	Armoring	Main - New	Y	Seattle														
2016	23	Armoring	Main - New	Y	Seattle							+		+		+			
2016	14	Armoring	Main - New	Y	Seattle				X					X		+		X	
2016	26	Armoring	Main - New	Y	Seattle									X		X		X	
2016	8	Armoring	Main - New	Y	Seattle					+		X	X		X	X			
2016	10	Armoring	Main - New	Y	Seattle											+			
2016	9	Armoring	Main - New	Y	Seattle						X		X		+				
2016	20	Armoring	Main - New	Y	Seattle														
2018	90	Armoring	Main - New	N	Seattle														
2016	11	Armoring	Main - New	N	Seattle											X			
2018	93	Armoring	Main - New	Y	Seattle	X													
2018	94	Armoring	Main - New	Y	Seattle											X			
2018	85	Armoring	Main - New	Y	Seattle														
2018	88	Armoring	Main - New	Y	Seattle														
2018	99	Armoring	Main - New	Y	Seattle														
2016	16	Armoring	Main - New	Y	Seattle				X					X		X		X	
2016	17	Armoring	Main - New	Y	Seattle														

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2016	21	Boat ramp	Main - New	N	Seattle				X					X		X		X	
2016	1	Clearing	Main - New	N	Seattle		X				X	X	X						
2016	152	Clearing	Main - New	N	Seattle		X				X	X	X						
2018	91	Other	Main - New	N	Seattle														
2018	84	Other	Main - New	Y	Seattle														
2016	18	Other	Main - New	Y	Seattle														
2016	7	Other	Main - New	N	Seattle							X							
2018	87	Other	Main - New	N	Seattle														
2016	19	Other	Main - New	N	Seattle														
2018	82	Other	Main - New	Y	Seattle								X						
2018	1	Other	Main - New	Y	Seattle														
2018	2	Other	Main - New	Y	Seattle														
2018	83	Other	Main - New	Y	Seattle														
2018	95	Other	Main - New	Y	Seattle														
2018	97	Other	Main - New	Y	Seattle														
2016	13	Other	Main - New	Y	Seattle						X	X	X						
2016	12	Other	Main - New	Y	Seattle														
2016	15	Other	Main - New	Y	Seattle														
2016	4	Other	Main - New	Y	Seattle														
2018	96	Stairs	Main - New	N	Seattle														
2016	2	Stairs	Main - New	N	Seattle		X					X	X						
2016	22	Stairs	Main - New	N	Seattle				X					X	X	X		X	