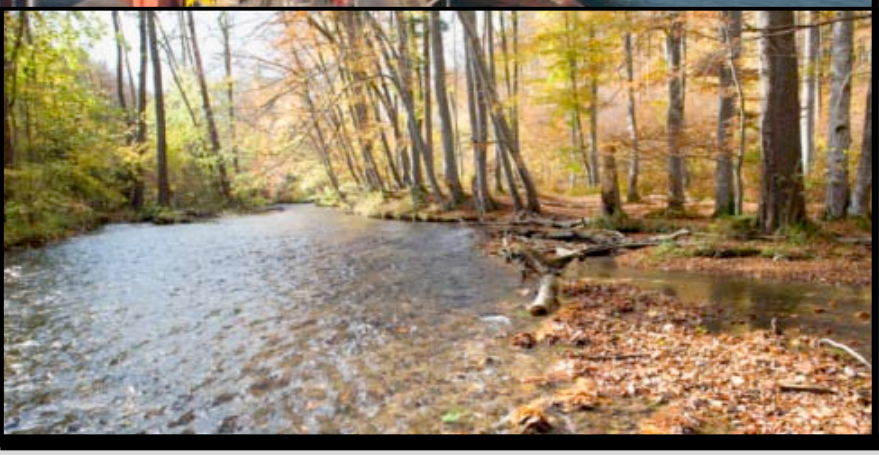
West Hayden Island Public Cost / Benefit Analysis



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Executive Summary

The City's preliminary plans for WHI include annexing WHI to the City for the purpose of developing 300 acres of the island for a potential future port facility (WHI port), and protecting and mitigating 500 acres for recreation and open-space use.[1] The purpose of our analysis is to give the City Council and others information on the potential economic effects of this decision. Specifically, our analysis compared the economic differences between current land uses on WHI—which we describe as the Baseline Scenario—with the economic effects of partitioning WHI between 300 acres of port development and 500 acres of open space—which we describe as the Development Scenario.

We include three types of economic effects in our analysis. The first type, economic values, represents the changes in values of goods and services available that result from the market and non-market activities of the Baseline and Development Scenarios. An increase in value is a benefit, a decrease in value is a cost. Representative values in our analysis include changes in the values of port goods and services, changes in values of ecosystem services, and changes in quality of life in the local community proximate to the WHI port. Technically, a benefit-cost analysis focuses exclusively on changes in economic values. We understand, however, that stakeholders and decision makers are interested in other economic outcomes of the Development Scenario and so our analysis looked beyond economic values to include two other types of economic effects, which we describe next.

The second type of economic effect, economic impacts, represents changes in jobs, employment income, and tax revenues. These impacts occur directly as workers are employed, e.g., on construction and mitigation projects, and indirectly, as dollars spent locally on construction and mitigation cycle through the economy and support other purchases, e.g., food purchased by construction workers. Economists frequently describe these changes using multiplier or impact analyses.

The third type of economic effect, economic distribution, represents the distribution of the other two types of economic effects. This portion of the analysis describes those who pay the costs, those who enjoy the benefits, and their locations.

The proposed development of WHI would not happen for some time, which makes describing some of the economic effects of the decision more challenging. Based on their experience with past annexations, and on details specific to WHI, City staff assume that construction would not begin until 2023, and would last for 3-5 years. Specific to our analysis of the economic effects of port operations, we therefore assume that port operations would not begin until approximately 2026-2028. We assume natural-resource mitigation would begin in 2018, 5 years prior to construction. We calculate economic effects for 100 years of the Baseline and Development Scenarios. Projecting economic activity that far into the future must

[1] Portland City Council Resolution 36805, July 29, 2010.

necessarily include not an insignificant amount of uncertainty. Given these conditions we felt it best to focus our analysis on describing economic effects in broad terms rather than try to more precisely define future conditions for which the available data do not support.

Our analysis of the Baseline Scenario assumes no significant changes in current land uses on WHI. Current conditions would continue for the foreseeable future. We base our analysis of the Development Scenario on the conditions, assumptions, and maps described in the preliminary draft of the Concept Plan for the proposed WHI development. The draft Concept Plan has information on the types and costs of infrastructure developments that would happen as part of developing WHI. In addition to the Concept Plan, other information upon which we based our analysis includes:

- The City's preliminary assessment of natural-resource mitigation that would happen as part of the Development Scenario.
- The City's preliminary assessment of the traffic impacts of the Development Scenario.
- The assumption that the Columbia River Crossing (CRC) project will happen as currently envisioned.
- The assumption that the Hayden Island Plan will happen as currently envisioned.
- The most recent forecasts of cargo that would pass through the WHI port.

Our analysis of the Baseline and Development Scenarios focused on four broad categories of economic effects. The first category, natural-resource effects, includes the economic effects of mitigating for the loss of 300 acres of habitat and changes in the supply and values of ecosystem services provided by natural resources on and around WHI. The second category, recreation effects, takes into account the new recreational opportunities in the Development Scenario. The third category, local effects, includes the changes in quality of life for residents and businesses on East Hayden Island. The fourth category, port effects, focuses on the costs of developing the WHI port and the economic values, jobs, employment income, etc. of the new facilities.

The uncertainties inherent in our analysis, and the associated data constraints, prevent us from quantifying and monetizing all of the relevant costs, benefits, economic impacts, or local quality of life effects. Hence, we describe the results using a mix of quantified and qualitative information. In cases where the data allowed, we measured and monetized economic changes. In cases where the data would not allow quantified measures of change, we described the change qualitatively.

In the remainder of this Executive Summary, we describe the results of our analysis for each of the four categories of economic effects: natural resources, recreation, local, and port. Taking into account the caveats and assumptions we describe throughout this report, we find it likely that the net economic benefits and impacts of the Development Scenario would exceed the net economic benefits and impacts of the

Baseline Scenario. We also conclude that the economic benefits local to the Portland area would exceed the local costs.

I. Natural Resource Effects

Under the Baseline Scenario, our analysis assumes WHI contains (and will continue to contain) 950 acres[2] of natural habitat including forests/woodlands, wetlands, shallow water areas, shrublands, and grasslands. These natural resources provide a range of valuable goods and services such as wildlife habitat, microclimate and shade, flow moderation and flood storage, and water quality control. Under the Development Scenario, our analysis assumes 283 of these acres are displaced due to the WHI port, and that the quality of remaining forest and woodland areas declines. Furthermore, we assume that the Development Scenario will implement mitigation efforts on 580 acres on and off WHI in an attempt to offset its effects on natural resources on WHI. Using data from the relevant literature, past research efforts on WHI, information collected from Portland Bureau of Planning and Sustainability staff, and information and comments from Portland Bureau of Environmental Services staff, our analysis estimates the NPV of benefits and costs associated with both the Baseline Scenario and the Development Scenario.

Table 1 summarizes our results. Under the Baseline Scenario, the 100-year NPV of natural resource benefits on WHI is approximately $19.3–$119.4 million, in 2011 dollars. Under the Development Scenario, the 100-year NPV of natural resource benefits ranges from $14.8–107.9 million ($2011) without mitigation, and $16.7–$113.8 million ($2011) with mitigation. The NPV of costs under the Development Scenario are about $24.5 million ($2011). After considering the 100-year NPV of costs, benefits, and forgone benefits, the Development Scenario would result in a net decrease in economic value of approximately $27.1–$30.2 million ($2011).

Analyzing the value of natural resources under the two scenarios sheds light on a number of important issues:

- It is difficult to fully mitigate on WHI because existing habitat currently provides high-level functionality, with little room for improvement.
- Promoting long-term success of mitigation efforts has high costs, and the long time horizons needed to realize the full benefits from mitigation efforts decrease their influence on the NPV from now and into the future.
- Wetland and shallow water habitat on WHI have the highest potential for improving benefits.
- The net costs of mitigation should be considered an additional share of the net costs of the Development Scenario, not an independent decision to be evaluated on its own efficiency.

The net economic impacts of the natural resource effects include approximately 140 job-years worth of direct employment impacts. One job-year represents one person employed for one year. The direct employment income associated with these job-years is $9.4 million ($2011).

[2] 800 acres of "dry land" and 150 acres of shallow water habitat.

Regarding the distribution of the economic values and economic impacts, the large majority of both would primarily be local to the Portland metropolitan area.

Table 1. 100-Year NPV of Benefits and Costs of Natural Resources on WHI ($2011)

Baseline Scenario	100-Year NPV (3% Discount Rate)
Benefits	$19.3–$119.4 million
Costs	$0
Development Scenario	**100-Year NPV (3% Discount Rate)**
Benefits (no mitigation)	$14.8–$107.9 million
Benefits (mitigation)	$16.7–$113.8 million
Costs	$24.5 million
Net Effect	**100-Year NPV (3% Discount Rate)**
Assuming Mitigation	($27.1)–($30.2) million

Source: ECONorthwest staff estimates.

II. Recreation Effects

Under the Baseline Scenario, recreation on WHI is limited due primarily to access restrictions and lack of recreation-based infrastructure. Under the Development Scenario the supply of recreation opportunities on WHI would increase by adding two miles of trails, improved beach access on the north shore of WHI, and a new non-motorized boat launch. Using data from the *2010 Entrix Report* we estimate that there are approximately 250–1,000 recreation days per year on WHI under the Baseline Scenario. Using data from recreation literature and surveys of recreation demand in other parks in the Portland area (Sellwood Riverfront Park and Willamette Park), we estimate that there would be a maximum of approximately 8,300 recreation days per year on WHI under the Development Scenario.

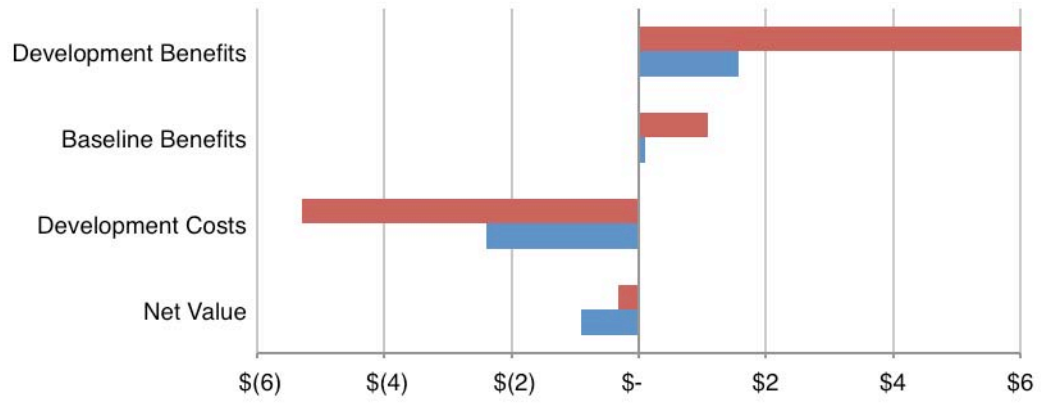
To estimate the value of these recreation days, we apply a range of consumer surplus values[3] from the literature. We included the following recreational activities in our analysis: fishing, hiking, rafting, canoeing, picnicking, swimming, wildlife viewing and general recreation. The value of recreation on WHI under the Baseline Scenario is approximately $3,000–$34,000 per year, with a 100-year NPV of approximately $0.1–$1.1 million ($2011). The value of recreation on WHI under the Development Scenario (once recreation construction is complete) is approximately $79,000–$294,000 per year with a 100-year NPV of approximately $1.6–$6.1 million ($2011). The NPV of construction, management, and maintenance costs associated with the Development Scenario is approximately $2.4–$5.3 million ($2011). Table 2 summarizes our results. The overall net value is equal to the range of benefits under the Development Scenario minus the costs under the Development Scenario and the forgone benefits under the Baseline Scenario. As Table 2 shows, the Development

[3] Typically individuals are willing to pay more for a good or service than they end up paying for it. Consumer surplus is the difference between how much an individual is willing to pay for something and how much he or she actually pays.

Scenario would result in a net decrease in overall recreation-related value of $0.3–$0.9 million.

Table 2. NPV of Benefits and Costs of Recreation on WHI

Development Scenario Benefits	Baseline Scenario Benefits	Development Scenario Costs	Net Value
$1.6–$6.1	$0.01–$1.1	$2.4–$5.3	($0.9)–($0.3)



Source: ECONorthwest staff estimates.

The net economic impacts of the recreation effects include approximately 5–14 job-years directly from construction and less than one annual job directly from management (these management duties likely will be filled by existing staff). The direct employment income associated with the construction-related jobs is $0.3–$0.9 million ($2011).

The large majority of the economic values and impacts of the recreation effects would be local to the Portland metropolitan area.

III. Local Effects

This portion of our analysis focuses on the effects of the Development Scenario on the quality of life (Q of L) in EHI. By quality of life we mean factors such as noise, light pollution, air quality, and traffic concerns. As we explain later in this report, uncertainty exists regarding the types of development that will take place on WHI and when the development will occur. More information exists about some aspects of the Development Scenario, e.g., the configuration of the rail line, than about other aspects, e.g., what activities will take place on the land set aside for marine-industrial uses and how these activities would affect EHI. These data constraints and uncertainties surrounding the Development Scenario prevent us from quantifying and monetizing the effects on Q of L measures. Instead, we identify the major categories of quality of life concerns (e.g., noise effects), and describe the potential effects as best the available information will allow. We begin with the potential traffic effects of the Development Scenario.

A. Traffic Effects

According to the City's traffic analysis, without a WHI bridge connecting to Marine Drive, the port facility would increase traffic by an average of 12 percent throughout the network of streets on EHI. The impact on traffic west of the mall, however, would be more significant. If there were a new bridge that connected WHI with Marine Drive, the traffic model predicts that 90 percent of the port traffic would use the bridge and connect to I-5 via Marine Drive. According to this study, even with the higher traffic impacts on NHID with the no-bridge alternative, the additional port traffic would not cause congestion or access problems for EHI drivers. This results depends on the assumption that the Columbia River Crossing (CRC) and Hayden Island Plan will be implemented as currently envisioned. To the extent that the on-island traffic improvements in the CRC and Hayden Island Plan do not happen as assumed in the City's traffic analysis, it will increase the probability that port-related traffic would generate negative traffic impacts. These impacts could include increased congestion on EHI roadways, increased delays and travel times, and increased traffic accidents. Another reason for the limited impact of the WHI port on traffic congestion is that the late afternoon or early evening traffic flow ("PM peak traffic") for the port traffic would be opposite the direction of other on-island traffic at that time.

B. Noise Effects

The Development Scenario could generate noise impacts from three sources. The first source is noise produced by unit trains as they travel the elevated railway that crosses the island and as they travel through the new rail yard on WHI. The second source is noise caused by the loading of autos and bulk materials onto rail cars. The third source is noise made by trucks traveling on NHID between the WHI port and I-5.

Based on experiences at other terminals of the Port of Portland (Port) and at ports elsewhere, we expect that the WHI port would likely generate noise effects. Data are not available at this time, however, that describe the type, severity or impact areas of those effects. This is especially relevant when calculating noise impacts because site-specific factors affect the severity of noise effects, including the distance from the noise source, topography, metrological conditions of air temperature, wind speed, and direction, and the location of sound blocking or reflection surfaces. Vehicle characteristics also affect the level of noise impacts including speed, frequency, types (rail, auto or truck), state of maintenance, and roadway- or rail-infrastructure characteristics. Other researchers who study Q of L impacts of port facilities on adjacent neighborhoods recommend collecting this type of information as part of a Health Impact Assessment (HIA) of the proposed development. These impacts could also be studied as part of an Environmental Impact Statement (EIS) for the port facility, should one be required.

Based on data reported in the literature on the distance over which noise from rail traffic affects property values, and the magnitude of those effects, trains traveling the elevated tracks could possibly impact less than 10 residences in EHI. Applying these data to property values for the potentially affected properties yields a potential

negative impact on property values of approximately $33,000. We stress that this impact is *illustrative* and not definitive for the proposed WHI port, for the reasons we list in the proceeding paragraph. We also note that trains currently travel the elevated rail line across WHI. To the extent that the rail traffic associated with the WHI port has no noticeable increase in noise impacts, our illustrative calculation overstates the potential cost of the noise effects attributed to port-specific rail traffic. A HIA or EIS could help determine the extent to which port-specific rail traffic would cause a noticeable increase in noise effects from rail traffic.

Regarding the potential noise effects of future port operations, perhaps the best indications may be the experiences with noise effects and mitigation results at Port of Portland Terminals 4 and 5 (T4 and T5). Activities at these terminals move the types of goods that may move through the WHI port—autos and bulk goods—and move these goods by rail and trucks, which would also transport goods from the WHI port. Based on this experience, mitigation worked better for some noise effects—filling and moving train cars—than for other noise effects—loading autos onto train cars. The distance between residential areas on EHI and the location of the WHI port will provide a buffer that will help mitigate noise and other effects from port operations. It is unknown at this time, however, the extent to which that buffer will sufficiently mitigate noise and other effects so that they have no impact on EHI residents and businesses. A HIA or EIS could help describe any such effects.

Regarding the potential noise effects of trucks traveling NHID to and from the WHI port, we found no data on study sites comparable to EHI. We note, however, that results from the North Portland Noise Study indicated that trucks traveling other freight corridors in the Portland area generate noise effect that exceed the Federal Highway Administration sound levels that would require mitigation, and also exceed the US Department of Housing and Development sound levels considered "acceptable" for residential areas.

C. Light Effects

The WHI port could generate light impacts due to the large expanse of work area outdoors and the possibility of loading and unloading operations continuing 24-hours a day. Also, worker safety regulations require a minimum amount of illumination.

The experience at Port of Portland T4 and T5, and at ports elsewhere in the US demonstrates that unmitigated light effects from port activities can negatively affect area residents. These experiences also demonstrate, however, that mitigation measures such as shielding and redirecting lights down and away from shining towards residential areas, using the minimum lighting required, putting lights on timers and turning off lights when not in use, can mitigate these negative effects.

D. Air Quality Effects

The Development Scenario could produce two sources of air-quality impacts. The first is particulate matter from diesel exhaust. Operations at port and rail facilities involve a number of diesel-powered engines including on ships docking at the WHI

port, engines on trains, and heavy trucks that move cargo within the port and transport cargo on roadways throughout the region. The second potential source of air-quality impacts is dust from loading and unloading bulk materials such as potash or grain.

At this time, no data exist on the magnitude or geographic extent of any potential air-quality effects of the WHI port. As we noted above in our discussion of potential noise impacts, researchers who study the impacts of ports on Q of L suggest developing a HIA, which could include air-quality effects. As we did with Noise Effects, we can illustrate the cost of air quality effects from port-generated vehicle traffic using data reported in the literature. Applying data on costs per vehicle to the estimated number of port-specific vehicles, we calculate that total per mile air quality cost for all port vehicles is approximately $45 ($2011). This represents the cost of air quality effects of all port-specific vehicles traveling one mile. We stress that this cost is *illustrative* and not definitive for the WHI port.

The air-quality effects at Port of Portland T4 and T5 provide some insights into potential air-quality effects of the bulk terminal proposed for WHI. Kinder Morgan moves soda ash through T4 and Columbia Gran moves grain through T5, the bulk terminal currently anticipated for WHI could process either or both of these commodities. Kinder Morgan received complaints about dust produced from their operations at T4. Kinder Morgan responded by setting up air monitors at the perimeter of their facility to track dust movement and improved the efficiency of their bag house and dust collectors. Columbia Grain took actions to mitigate the air-quality impacts of their operations including hiring a consultant who provides ongoing monitoring at the facility, upgraded some of their bag houses, and began applying food-grade oil to grain to reduce dust produced with grain movement.

While the Development Scenario may generate negative local air quality effects, effects at the regional level could be positive. To the extent that the WHI port improves the efficiency of ship, rail and truck traffic, it would help reduce regional air-quality effects below what they would be without it.

E. WHI Bridge

The Concept Plan for the proposed annexation and development of WHI includes a bridge that connects WHI with Marine Drive (WHI bridge). The bridge would significantly reduce the traffic and related noise effects on EHI of traffic to and from the WHI port because the large majority of this traffic would cross the WHI bridge rather than travel NHID through EHI. The port traffic using the bridge would also save travel time between the WHI port and I-5 that has an estimated annual value of approximately $494,000 ($2011). By reducing port-related traffic that travels through EHI, the bridge would also help protect the livability and proposed developments on EHI as envisioned in the Hayden Island Plan. To the extent that NHID is the main access for the WHI port and industrial-type development on WHI, it may limit the interest of prospective developers to make the investments that would support the types of growth and development envisioned in the Hayden Island Plan. The risk is that because of the port traffic, EHI develops the feel and reputation of an industrial area, rather than residential or retail area.

F. Summary of Local Effects

Relative to the Baseline Scenario, the population of EHI would benefit from the Development Scenario through access to more and improved recreational opportunities. Our analysis of recreation effects includes these benefits. The Development Scenario would also likely negatively affect the Q of L on EHI due to noise, light and air-quality effects. Conducting a HIA or studying these effects as part of an EIS, should one be required for the port facility, could help quantify the potential negative Q of L effects. Experiences at the Port and ports elsewhere provide information on measures that could mitigate negative Q of L effects. The proposed WHI bridge would significantly reduce potential traffic and related noise effects by reducing the port-specific traffic that travels NHID through EHI.

IV. Port Effects

In recent years, ports' role in local economies changed and thus the economic effects associated with port development have become more uncertain. Given these uncertainties, we cannot precisely calculate the potential economic effects of port development. Instead, we outline key relationships, trends, and data that will help decisionmakers and stakeholders understand the costs, benefits, and economic tradeoffs of investing public funds in a WHI port facility. Specifically we emphasize the following:

(1) Many of the benefits created by port development are enjoyed globally – by firms and consumers outside of Portland; however, many of the costs of developing and operating the report remain concentrated locally.

(2) Historically, ports played a significant role in local economic development – firms found it advantageous to locate near ports because locating near a port meant substantially lower transportation costs; however, significant declines in transportation costs have diminished the effect of ports on firm location and local economic development.

(3) A successful port facility is a large traded sector entity (that is, it sells services produced in Portland to consumers outside the region). As such, it likely generates local economic benefits similar to those generated by the development of a large factory (or other traded sector entity). Such benefits may include more jobs and higher incomes for local workers, higher property values for homeowners, greater tax revenue for local government, and greater productivity in related industries.

(4) In the absence of the development of WHI, the resources that would have been devoted to WHI may have been used to invest in other projects that promote local economic development. Developing WHI produces net benefits to the extent that the port facility (and other aspects of WHI development) generates larger local economic benefits than these alternatives.

(5) The existence of economic benefits from port development hinge on the existence of demand for the facility. An un- or under-utilized facility produces few local economic benefits.

The local economic benefits generated by a WHI port depend on the benefits it creates for each of the potential beneficiaries – port users, the port entity, and indirect beneficiaries of port attracted or induced investments.

A WHI port will likely generate few local user benefits. The current plan envisions WHI as a convenient transshipment point for far away producers shipping goods to far away consumers. Local user benefits could materialize if the auto terminal allows local auto dealers and consumers to get cars at lower costs. Local user benefits could also stem from the 14-acre marine industrial facility. The magnitude of local user benefits from the marine industrial facility will depend on (a) whether the firm is locally owned and (b) where its consumers are located. It is also possible that a WHI port would increase overall port efficiency (perhaps due to economies of scale) so that port users throughout region (more of whom are local companies) benefit. Ultimately, the magnitude of local user benefits will likely be small, but that could change as facility users change over the 50-100 years covered in this analysis.

The WHI port and those that provide support services to the port will likely collect a substantial share of the local economic benefits generated by the WHI port. Moving goods through the WHI port requires more than the port itself. It relies on rail, truck and barge transportation firms, terminal operators, ILWU and its workers, etc. When port development allows for greater port activity, the port entity and these groups benefit to the extent that they earn higher profits or wages than they would have earned otherwise.

A WHI port could generate additional local benefits if it spurs local investment and economic activity that would not otherwise occur. To the extent that port investments attract and induce other investments in the local economy, it could create additional economic benefits. Another benefit could be tax revenues paid by non-local port users. Such tax payments would represent net benefits for the Portland metropolitan economy.

Existing data and analysis provide some information about the potential economic activity associated with a port facility like the one envisioned for WHI. We must interpret this information with caution because any calculation of the economic benefits of a WHI port will rely on several layers of assumptions, many of which have relatively weak empirical support—weaknesses that will only be exacerbated by the passage of time between now and the assumed commencement of port operation in 2026.

Researchers commonly describe the economic activity created by ports using something known as a Port Impact Study (PIS). PIS attempt to flesh out the relationship between port activity and the rest of the economy in order to quantify the economic benefits (typically measured in jobs or incomes) created by the port. In the second column of Table 3 (below), *Total Portland Harbor*, we present the results from the most recent Martin and Associates PIS report on the economic impacts of

the Portland Harbor area as a whole. According to these analyses, activity at the Port generates 7,011 direct jobs, 17,512 total jobs, and a total personal income of over $1.4 billion. To place these values in context, these values amount to 0.7 percent, 1.7 percent, and 1.6 percent of total employment and personal income in the Portland-Vancouver metropolitan area.

In 2010, Martin and Associates conducted an analysis specific to WHI, based on a slightly different development concept than the current Development Scenario in our analysis. Rather than a port expansion of 300 acres total for bulk, auto and marine industrial uses, this analysis assumes that the Development Scenario would include 250 acres of port and 100 acres of marine industrial uses, for a total port-expansion of 350 acres. This analysis does not present results based on the commodities expected to flow through WHI. Instead, it assumes that impacts from the port would equal the average per-acre impacts from all of Portland Harbor. We modified the Martin and Associated results to adjust for the smaller development footprint in the Development Scenario in our analysis. We scaled down the Martin and Associates estimates for a 350-acre port facility to reflect a 300-acre facility by simply multiplying all values by .857 (or 300/350). We report the results in the third column of Table 3, *West Hayden Island Estimate #1*.

Table 3. Summary of Results from Recent Economic Impact Analyses

	Total Portland Harbor	West Hayden Island Estimate #1	West Hayden Island Estimate #2
Jobs (Employment Years)			
Direct	7,011	1,175	937
Induced	6,668	1,591	891
Indirect	3,833	847	512
Total	17,512	3,613	2,340
Personal Income ($1,000s)			
Direct	$355,907	$64,003	$47,566
Induced	$871,367	$192,764	$116,456
Indirect	$193,015	$39,441	$25,796
Total	$1,420,288	$296,208	$189,818
Business Revenue ($1,000s)	$1,481,570	$240,324	$198,008
State and Local Taxes ($1,000s)			
Oregon	$80,998	$19,977	$10,825
Washington	$55,221	$10,292	$7,075
Total	$136,219	$30,269	$17,900

Source: ECONorthwest staff estimates with data from Martin and Associates (2010).

We also calculate the potential impact of a WHI port using information from the 2010 Martin and Associates analysis of WHI, and from our recent harbor lands analysis.[4] We take Martin and Associates' estimates for the relationship between

[4] Moore, T. and N. Popenuk. 2012. *Portland Harbor: Industrial Land Supply Analysis*. ECONorthwest. Prepared for the City of Portland: Bureau of Planning and Sustainability. In association with Maul Foster & Alongi, Inc. and Bonnie Gee Yosick. March.

direct jobs and commodity throughput, and multiply these figures by the number of direct jobs per 1,000 tons of capacity shortfall in the "most likely" scenario in the ECONorthwest (ECONW) harbor lands report. We report the results in the fourth column of Table 3, *West Hayden Island Estimate* #2.

We caution that readers should not interpret the results in Table 3 as precise calculations of the expected economic impacts of the WHI port. They are best viewed as providing a rough baseline order of magnitude of impact. Based on these results, we recommend that readers assume that the WHI port will generate the direct employment of approximately 900–1,200 people and associated personal income of $45–$65 million. Including multiplier effects, the WHI port may be associated with 2,000–4,000 jobs, $200–$300 million in personal income, and approximately $18–$30 million in state and local tax revenue. This range roughly reflects the range between our *West Hayden Island Estimates #1* and #2.

Port impact studies do not precisely describe the impact of port facilities on economic activity. Results of the port impact analyses must be interpreted with caution for a variety of reasons. How researchers identify direct effects varies from study to study, and what researchers choose to include will affect the results. Also, port impact studies do not capture all of the potential spillover benefits of port developments, e.g., improved efficiency at the port or improved transportation efficiencies. As such, we cannot say today how closely the results above will represent outcomes that would exist between 2026 and 2126, the period considered in this analysis. More important, the economic impacts described in Table 3 are not equivalent to the net economic benefits considered in a benefit-cost analysis (BCA). Economic impact analyses do not describe many of the potential port benefits, e.g., any effects on property values, any effects on port/transportation efficiency, any effects on the location decisions of other firms, etc.

Also, in the area of potential benefits most closely related to economic impact analyses – impacts on producers and workers, economic impact analyses do not, by themselves, describe economic benefits. Economic impact analyses describe the number of jobs and amount of income that may by traced back to port activity; however, the jobs and incomes created by port activity may not constitute *net* economic benefits.

Whether or not the jobs created by port development generate net economic benefits depends on conditions in the relevant labor markets and the geography of interest to decisionmakers and stakeholders. Regarding local labor markets, the extent to which the results of an economic impact analysis characterize net economic benefits of port development depends on the extent to which workers would remain under- or un-employed in the absence of development. When unemployment is high, some workers may enjoy large benefits from projects that increase employment; however, when unemployment is low, workers will enjoy relatively small benefits.

Regarding the geography of interest in an analysis, some argue that projects, like port investment, can generate net economic development benefits within specific regions because greater potential exists for some resources to be un- or under-

employed in a local context.[5] This may occur because some resources (including many people) cannot or do not want to move to the places where they could be more fully employed. If that were the case here, the assumption of full employment would not hold and some of the jobs and incomes generated by the port would represent net economic benefits.

Without sufficient demand for the WHI port, the Port is unlikely to devote scarce resources to developing the property and the rest of the potential benefits would not materialize. Thus, the existence of a sufficient level of demand is a necessary condition for the WHI port to generate any benefits. Since 2004, forecasters have completed 5 forecasts for port demand in Portland and other Lower Columbia River ports. Since 1962, the volume of cargo moved through Lower Columbia marine facilities has nearly quadrupled. In simple terms, this long-run growth trend provides the foundation for the forecasted growth. Forecasters expect volumes to grow because they have grown over a long period of time.

The available forecast information suggests that volumes will grow and that additional port capacity in the Lower Columbia may be utilized in the future; however, growing volumes do not necessarily imply that a WHI port will be utilized. Other capacity exists to satisfy some potential demand elsewhere in the region. For example, analysts from ENTRIX concluded in a 2010 study of WHI, "If WHI is not developed, it appears that the existing and planned terminals at ports located on the Washington side of the Lower Columbia River may be able to meet forecasted cargo demand."[6] A more recent study conducted by ECONW relied on the most recent BST forecast found that if demand falls in the low end of the range, Portland/Vancouver Harbors will require one additional auto terminal and one additional dry bulk terminal by 2040; however, at the high end of the range, demand would support three auto terminals, three grain terminals, and ten dry bulk terminals (as well as one terminal each for containers, breakbulk, and liquid bulk).

Shipments of individual commodities can fluctuate, sometimes significantly, over time. Long run trends in overall demand for port services, however, have increased relatively consistently, and reflect overall growth in the global economy. So, while past forecasts may not have accurately predicted the types of commodities shipped today, the overall volumes of total goods shipped has increased at relatively predictably rates. Ultimately, whether or not demand for additional port facilities on the lower Columbia materializes will depend on the factors that affect both the demand for and supply of port services, including:

- Demand for exports (e.g., grain, dry bulk, etc.) produced in Port's hinterland
- Demand for imports (e.g., autos) consumed in Port's hinterland
- Investments at competing ports
- Investments in rail and road networks that connect to regional (and competitor) ports

[5] Hughes, D.W. and D.W. Holland (1993) "Economic Impacts, Value Added, and Benefits in Regional Project Analysis: Comment" American Journal of Agricultural Economics 73: 759-762; Eberts (1998)

[6] Entrix (2010)

- Advances in port and/or shipping technology

In brief, factors that affect the price or competitiveness of the port relative to other ports or affects the volume of trade flowing through the Pacific will change demand. Given that many such events have not (and will not) be incorporated into forecasts until they occur in the future, the available forecasts should be interpreted with these caveats in mind.

V. Conclusions

As we describe in the section on Port Effects, any calculation of the economic benefits of a WHI port would necessarily rely on several layers of assumptions, many of which would have relatively weak empirical support—weaknesses that would only be exacerbated by the passage of time between now and the assumed commencement of port operations in 2026. Rather than present a calculation of port benefits based on many assumptions that lack a solid foundation, we reverse the question. Instead of asking "are benefits larger than costs," we ask, "how large would local port benefits need to be to justify the local costs?

We begin by describing the net economic costs and benefits of the Development Scenario. In Table 4 we summarizes the net costs and benefits for the natural resource and recreation effects, and the costs of port-specific development, including the WHI bridge. In effect, the totals in Table 4 represent the net quantifiable costs of the Development Scenario relative to the Baseline Scenario.

Table 4. Net Costs of the Development Scenario, in 2011 dollars

Cost Category	City of Portland	Port of Portland	Change in NPV of Ecosystem Services	Total
Developing WHI Infrastructure	$6.5 million	$64.5 million		$71 million
WHI Bridge[1]	$5 million	$11.25 million		$16.25 million
NPV of Natural Resource Mitigation Costs (100 years)[2]		$24.5 million	$2.6–$5.6 million	$27.1–$30.1 million
NPV of Recreation-Related Costs (100 years)	$1.2-$2.65 million	$1.2-$2.65 million	($1.59) – ($5)[3] million	$0.3-$0.9 million
Local Effects	*Not Quantified*			
Total	**$12.7-$14.15 million**	**$101.45-$102.9 million**	**$1.01– $0.6 million**	**$115–$118 million**

Source: ECONorthwest staff estimates with data from elsewhere in the report.
Notes:
[1] Total cost of the bridge estimated at $100 million. BPS staff estimate that in addition to the funds paid by the City of Portland and the Port of Portland, port developers would pay $25 million and State and Federal transportation funds would provide the remaining $58.75 million.
[2] Including value of ecosystem services.
[3] Dollar amounts in parenthesis are benefits, not costs.

Ultimately, for the Development Scenario to prove worthwhile, the net present value of the WHI port and port-related benefits should exceed $115 to $118 million plus the amount of the negative local effects.

If we rely on assumptions similar to those used to calculate the NPV of recreation and natural resource effects (e.g., extend analysis through 2112, assume a discount rate of 3 percent), and we assume that the WHI port earns sufficient revenue to cover all operation, maintenance, and replacement costs, the port must generate an average of approximately $5.5 million dollars of net benefit each year it operates to produce a sufficient level of benefit to cover this level of costs. Changing the assumptions would change this value. For instance, performing the calculation using 50 years of port operation changes the average, annual net benefit to approximately $6.5 million.

Thus, the question facing policymakers regarding the economic differences between the Development and Baseline Scenarios boils down to whether or not they expect the WHI port, other port inputs, any local users, and other local owners of land, labor, or capital to benefit by approximately $5.5 million per year, on average. If the Port or any other party suffers losses (including local residents), the benefits to remaining parties must cover these losses in addition to the $5.5 million described above.

As we describe in the Port Section, we use existing port economic impact studies to project the potential impact of a WHI port facility on local economic activity. (See Table 3 above.) Applying existing economic impact estimates to the expected development of WHI, we project that a WHI port facility may directly employ 900–1,200 people who may earn associated personal income of $45–$65 million. Adding in multiplier effects, the WHI port may be associated with 2,000–4,000 jobs, $200–$300 million in personal income, and approximately $18–$30 million in state and local tax revenue.

Table 5 below we present a range of assumptions that decision-makers can use to adjust the results of the economic impact analysis in order to determine whether or not annual port related local economic benefits will likely exceed the threshold ($5.5 million) required for local economic benefits to exceed local economic costs.

The rows in Table 5 present different assumptions that one could make about what share of the potential economic impacts described in the column *West Hayden Island Estimate #1* of Table 3 would represent net economic benefits. The columns present different assumptions that one could make about how much of the personal income calculated for this estimate would have been earned regardless of the WHI port. For instance, if one assumes that the actual impact of a WHI port will be 50 percent of the approximately $300 million estimated under *West Hayden Island Estimate #1* and that only 5 percent of that income would not have been earned in the absence of the WHI port, then the net income created by the WHI port will exceed $7.5 million per year.

Table 5. Impact of Alternative Assumptions for Net Benefits from the Development Scenario (millions of dollars)

		Share of impact on personal income that would not have been earned without the Development Scenario			
Share of Martin		**0.05**	**0.1**	**0.2**	**0.3**

& Associates (2010) estimated impact that will actually be realized local	**1**	$15.00	$30.00	$60.00	$90.00
	0.75	$11.25	$22.50	$45.00	$67.50
	0.5	$7.50	$15.00	$30.00	$45.00
	0.25	$3.75	$7.50	$15.00	$22.50
Source: ECONorthwest staff estimates with data from Martin and Associates (2010).					

Thus, for net port benefits to fall below the net costs of the Development Scenario, one must assume that impacts will be *significantly* lower than the amount estimated by Martin and Associates and one must assume that *nearly all* of the income related to the WHI port would have been earned even without port investment.

Comparing the figures above from Table 5, with the estimated annual income and revenues to cover expected costs of $5.5 million, we see that for incomes not to cover costs in this illustration, we have to assume that the WHI port would provide less than 50 percent of the economic activity described in *West Hayden Island Estimate #1*, and that between 5 and 10 percent of personal incomes in this estimate would not otherwise exist without the WHI port.

We conclude that, given the relatively small annual value that would need to be created to offset the costs, it is likely that the Development Scenario would generate net local economic benefits relative to the Baseline Scenario. Our conclusion assumes demand for the WHI port is sufficient to justify port investment.

We describe the distribution of economic effects as follows.

The Development Scenario would provide new recreation amenities and benefits not available in the Baseline Scenario. Residents local to the Portland area would enjoy the large majority of these benefits. The City and Port of Portland would share the costs of developing these facilities. Thus, the large majority of costs and benefits associated with the recreation effects would be local.

The Development Scenario would reduce the supply and value of ecosystem services relative to the Baseline Scenario. We expect that the reduced value of ecosystem services would mostly affect those in the Portland area. The Port of Portland would pay the costs of natural resource mitigation. Given these conditions, the costs of the natural resource effects would happen locally, with no offsetting net benefits locally or otherwise.

A large portion of benefits of the new port facility would accrue to port users located outside the Portland area. Some benefits, though, would happen locally (e.g., at the Port of Portland and for workers at the port). The Port of Portland would pay the large majority of the infrastructure costs of developing the facility. The City of Portland would pay a small portion of these costs. Port tenants and State and Federal taxpayers would pay the remainder. Given these conditions, some benefits and some costs would happen locally and some would happen nationally or globally.

Residents of EHI would enjoy the benefits of the new recreation facilities described above, but could experience significantly negative impacts on their quality of life.

We recommend studying more closely the potential quality-of-life impacts as part of a Health Impact Assessment or an EIS, should one be required for the new port facility.

We conclude that if the port facility generates $5.5 million per year in net economic benefits, it would justify the expenditure of costs incurred by the City and Port of Portland. We conclude that it is likely that this would be the case. Thus, we expect that the local benefits of the Development Scenario would exceed the local costs.

Purpose and Overview

In this section we describe the purpose and overview of our analysis as an introduction to the remaining sections of this report. In the following sections we describe the results of our analysis of the natural resource, recreation, local and port effects of the Baseline and Development Scenarios, respectively.

I. The Purpose of Our Analysis

The purpose of our analysis is to describe the economic effects of the proposed development of West Hayden Island (WHI). Our analysis takes as given information from City Council Resolution 36805, the preliminary Concept Plan for the annexation of WHI, and related documents that describe some of the details of the two scenarios in our analysis. Specifically, we take as given that the Baseline Scenario maintains current land uses on WHI for the foreseeable future, and that the Development Scenario includes 300 acres of port facilities (WHI port) and 500 acres of open space. These conditions affect our analysis and what we did and did not focused on.

Our analysis compared the net economic effects of the Baseline Scenario with the net economic effects of the Development Scenario. Analytical questions which some may be interested in regarding the WHI port, but which our analysis does not address, include the following.

Should WHI be developed?

Should all 800 acres currently in open space be protected and restored?

Should 600 acres be dedicated to the WHI port facilities?

What are the economic tradeoffs of using an acre of WHI for port or open-space use?

What are the opportunity costs to port use of the 500 acres of open space?

What are the opportunity costs to open-space use of the 300 acres of port facilities?

Our analysis takes as given the distribution of 300 acre port-use and 500 acres open-space use. Our analysis did not revisit or address the question of if this is a "good" or "optimal" use of WHI from an economic perspective. Rather, we conducted an economic comparison of the Baseline and Development Scenarios as described.

II. Overview of Our Analysis

In this subsection we describe the major types of economic effects included in our analysis, the special and temporal boundaries of our study, and the Baseline and Development Scenarios that are the focus of our analysis.

A. Types of Economic Effects

Among the tools economics offers for comparing competing alternatives, the most widely know and frequently used is benefit-cost analysis (BCA). A BCA describes the differences in net economic values—economic benefits minus economic costs—across

alternatives. In our experience, stakeholders and decision makers frequently care about other types of economic consequences besides changes in economic values. They want to know how policy alternatives will affect things like jobs and income, which economists describe as economic impacts, and the distribution of changes in economic values and impacts among stakeholder, which economists generally address as economic equity or distribution. For these reasons, our analysis of the economic effects of the WHI port has three parts.

The first part, economic values, represents the changes in values of goods and services available that result from the market and non-market activities of the Baseline and Development Scenarios. An increase in value is a benefit, a decrease in value is a cost. Representative values in our analysis include changes in the values of port goods and services, changes in values of ecosystem services, and changes in quality of life in the local community proximate to the WHI port.

The second part, economic impacts, represents changes in jobs, employment income, and tax revenues. These impacts occur directly as workers are employed, e.g., on construction and mitigation projects, and indirectly, as dollars spent locally on construction and mitigation cycle through the economy and support other purchases, e.g., food purchased by construction workers. Economists frequently describe these changes using multiplier or impact analyses.

The third part, economic distribution, represents the distribution of the other two economic effects. This portion of the analysis describes economic winners and losers. Those who pay the costs, those who enjoy the benefits, and their locations.

How we define the spatial and temporal boundaries of the analysis will influence the results of the analysis. We describe these two aspects of our analysis in the next two subsections.

B. Spatial Boundary of the Analysis

The spatial boundary of our analysis matters because it influences the types and amounts of economic effects we include in the analysis. We focus our analysis on the Portland metropolitan area because the economic effects that happen in this geography likely matter most to local stakeholders and decision makers. Using this boundary our analysis captures effects such as: the values of ecosystem services on WHI, the jobs and employment incomes of port workers that move goods through the WHI port, and the values of the hiking trails and other recreational infrastructure included in the Development Scenario.

Not all the potential economic effects of the WHI port will occur within the Portland metropolitan area. For example, the goods transported through the WHI port may originate in Asia or Canada, which means some—perhaps many—of the benefits of the WHI port will accrue far from Portland. For economic effects that happen outside the Portland metropolitan area we identify and describe these effects, but we do not quantify them. For example, we do not calculate the jobs in Asia related to the autos that would be imported through the WHI port.

Within the Portland Metropolitan area we pay special attention to the potential impacts of the Development Scenario on the quality of life (Q of L) of residents of East Hayden Island (EHI). We do so for two reasons. First, its clear from the public record on the current and previous development proposals for WHI that Q of L effects on EHI are important to some stakeholders and decision makers. Second, understanding these Q of L effects will help us better understand the distribution of economic outcomes of the Development Scenario. Residents of EHI will benefit from the improved access to park facilities, but may also experience the bulk of potential negative effects including increased traffic, noise and light pollution.

C. Temporal Boundaries of the Analysis

Based on input from City staff and the estimated time for the proposed annexation, we assume construction of the WHI port would not begin until 2023. Mitigating natural resource would begin 5 years prior to that, in 2018. Our analysis of economic effects continues for 100 years, through 2112. Construction of the WHI port would take approximately 3–6 years. We assume port operations would begin in 2026–2028.

D. Baseline and Development Scenarios

The City's preliminary plans for WHI include annexing WHI to the City for the purpose of developing 300 acres of the island for a WHI port, and protecting and mitigating 500 acres for recreation and open-space use.[1] The purpose of our analysis is to give the City Council and others information on the economic effects of this decision. Specifically, our analysis compared the economic differences between current land uses on WHI—which we describe as the Baseline Scenario—and partitioning WHI between 300 acres of port development and 500 acres of open space—which we describe as the Development Scenario.

Our analysis of the Baseline Scenario assumes no change in current land uses on WHI. Given that the current land use is open space with no port use or recreation use beyond a minimal number of hikers and boaters that walk the beach, the major portion of the analysis of the Baseline Scenario focused on the ecosystem services currently supplied by WHI's natural resources.

The Development Scenario differs from the Baseline Scenario in the following ways. We assume that the Concept Plan for the annexation describes the major land uses that will happen on WHI with the port. For example, the Concept Plan describes the development of port infrastructure to support an auto-import terminal and facilities to export bulk products such as potash. It also assumes an area that would be occupied by a marine-industrial use, such as a marine- or port-related fabrication business. The Development Scenario includes mitigating the damage to natural resources caused by developing the WHI port. Some of this mitigation will happen on WHI and some of it will happen elsewhere in the region. It also includes provisions to protect the 500 acres of open space from future development. Recreational improvements include a ramp for non-motorized boats, with adjacent parking, and new hiking trails. The Development Scenario also includes a new bridge that would connect WHI with Marine Drive.

[1] Portland City Council Resolution 36805, July 29, 2010.

Our analysis takes into account the major economic changes projected to affect WHI, but which are unrelated to the WHI port. These projected changes include the Columbia River Crossing (CRC) project, and the growth and development of EHI as described in the Hayden Island Plan. We assume that both the CRC and Hayden Island Plan will happen as currently described. To the extent that neither or both of these changes do not happen, the consequences would mostly affect the results of our analysis of Q of L effects of the proposed development on EHI. We describe these consequences in our description of the effects of the development on Q of L in EHI.

Natural Resources

I. Introduction

The overall content, connectivity, and expanse of West Hayden Island's (WHI) natural resources and habitat make it an ecologically functional and valuable area. This is especially true given the scarcity of this combination of characteristics in the Portland Metro area. In this chapter, we describe our analysis of the effects of the Development Scenario on WHI's natural resources. The major parts of our analysis include: describing the natural resource, habitat types and related values under the Baseline Scenario, describing the changes likely to occur under the Development Scenario, and estimating the value of the changes in the natural capital and associated ecosystem goods and services. We also consider the distribution of these values, including impacts on jobs and incomes. A detailed assessment of WHI's natural assets can be found in the *Hayden Island Natural Resource Inventory* (Inventory).[1]

II. Background and Methodology

In this section, we describe the concept of ecosystem services and the economic values of these services. Because ecosystem services do not typically have the same characteristics as other goods or services, they are rarely traded in markets. That means analyses such as ours cannot rely on market prices when valuing ecosystem services. Therefore we rely on results of analyses conducted under conditions similar to those in and around WHI. In this case, we rely on a previous study of the values of ecosystem services on WHI, which we refer to as the *2010 Entrix Report*[2]. The intention of this chapter is not to fully recreate or repeat the *2010 Entrix Report* but rather to review and revise their results as needed, to use their results to help verify values reported by other sources, and to apply the values to the particular scenario under consideration for WHI.

A. Background on Ecosystem Services

Historically, society has considered public enjoyment as the primary benefit derived from urban parks, green spaces, and other natural areas. Increasingly, however, society recognizes that the natural biophysical structures and ecological processes in these undeveloped areas can provide other beneficial goods and services, collectively known as ecosystem services. Examples of ecosystem services include water supply, water filtration, pollution uptake, and habitat provision.

Research conducted by ecologists and economists over the past several decades confirms that ecosystems supply a wide variety of services that provide many of the essential

[1] Bureau of Planning and Sustainability, City of Portland. 2011. *Draft Hayden Island Natural Resource Inventory.* June.

[2] Entrix. 2010. *WHI Environmental Foundation Study*. City of Portland Bureau of Planning and Sustainability. Portland, Oregon. July.

basic requirements for living organisms, regulate physical and biological processes, and contribute to the quality of life for individuals and communities.[3]

In some cases, communities and government agencies have established markets for ecosystem services so that beneficiaries compensate suppliers. For example, markets now function for water quality and quantity, air quality, habitat, biodiversity, and carbon sequestration. Because ecosystem services do not typically have the same characteristics as traditional private services, markets do not tend to form and function in a way that allows forces of supply and demand to reveal prices and values.[4] Consequently, society does not have as ready access to value estimates for ecosystem goods and services as normal market goods and services. Economists have developed techniques for calculating ecosystem service values based on the characteristics of the service and benefiting population. The U.S. Environmental Protection Agency provides guidelines for valuing ecosystem services.[5] Typically, we calculate the value of ecosystem services by analyzing the supply of the ecosystem services provided in a particular area alongside the demand for those services by the local and regional community.

Due to time, budget, and data constraints, the analysis we present in this chapter relies on supplementing the *2010 Entrix Report* and revising its estimates of ecosystem service values for WHI rather than the collecting new primary data.[6] We divide the values into two groups: (1) those that describe the value of habitat provision for wildlife on WHI, and (2) those that describe the value of other ecosystem services like air purification, water quality improvement, and carbon sequestration. Furthermore, we apply different values for the different habitat types[7] found on WHI (forest/woodland, shrubland, grassland, wetland, and shallow water). The range of values we use in our analysis reflects the low-to-high range of values reported in the literature we reviewed, including the *2010 Entrix Report*.

B. Ecosystem Services on WHI

In this analysis, we study the ecosystem services provided on WHI under two scenarios. In the Baseline Scenario, we describe the natural resources and ecosystem services on WHI as they are now, and as they will be in the future assuming no development. In the

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[3] Millennium Ecosystem Assessment. 2003. *Ecosystems and Human Well-being.* De Groot, R., M. Wilson, and R. Boumans. 2002. "A Typology for the Classification, Description and Valuation of Ecosystem Functions, Goods and Services." Ecological Economics 41: 393-408; Kusler, J. 2003. Assessing Functions and Values. Institute for Wetland Science and Public Policy and the Association of Wetland Managers, Inc.; and Postel, S. and S. Carpenter. 1997. "Freshwater Ecosystem Services." in Nature's Services: Societal Dependence on Natural Ecosystems. Edited by G.C. Daily. Washington, D.C.: Island Press, pgs. 195-214.

[4] Goods and services are considered private, efficiently priced and allocated by markets only when they are rival (one person's consumption affects the consumption of another person) and excludable (one person can prevent consumption by another person). Ecosystem services are typically not excludable, and often not rival either.

[5] EPA Science Advisory Board. 2009. *Valuing the Protection of Ecological Systems and Services*. May.

[6] Entrix. 2010. "WHI Environmental Foundation Study." City of Portland Bureau of Planning and Sustainability. Portland, Oregon. July.

[7] Throughout this chapter, we use the term "habitat type" to differentiate between areas with different vegetative covers.

Development Scenario, we describe ecosystem services on WHI with the proposed port facility (WHI port). We begin by describing ecosystem services under the Baseline Scenario. Our description relies on an inventory of the island's natural resources as described by staff from the City of Portland.

1. The Hayden Island Natural Resource Inventory

In 2011, Portland's Bureau of Planning and Sustainability (BPS) published its *Draft Hayden Island Natural Resource Inventory* (Inventory). The Inventory provides a detailed description of the natural resources and ecosystem services on WHI. The Inventory describes natural resources on WHI in terms of habitat type, ecosystem function, wildlife habitat, and special habitat areas (SHAs). We discuss each of these categories as background and support for the assumptions, provided by Bureau of Environmental Services (BES) staff, regarding the levels of ecosystem function and wildlife habitat on WHI under the Baseline Scenario. This information is also relevant to describing the potential lift in ecosystem function and habitat quality from mitigation efforts. We do not directly incorporate the Inventory's results into our analysis, rather, we use the general conclusions from the Inventory—that WHI provides high ecosystem function and high quality wildlife habitat under the Baseline Scenario with little room for improvement from onsite mitigation efforts—to inform our analysis.

Habitat Type

The Inventory identified habitat types across WHI and contains maps showing their location. Habitat types include: wetlands, forests, woodlands, shrublands, grasslands/sparsely vegetated areas, and shallow water. Map 1 shows the distribution of habitat types on WHI.

Natural Resource Function

The authors of the Inventory describe WHI's ecosystems using the six riparian-corridor functions listed in Table 1. The Inventory identifies the quality of each function as either primary or secondary function, based on the vegetation type, proximity to water bodies and extent of the flood area. The accompanying maps show the primary and secondary areas for each riparian function. The Inventory includes a Relative Riparian Rank, which generally describes the quality of natural resource function, by combining primary and secondary functionality (see Map 2) .

Table 1. Riparian Corridor Functions Identified in the Inventory

Microclimate and Shade	Large Wood and Channel Dynamics
Flow Moderation and Flood Storage	Organic Inputs and Food Web
Water Quality Control	Riparian Movement Corridor

Source: City of Portland, Bureau of Planning and Sustainability. 2011. *Hayden Island Natural Resource Inventory*. June.

Wildlife Habitat

In addition to the general natural resource functions associated with the Inventory's Relative Riparian Rank, land on WHI provides important habitat for several different species. The Inventory ranked[8] areas on WHI as high value (worth three points), medium value (worth two points), and low value (worth one point) wildlife habitat across four categories: (1) habitat patch size, (2) interior habitat area, (3) connectivity to other patches, and (4) connectivity to water.

Special Habitat Areas

The Inventory augmented its analysis of wildlife habitat by also considering the distribution of Special Habitat Areas (SHAs) across WHI. SHAs are based on Metro's *Title 13 Habitats of Concern*, which are areas with "sensitive/threatened fish or wildlife species, sensitive/unique plant populations, wetlands, native oak, hardwood forests, riverine islands, river delta, migratory stopover habitat, connectivity corridors, upland meadow, and other unique natural or built structures or resources."[9] The City of Portland has also updated its SHA criteria by: (1) updating the list of at-risk wildlife species, including a list of wildlife associated with grasslands, and (2) adding unique features such as bridges that provide nesting habitat for Peregrine Falcons.[10] The Inventory awarded all SHAs on WHI with a high quality Relative Wildlife Rank. Table 2 describes why each area is identified as an SHA. Map 3 shows the distribution of Relative Wildlife Rank and SHAs on WHI. As shown in Map 3, all of WHI is designated as SHA.

Combined Relative Rank

The Inventory used Relative Riparian Rank, Relative Wildlife Rank, and SHAs to derive Combined Relative Ranks (low, medium, and high) across WHI. To categorize land on WHI according to the Combined Relative Ranks, the Inventory stacked other Rank maps and used the higher rank. In other words, if an area had a low Relative Riparian Rank and a high Relative Wildlife Rank, the Inventory designated it with a high Combined Relative Rank. Since all the land on WHI is designated as SHAs (thus receiving a high Relative Wildlife Rank), the Inventory categorized all the land on WHI as having a high Combined Relative Rank. Map 4 shows the distribution of Combined Relative Rank on WHI.

[8] The wildlife habitat model ranks only forests and wetlands that are two acres or greater in size.

[9] City of Portland, Bureau of Planning and Sustainability. 2011. *Hayden Island Natural Resource Inventory*. June.

[10] City of Portland, Bureau of Planning and Sustainability. 2011. *Hayden Island Natural Resource Inventory*. June.

Table 2. Description of Special Habitat Area Criteria on WHI

All habitats on WHI are characterized as Special Habitat Areas because they meet one or more of five criteria:

- Riverine island.
- Wildlife connectivity corridor habitat.
- Wetland.
- Bottomland hardwood forests.
- An at risk species uses the habitat area or feature on more than incidental basis to complete one or more life history phases.

Shallow water habitat areas along the Columbia River and Oregon Slough are characterized as Special Habitat Areas because they meet one or more of three criteria:

- An at risk species uses the habitat area or feature on more than incidental basis to complete one or more life history phases.
- Migratory stopover habitat.
- Wildlife connectivity corridor.

All land in the Dredge Deposit Management Area and T6 Vacant Industrial Lands is characterized as Special Habitat Areas because it meets one or more of four criteria:

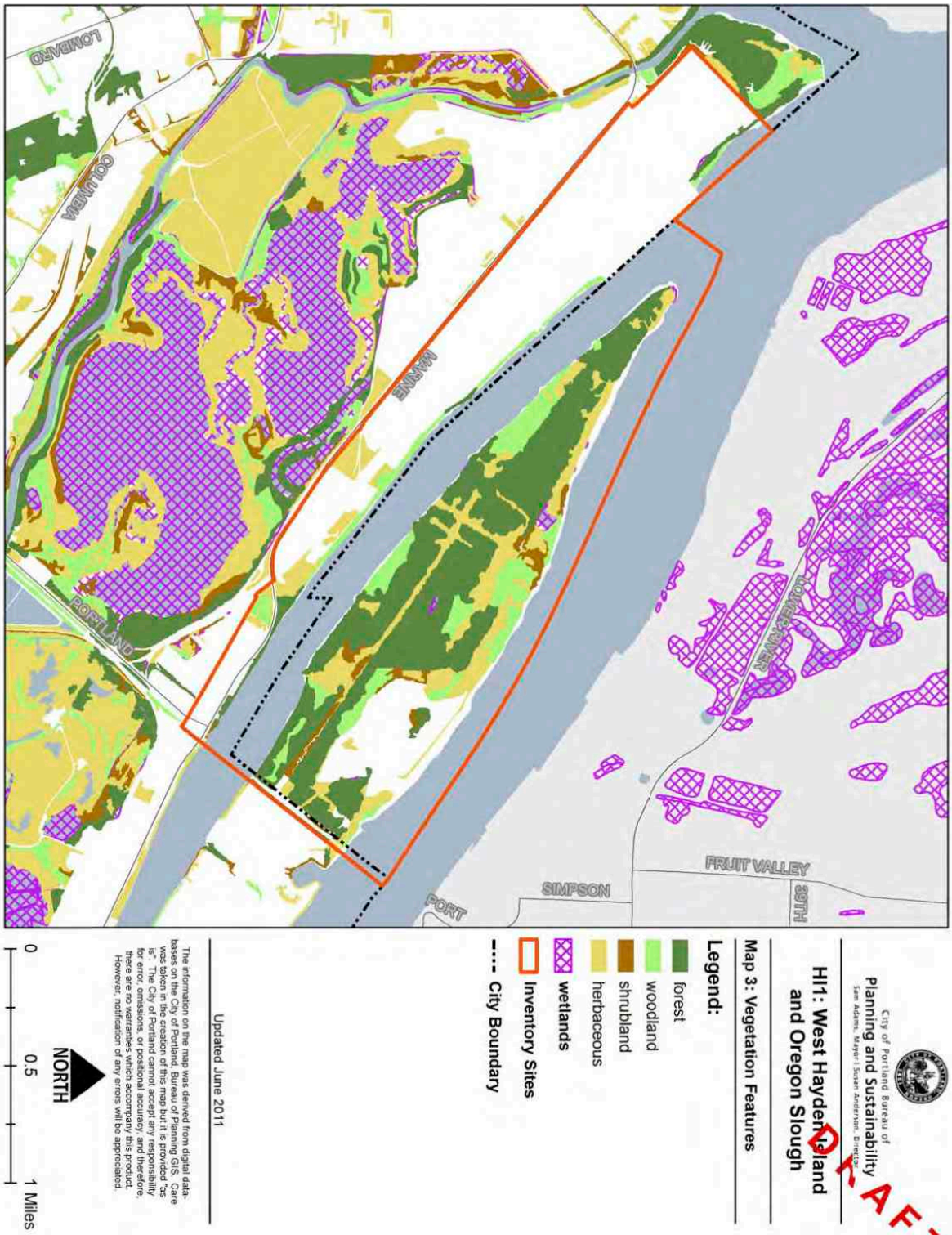
- Riverine island.
- Wildlife connectivity corridor habitat.
- Features important to individual grassland-associated species or assemblages of grassland-associated species on more than an incidental basis.
- An-at risk species uses the habitat area or feature on more than incidental basis to complete one or more life history phases.

Special Status Species:

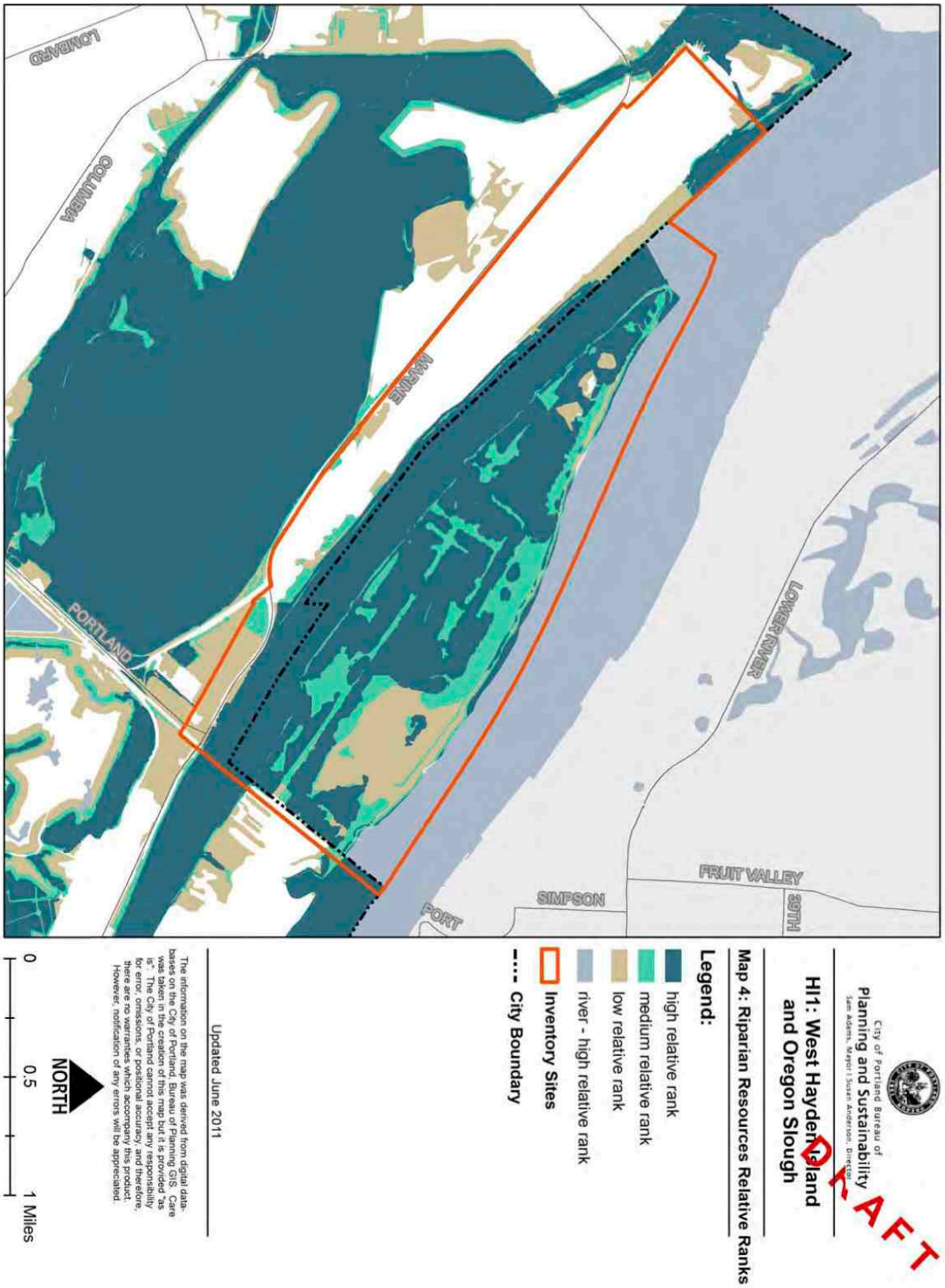
- **Fish**. Chinook salmon, chum salmon, coho salmon, sockeye salmon, steelhead trout, bull trout, eulachon, pacific lamprey, white sturgeon
- **Birds**. American kestrel, bald eagle, band-tailed pigeon, black-throated gray warbler, brown creeper, Bullock's oriole, bushtit, chipping sparrow, common yellowthroat, downy woodpecker, great blue heron, hooded merganser, house wren, merlin, northern harrier, orange-crowned warbler, pacific-slope flycatcher, peregrine falcon, pileated woodpecker, purple finch, red-necked grebe, rufous hummingbird, Swainson's thrush, varied thrush, western meadowlark, western wood-pewee, white-breasted nuthatch, willow flycatcher, Wilson's warbler, winter wren, wood duck, yellow warbler, yellow-breasted chat
- **Mammals**. American beaver
- **Reptiles**. western painted turtle
- **Amphibians**. northern red-legged frog (Rana aurora)

Source: City of Portland, Bureau of Planning and Sustainability. 2011. *Hayden Island Natural Resource Inventory*. June.

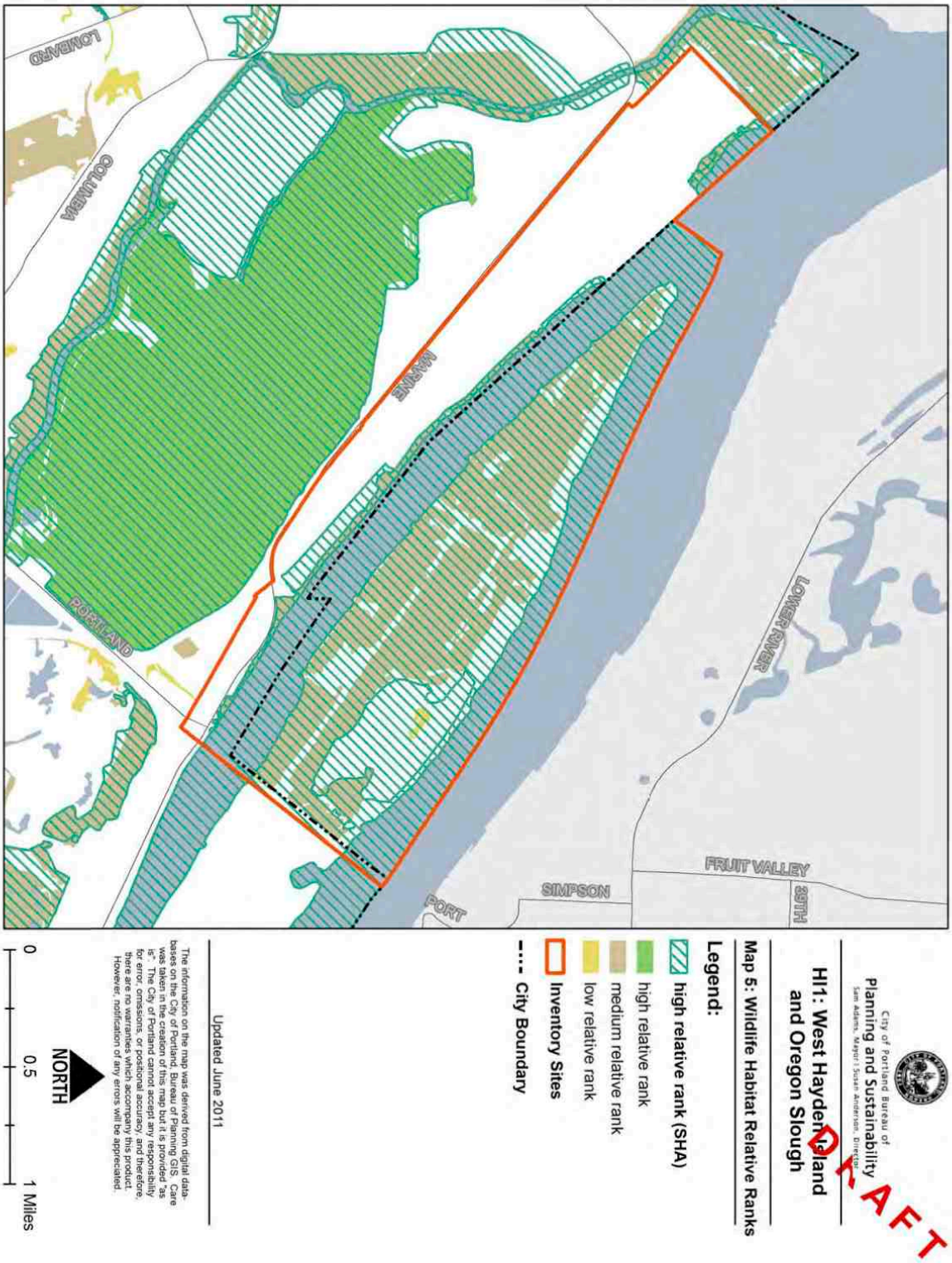
Map 1. Habitat Types on WHI



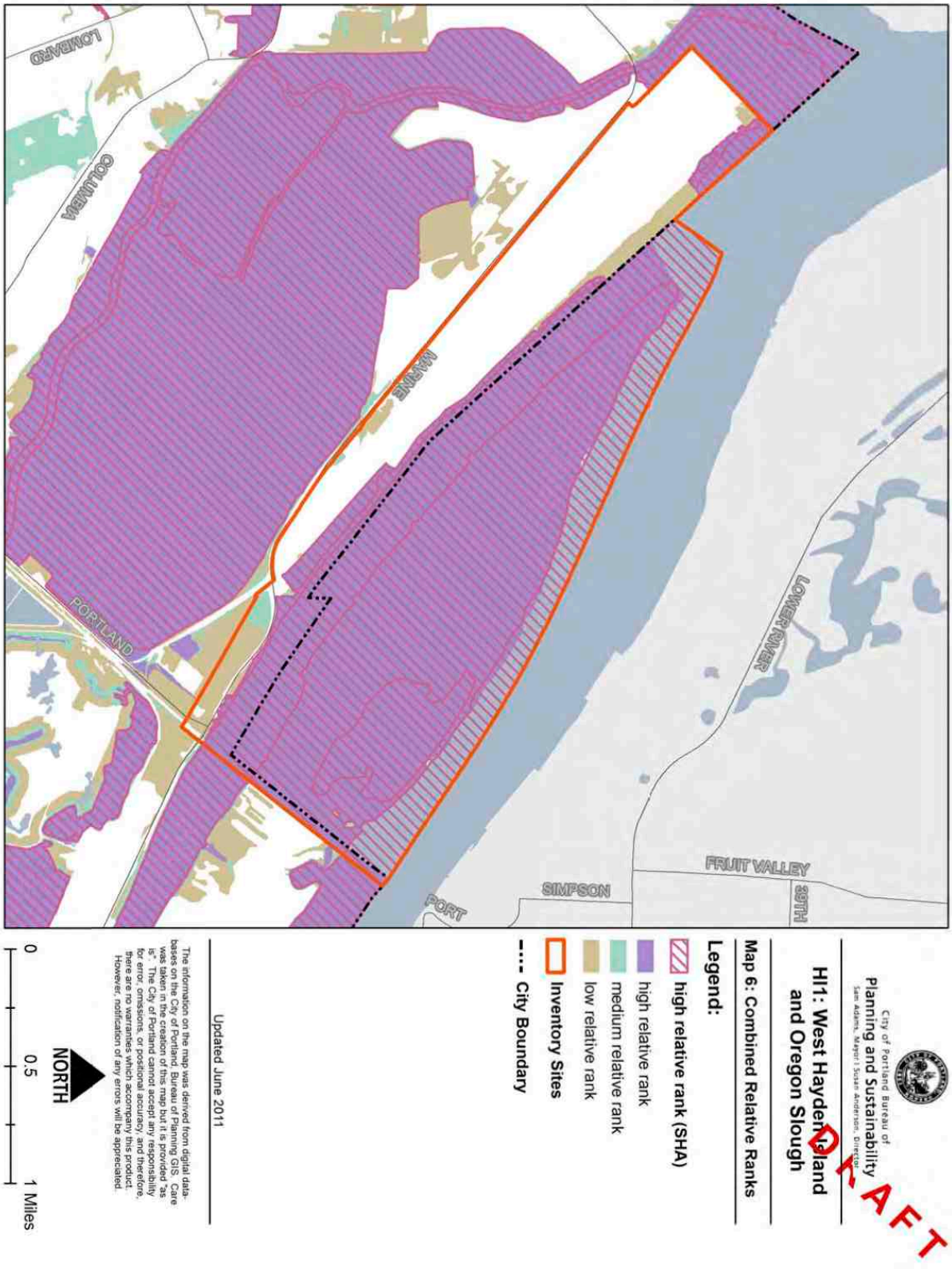
Map 2. Relative Riparian Rank on WHI



Map 3. Relative Wildlife Rank and Special Habitat Areas on WHI



Map 4. Combined Relative Rank on WHI



2. Our Approach to Analyzing Costs and Benefits Associated with Ecosystem Services on WHI

Our approach to analyzing the ecosystem services on WHI relies primarily on four pieces of information:

- Annual, per-acre values associated with habitat provision and other ecosystem services provided by the different habitat types on WHI.
- The Inventory, along with information from BES staff, describing the quality of habitat and ecosystem services on WHI and the potential for improvement through mitigation, by habitat type.
- Portland BPS estimates of acres of land, by habitat type, on WHI under the Baseline Scenario and impacted under the Development Scenario.
- Likely mitigation efforts and mitigation costs, as described by BPS staff, applied under the Development Scenario.

Using the information listed above, we conduct several analyses based on available data, looking at the benefits and costs associated with the different scenarios over the next 100 years from a number of perspectives. We take this approach because no single data source comprehensively addresses all potential natural resource effects. We describe each of these analyses below.

Benefits - Baseline Scenario

We consider descriptions of habitat and quality from the Inventory, along with information from BES staff and values of ecosystem services and habitat provision on WHI to estimate average annual per-acre values for each habitat type under the Baseline Scenario. We multiply these per-acre values by the number of acres of each habitat type on WHI as reported by Portland BPS. We project these values 100 years into the future, and discount them to summarize the 100-year net present value (NPV) of benefits under the Baseline Scenario across WHI.

Benefits - Development Scenario (No Mitigation)

We multiply the per-acre values of ecosystem services and habitat provision on WHI by the number of acres (for each habitat type) impacted under the Development Scenario as identified by BPS staff. We assume benefits derived under the Baseline Scenario continue until development begins in 2023. Then, in 2023, we subtract the value of ecosystem services and habitat provision associated with the impacted acres from the value under the Baseline Scenario. We project that value to the end of our 100-year analysis period, and discount the annual values. This gives us the 100-year NPV of ecosystem service and wildlife benefits on WHI under the Development Scenario, assuming no mitigation.

Benefits - Development Scenario (Mitigation)

Here, we follow the same steps as we do assuming the Development Scenario with no mitigation. To that analysis, we add the potential ecosystem service and habitat provision benefits from mitigation efforts both on and off WHI. We assume mitigation begins five years prior to development (in 2018). We assume each acre of mitigation on WHI provides only marginal improvement in ecosystem services and habitat provision

on that acre (as suggested by BES staff). Mitigation on undeveloped areas of WHI cannot provide full compensation for ecosystem service and wildlife losses from development because, without mitigation, these areas are already providing a high level of natural resource functionality and wildlife habitat provision. For offsite mitigation, we assume that each mitigated acre provides one full acre's worth of ecosystem service and habitat provision benefits (we provide a sensitivity analysis that discusses the values associated with less potential for improvement from offsite mitigation). We assume the full benefits from mitigated areas accrue linearly over 2–70 years, depending on the habitat type, as described by Portland BPS.

Costs – Baseline Scenario

We assume there are no costs associated with the Baseline Scenario.

Costs – Development Scenario

We assume the only costs associated with the Development Scenario are costs associated with mitigation efforts. BPS staff provided per-acre cost estimates for these mitigation efforts on different habitat types. We apply these per-acre costs to the appropriate number of mitigated acres, by habitat type, in the year of mitigation (2018) and discount the values to estimate the NPV of costs under the Development Scenario. We assume these mitigation costs include all potential costs associated with mitigation, and that they have considered and properly discounted potential future costs associated with maintenance and monitoring of mitigation efforts.

III. Baseline Scenario

In this section, we describe the ecosystem services and habitat on WHI under the Baseline Scenario. BPS staff estimate that there are 950 acres of land[11] on WHI that are applicable to our analysis. They divide these acres into five habitat types (forests/woodlands, shrublands, grasslands, wetlands, and shallow water). We characterize the ecosystem services in terms of the acres by functional quality level, using information from the Inventory and input from BES staff. In general, we assume that future ecosystem services and wildlife habitat on WHI would remain as they are now (without the development). It may, however, be the case that, without the development, other development on WHI may decrease the value of benefits derived from ecosystem services and wildlife on WHI.

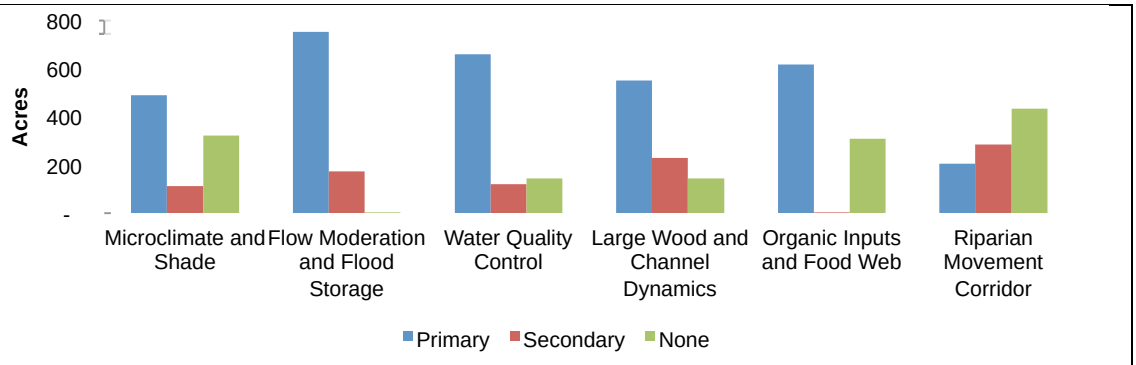
A. Baseline Scenario: Primary and Secondary Functions and Relative Riparian Rank

The Inventory describes WHI in terms of whether an area provides primary, secondary, or no functionality under six different types of natural resource functions. Figure 1 shows the distribution of natural resource functionality by the different types of functions. For example, about 500 acres on WHI provide primary functionality of microclimate and shade, while about 100 acres provide secondary functionality, and about 350 acres provide no microclimate and shade function. The most prevalent

[11] 800 acres of "dry" land and 150 acres of shallow water habitat.

function on WHI is flow moderation and flood storage. Data suggest that about 750 acres (80 percent of all acres on WHI) provide primary flow moderation and flood storage functionality, while about 170 acres provide secondary functionality.

Figure 1. Acres of Primary and Secondary Riparian Corridor Function on WHI (Baseline Scenario)



Source: ECONorthwest staff estimates with data from the *Inventory* and *Portland BPS*.

Notes: To estimate these values, we used GIS data from the Inventory to approximate the percentage of primary, secondary, and no functionality for each function. We then multiplied these percentages by the total number of acres on WHI provided by Portland BPS.

Many functions overlap, therefore acres reported in this table are not additive.

The Inventory compiles primary and secondary functionality data to calculate Relative Riparian Rank. According to the Inventory, all wetland areas have a high Relative Riparian Rank and nearly all forests and woodland areas have a high Relative Riparian Rank. Overall, about 70 percent of the land on WHI is designated a high Relative Riparian Rank. Data were insufficient to analyze Relative Riparian Rank in shallow water habitat areas at the per-acre level, however all water features have a high Relative Riparian Rank.

B. Baseline Scenario: Relative Wildlife Rank

The Inventory quantifies the quality of wildlife habitat on WHI according to four variables: habitat patch size, interior habitat, connectivity to other patches, and connectivity to water. It uses these variables to categorize land on WHI as low, medium, or high Relative Wildlife Rank. In general, the Inventory states that areas with high Relative Wildlife Rank have large forests and wetlands areas like Forest Park or Smith and Bybee Wetlands. Areas with medium Relative Wildlife Rank have moderate sized forests and wetlands like Kelley Point Park, and areas with low Relative Wildlife Rank have smaller forests and wetlands.

Table 3 lists the bird and mammal species observed on WHI, as described in the Inventory. There likely are additional bird and mammal species that can be found on WHI that are not listed in Table 3. In addition to these species, many plant, insect, and aquatic species rely on WHI for habitat and forage including special status fish species such as Chinook salmon, chum salmon, coho salmon, sockeye salmon, steelhead trout, bull trout, eulachon, pacific lamprey, and white sturgeon. As previously described, all

land on WHI is classified as a Special Habitat Area, and that it provides unique habitat opportunities for wildlife in the Portland area.

Table 3. Birds and Mammals Found on WHI

American Crow	Cassin's Vireo	**Hooded Merganser**	**Purple Finch**	Violet-green Swallow
American Goldfinch	Cedar Waxwing	Horned Grebe	Raccoon	Vole
American pipit	**Chipping Sparrow**	House Finch	Red-breasted Nuthatch	Warbling Vireo
American Robin	Cliff Swallow	**House Wren**	Red-breasted Sapsucker	Western Grebe
Anna's Hummingbird	Common Goldeneye	Hutton's Vireo	**Red-necked Grebe**	Western Medowlark
Bald Eagle	Common Merganser	Killdeer	Red-tailed Hawk	Western Scrub Jay
Band-tailed Pigeon	Common Raven	Lesser Canada Goose	Red-winged Blackbird	Western Tanager
Barred Owl	**Common Yellowthroat**	Lesser Goldfinch	Ring-billed Gull	**Western Wood-Pewee**
Beaver	Cooper's Hawk	Lesser Scaup	Ring-necked Duck	**White-breasted Nuthatch**
Belted Kingfisher	Coyote	Lincoln's Sparrow	River Otter	White-crowned Sparrow
Bewick's Wren	Double-crested Cormorant	Long-toed Salamander	Ruby-crowned Kinglet	White-throated Sparrow
Black-capped Chickadee	**Downy Woodpecker**	**Merlin**	**Rufous Hummingbird**	**Willow Flycatcher**
Black-crowned Night Heron	European starling	Mew Gull	Savannah Sparrow	**Wilson's Warbler**
Black-headed Grosbeak	Fox Sparrow	Mourning Dove	Sharp-shinned Hawk	**Winter Wren**
Black-tailed Deer	Glaucous-winged Gull	Northern Flicker	Shrew	**Wood Duck**
Black-throated Gray Warbler	Golden-crowned Kinglet	**Orange-crowned Warbler**	Song Sparrow	**Yellow Warbler**
Brewer's Blackbird	Golden-crowned Sparrow	Oregon Junco	Spotted Sandpiper	**Yellow-breasted Chat**
Brown Creeper	**Great Blue Heron**	Osprey	Spotted Towhee	Yellow-rumped Warbler
Brown-headed Cowbird	Great Egret	Pacific Chorus Frog	Surf Scoter	
Bullock's Oriole	Great Horned Owl	**Pacific-slope Flycatcher**	**Swainson's Thrush**	
Bushtit	Green-winged Teal	**Peregrine Falcon**	Townsend's Warbler	
Cackling Goose	Hairy Woodpecker	**Pileated Woodpecker**	Tree Swallow	
Canada Goose	Hermit Thrush	Pine Siskin	**Varied Thrush**	

Source: City of Portland, Bureau of Planning and Sustainability. 2011. *Hayden Island Natural Resource Inventory*. June.
Notes: Bolded species are listed as "special status" in the *Inventory*.

IV. Development Scenario

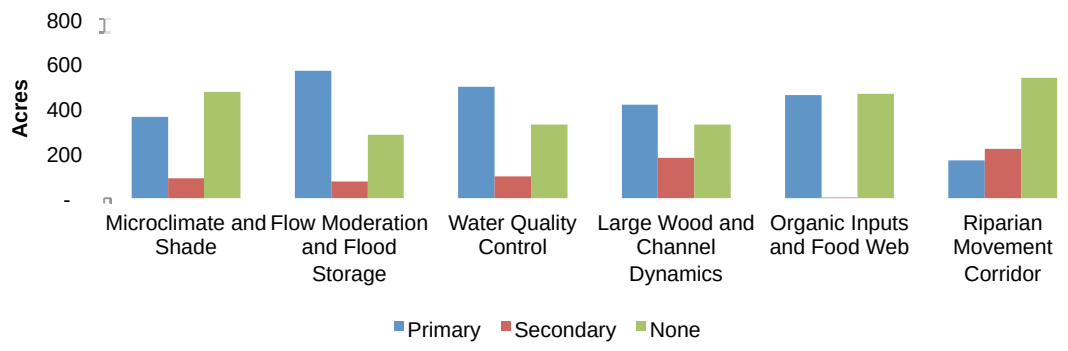
In this section, we describe the ecosystem services and habitat WHI provides under the Development Scenario. First, we describe the natural resources in terms of the acres of primary and secondary riparian function, as described in the Inventory. Then, we describe overall quality of the ecosystem services on WHI by habitat type and Relative Riparian Rank. We also describe how wildlife habitat on WHI likely will be impacted by the development.

A. Development Scenario: Primary and Secondary Functions and Relative Riparian Rank

Figure 2 shows the distribution of natural resource functionality by the different types of functions under the Development Scenario. To account for the impact of the Development Scenario we subtract the acres on WHI affected by the development

footprint from the blue and red columns reported in Figure 1 and moves those acres to the green columns. In nearly all categories, the Development Scenario decreases the number of acres providing primary and secondary functionality, and increases the number of acres providing no functionality. These values describe the Development Scenario assuming no mitigation efforts are taken to offset the potential impacts.

Figure 2. Acres of Primary and Secondary Riparian Corridor Function on WHI (Development Scenario)



Source: ECONorthwest staff estimates with data from the *Inventory* and *Portland BPS*.
Notes: To estimate these values, we used GIS data from the Inventory to approximate the percentage of primary, secondary, and no functionality for each function. We then multiplied these percentages by the relevant number of acres on WHI provided by Portland BPS.

The Inventory compiles primary and secondary functionality data to calculate Relative Riparian Rank. About 60 percent of the land displaced under the development footprint is classified as having high Relative Riparian Rank and nearly all the rest is classified as having medium Relative Riparian Rank. Data were insufficient to analyze Relative Riparian Rank in shallow water habitat areas at the per-acre level, however all water features have a high Relative Riparian Rank. Of the undisturbed land, nearly all forests and woodlands have a high Relative Riparian Rank and all wetlands have a high Relative Riparian Rank.

B. Development Scenario: Relative Wildlife Rank

The Development Scenario would displace 280 acres of wildlife habitat on WHI, resulting in negative effects on the quality of wildlife habitat due to habitat isolation and edge relationships. Habitat on WHI is isolated from other terrestrial areas by the Columbia River that surrounds the island. By displacing wildlife habitat on WHI, the Development Scenario would further isolate the island's existing habitat, threatening the viability of its wildlife populations.[12] By decreasing the area of existing habitat, the Development Scenario likely would decrease the amount of edge habitat along forest/woodland areas that interact with other habitat types and increase the prevalence of hard edges (where wildlife habitat meets developed areas). The edges created when forest habitat meets other habitat types provide valuable wildlife habitat for some

[12] See, for example, Lehmkuhl, J. and L. Ruggiero. 1993. "Forest Fragmentation in the Pacific Northwest and its Potential Effects on Wildlife." *In* Ruggiero, L, K. Aubry, and M. Brooks. *Wildlife and Vegetation of Unmanaged Douglas-fir Forests.* US Forest Service, Pacific Northwest Research Station.

species, including some bird species.[13] By decreasing the area of forest/woodland habitat on WHI, the Development Scenario would decrease the length of these beneficial edges, and increase the length of harmful hard edges (where developed areas meet other habitat areas), which would negatively affect the quantity and quality of wildlife habitat on the undisturbed area on WHI.

In addition to displacing habitat, construction and operations under the Development Scenario (as well as potential increases in recreation-related activities) would generate noise, light, and air quality effects that could impact nearby wildlife populations.

- Noise pollution likely would come from unit trains as they travel the elevated railroad tracks that cross the island and rail car loading and offloading, and from people coming to WHI for recreation.
- Light pollution likely would come from large outdoor work areas illuminated 24-hours a day for full-day operations at the site.
- Air pollution likely would come from increased particulate matter from diesel exhaust and dust from loading and unloading bulk materials like potash.

The literature demonstrates a well-documented impact of industrial and other human sources of noise on wildlife populations, although much of the literature is complicated by the fact that it is impossible to isolate the noise from other factors that influence the behavior and physiology of wildlife. Busnel (1978) was one of the first to thoroughly document the physiological and behavioral responses of wildlife introduced to human-made noise. The documented responses include: increased heart rate, altering of metabolism and hormone balance, and panic and escape behavior.[14] He notes these responses can result in bodily injury, energy loss, decreased food intake, habitat avoidance, and reproductive loss. Knight (1984) finds boat noise and activity have significant negative effects on the feeding activity of bald eagles, which reduced their energy intake.[15] This is particularly relevant to the WHI port as bald eagles use WHI as a movement and hunting corridor, as well as for nesting.

Artificial light, particularly at night, from the WHI port could also stress nearby wildlife populations. Birds are attracted to light--particularly during low cloud cover, overcast skies, and foggy or drizzly conditions that are in particular characteristic of the Pacific Northwest—and will often circle the source for hours to days.[16] Bourne (1979) and Wiese et al (2001) both document the mass collisions and incidences of circling birds at coastal and offshore artificial light sources, which can lead to high-levels of mortality, particularly among nocturnally-migrating songbirds.[17] Insects are also particularly attracted to artificial light, which interferes with their ability to migrate, mate, and

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[13] See, for example, Gates, J. and J. Mosher. 1981. "A Functional Approach to Estimating Habitat Edge Width for Birds." *American Midland Naturalist*. 105(1): 189-192.

[14] Busnel, R.G. and J. Fletcher (eds). 1978. *Effects of Noise on Wildlife.* New York: Academic Press.

[15] Knight, R. 1984. "Responses of Wintering Bald Eagles to Boat Activity." *Journal of Wildlife Management* 48(3): 999-1004.

[16] Rich, C. and T. Longcore. *Ecological Consequences of Artifical Lighting*.

[17] Bourne, W. 1979. "Birds and gas flares." *Marine Pollution Bulletin* 10: 124-125.; Wiese, F.K., W. Montevecchi, G. Davoren, F. Huettmann, A. Diamond, and J. Linke. 2001. "Seabirds at risk around offshore oil platforms in the northwest Atlantic." *Marine Pollution Bulletin* 42:1285-1290.

search for food. This behavior can reduce insect populations, thereby reducing the available food sources for birds and bats.[18]

Air pollution from industrial activities can also have significant adverse effects on nearby wildlife populations, either through inhalation, absorption, or ingestion. Newman (1979) documents the numerous effects of industrial air pollution on wildlife, including direct mortality, debilitating injury and disease, physiological stress, anemia, and bioaccumulation. He notes these effects can also lead to a change in the distribution of certain wildlife species.[19] Increased air pollution can also indirectly affect wildlife through the contamination of food resources and habitat loss.

While the studies described above did not specifically look at the impacts of noise, light, and air pollution on wildlife and WHI, they do provide a general description of potential impacts on WHI. This analysis does not use specific data from these studies, but rather uses the evidence as background and justification for the assumptions provided by Portland BES regarding harm to adjacent areas under the Development Scenario. A related point is the fact that WHI sits within the operating areas of the Port of Vancouver (directly to the north), and the Port of Portland (directly to the south). It's not clear, based on the available information, the extent to which development on WHI would cause a noticeable increase in noise, light, or air-pollution impacts on wildlife beyond current baseline conditions.

V. Mitigation

In previous sections, we summarized the distribution of acres across habitat types and ecosystem quality available on WHI under the Baseline Scenario and the Development Scenario. Here, we discuss mitigation in general, and the specific mitigation efforts proposed under the Development Scenario. We know from earlier sections that mitigation projects of equivalent quality will be difficult to find offsite, particularly in terms of geography and size. We also know that the overall high quality of ecosystems on WHI means that there is little capacity to ecologically improve upon existing conditions per acre.

A. How Successful are Mitigation Efforts?

The objective of most mitigation efforts is to make up for disturbances or damages to the natural resource functions in a natural area by improving the functional capacity in another area. In many instances state or federal agencies have guidelines outlining the proper mitigation ratios to consider for a particular type of mitigation. At the state level, wetlands, for example, have a mitigation ratio of 3:1. This means that for every acre of wetlands that is destroyed, three acres of wetlands must be enhanced. One reason mitigation ratios like these are applied is because mitigation efforts are not always successful. In fact, several studies tracking the success of mitigation projects have found that many, sometimes most, mitigation efforts do not result in successfully functioning ecosystems.

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[18] Duffek, J. 2008. "Light Pollution and Wildlife." The Smithsonian/ NASA Astrophysics Data System. American Geophysical Union. Fall Meeting.

[19] Newman, J. 1979. "Effects of industrial air pollution on wildlife." *Biological Conservation* 15(3): 181-190.

- Benayas (2009) conducted a meta-analysis of 89 restoration assessments of many different habitat types. He found that while, on average, these restoration efforts increased biodiversity by 44 percent and improved ecosystem services by 25 percent, the restored areas still underperformed when compared to undisturbed natural areas.
- Moreno-Mateos (2012) conducted a meta-analysis of 621 wetland sites across the world. He found that restoration efforts, even decades later, did not function at the level of reference wetlands. On average, the biological structure of the restored areas was 26 percent lower than the reference sites and biogeochemical functioning was 23 percent lower. The study found that restoration efforts on projects with larger contiguous areas tended to be more effective than smaller efforts.[20]
- A 2005 literature review of success rates of wetland mitigation efforts found that 25–66 percent of the projects in the literature achieved intermediate levels of success, 3–43 percent achieved full success, and 7–97 percent were unsuccessful.[21] The review included three Washington-specific studies. One study, looking at 24 projects, found that 13 percent were fully successful, 33 percent were moderately successful, 33 percent were minimally successful, and 21 percent were not successful.[22] Another study, looking at 38 projects in King County, found that three percent were successful while 97 percent were not successful.[23] A third study, looking at 17 projects in Western Washington, found that 23 percent functioned well ecologically, while 65 percent functioned poorly, and 12 percent were not completed.[24] The studies evaluated success based on a number of factors including wetland function, wetland acreage, hydrology, soil, buffer condition, wildlife habitat, and structural and biological diversity.

These studies suggest that risk and uncertainty pervade the potential success of mitigation efforts associated with the Development Scenario. Some restoration efforts likely will be successful in achieving the expected level of natural resource functions, others likely will not. Several factors influence the ultimate effectiveness of mitigation efforts including site selection, site potential, future uncertainty, and monitoring. In many instances, well-planned monitoring efforts help support the long-term effectiveness of mitigation. Regardless, it is likely that either substantial monitoring and maintenance, or a large portfolio accepting that a share is likely to fail, would be necessary to achieve full environmental mitigation with a high level of likelihood.

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[20] Moreno-Mateos, D., M. Power, F. Comin, R. Yockteng. 2012. "Structural and Functional Loss in Restored Wetland Ecosystems." *PLoS ONE*. 10(1): e1001247.

[21] Sheldon, D., T. Granger, T. Hruby, et al. 2005. *Wetlands in Washingotn State - Volume 1: A Synthesis of Science*. Ecology Publication No. 05-06-006.

[22] Johnson, P., D. Mock, A. McMillan, et al. 2002. *Washington State Wetland Mitigation Evaluation Study Phase 2: Evaluating Success*. Ecology Publication No. 02-06-009.

[23] Mockler, A., L. Casey, M. Bowled, et al. 1998. *Results of Monitoring King County Wetland and Stream Mitigation*. King Count Department of Development and Environmental Services.

[24] Storm, L. and J. Stellini. 1994. *Interagency Follow-Through Investigation of Compensatory Wetland Mitigation Sites: Joint Agency Staff Report*. Environmental Protection Agency, Region 10, US Fish and Wildlife Service, and Ecological Services.

B. Mitigation – The Development Scenario

BPS staff developed the mitigation assumptions upon which our analysis relies. We summarize these assumptions in Table 4. For each habitat type, Table 4 identifies the number of acres impacted under the Development Scenario, the proposed amount of onsite and offsite mitigation, the costs associated with mitigation, and the number of years after mitigation it would take for each habitat type to reach full functionality. In terms of area, most efforts will be devoted to efforts mitigating impacted forest/woodland areas. Per acre, shallow water habitat requires the most costly mitigation, at about $1 million per acre. Grassland areas would recover the fastest (two years after mitigation), while forest/woodland areas would take 70 years to recover. No mitigation is proposed for impacted shrubland. For all habitat types, we assume mitigation efforts occur in 2018, five years before development begins. We assume the costs presented in Table 4 include all costs associated with mitigation that would occur in 2018, in 2011 dollars.

Table 4. Mitigation Assumptions under the Development Scenario

	Shallow Water	Wetlands	Forest / Woodland	Shrubland	Grassland
Impacted Habitat (acres)	1	10	140	5	125
Total Mitigation (acres)	5	25	420	-	150
On-Island Mitigation (acres)	5	25	340	-	-
Off-Island Mitigation (acres)	-	-	80	-	150
Mitigation Costs	$5 million	$3.5 million	$19.3 million	-	$1.5 million
Years to Full Functionality	5	5	70	-	2

Source: ECONorthwest with data from Portland BPS. 2012. *WHI Mitigation and Enhancement City Draft Term Sheet*. March 23, 2012.

Notes: Since the Draft Report, the City has refined its assumptions regarding mitigation ratios and costs. The values in this table represent the most recent assumptions as of May 2012.

VI. Benefits and Costs

In this section, we describe the benefits and costs associated with each of the scenarios. The objective of this section is to estimate the difference between the value of benefits under the Baseline Scenario and the value of benefits under the Development Scenario, while accounting for relevant costs, over time. This analysis does not consider or discuss alternative approaches to implementing the Development Scenario beyond the potential mitigation efforts that BPS staff provided. First we describe the benefits derived from ecosystem services and wildlife on WHI for each scenario, and the jobs and incomes associated with mitigation efforts. Then we describe the costs of the mitigation efforts associated with the Development Scenario. We conclude this section by comparing the costs and benefits. Throughout this section, we report our final estimates in terms of their NPV, assuming a discount rate of 3 percent to take into account the time-preference of money.

A. Benefits

In this section, we describe the benefits related to natural resources and mitigation efforts on WHI under the Baseline Scenario, the Development Scenario without mitigation, and the Development Scenario with mitigation. First we summarize the literature describing the value of benefits derived from ecosystem services from areas like those found on WHI. Next, we identify the values we use in our analysis, and our understanding of mitigation potential on WHI under the Development Scenario. We then apply the values to the Baseline Scenario and the Development Scenario. We use the *Economic Impacts of Restoration Calculator*, created by the Institute for a Sustainable Environment's Ecosystem Workforce Program at the University of Oregon, to estimate the number of jobs and value of incomes associated with mitigation efforts.

1. Background on Value of Benefits from Ecosystem Services

Our analysis of the benefits related to natural resources and mitigation on WHI under the two scenarios relies on the per-acre values identified in the *2010 Entrix Report*. Our assessment of the *2010 Entrix Report* uncovered a few errors in the interpretation and/or presentation of per-acre values. We corrected these errors and updated the values to 2011 dollars. Throughout this section, we briefly introduce several values from the literature that describe the benefits associated with natural resources provided by different types of ecosystems. This discussion supports our decision to use the values identified in the *2010 Entrix Report*, as those value by and large fall within the range of values reported in the literature.

Forests and Woodlands

Riparian forests (the vegetated areas adjacent to rivers and streams) provide several different types of ecosystem services. One way to estimate the values of these ecosystem services is to evaluate the willingness of individuals, municipalities, or other agencies to pay for restoring riparian habitat. The City of Portland, for example, avoided purchasing a $200 million filtration treatment system for its water supply by protecting 102 square miles of its watershed. This avoided cost constitutes a one-time economic benefit of $3,000 per acre for water filtration services.[25] Similarly, Clean Water Services, a water-resource management utility in northwest Oregon avoided investing in a chiller for a water treatment plant on the Tualatin River by planting riparian vegetation to shade and cool the river, for a savings of $50 million.[26]

In 2000, the U.S. Forest Service estimated restoration costs associated with streambank stabalization and riparian management in Gifford-Pinchot National Forest in Washington. They estimated total costs for river restoration would be $76,000–$422,000 per river mile, of which we calculate $46,000–$240,000 would be needed for riparian restoration efforts.[27] This range of values represents a one-time payment for present and

[25] ECONW, with data from the Portland Water Bureau, http://www.portlandonline.com/water/index.cfm?c=29784; and Krieger, D. 2001. *Economic Value of Forest Ecosystem Services: A Review.* The Wilderness Society.

[26] Niemi, E., K. Lee and T. Raterman. *Net Economic Benefits of Using Ecosystem Restoration to Meet Stream Temperature Requirements.* ECONorthwest.

[27] Bair, B. 2004. *Stream Restoration Cost Estimates*. US Department of Agricultural, Forest Service.

future benefits derived from riparian habitat. Yet another estimate of the value of riparian habitat, based on the net primary productivity of various landscapes in the U.S. National Wildlife Refuge System, suggests that the ecosystem service values of forests, generally, may be about $1,000 per acre per year.[28] This estimates comes from a meta-analysis of many individual site-specific studies. Riparian areas are unique in that they interact with aquatic systems and thus provide more services than general forests, so the general forest value from the meta-analysis likely understates the value of riparian forests.

The *2010 Entrix Report* identified three main components of ecosystem service value derived from forests and woodlands: wildlife-related benefits, carbon-related benefits, and other air quality-related benefits. We discuss wildlife-related benefits associated with forests and woodlands on WHI later in this section. To estimate carbon-related benefits, the *2010 Entrix Report* multiplied WHI's annual carbon sequestration rate (0.6 metric tons per acre) by the social cost of carbon emissions ($41–$149 per metric ton) for a total of $26–$92 per acre per year. To estimate air quality benefits, the *2010 Entrix Report* multiplied WHI's annual pollutant removal (based on a Portland-specific model developed by the U.S. Forest Service) by pollutant-specific values from the literature. Table 5 shows the rate of pollutant removal for five different pollutants, the annual value associated with pollutant removal, and the annual value per acre (for each pollutant) provided by forests and woodlands on WHI.

Table 5. Annual Quantity and Value of Pollutant Removal by Forestland (2011$)

Pollutant	Annual Kilograms Removed per Acre	Annual Value per Ton	Annual Value per Acre
CO	2.03	$1,403	$3
NO^2	3.65	$4,039 – $9,875	$15 – $36
O^3	14.57	$2,019 – $9,875	$29 – $144
PM^{10}	10.53	$6,593	$69
SO^2	2.83	$2,418 – $9,546	$7 – $27

Source: ECONorthwest staff estimates with data from Entrix. 2010. "WHI Environmental Foundation Study." City of Portland Bureau of Planning and Sustainability. Portland, Oregon. July.

Wetland Habitat

Wetlands have the potential to provide several different ecosystem services. Table 6 summarizes several values associated with some of the ecosystem services wetlands provide. The first set of rows summarizes values associated with single-service wetlands. In many cases, however, a wetland may provide multiple services. The range of values associated with single-service wetlands is about $2–$9,669 per acre per year. The second set of rows shows the values associated with specific ecosystem services provided by both native and restored wetlands. The total value associated with native wetlands is about $29,400 per acre per year and that the total value associated with restored wetlands is about $27,400 per acre per year. Another estimate, based on the net primary productivity of various landscapes in the U.S. National Wildlife Refuge System,

[28] Ingraham, M. and S. Foster. 2008. "The Value of Ecosystem Services Provided by the U.S. National Wildlife Refuge System in the Contiguous U.S." *Ecological Economics*. 67:608-618.

suggests that the ecosystem services wetlands provide, generally, have a value of about $2,900–$14,700 per acre per year.[29] All these estimates come from meta-analyses of many individual, site-specific studies.

Table 6. Value of Ecosystem Services Associated with Wetlands ($/Acre/Year)

Single-Service Wetland Type	Mean Value	Range of Values
Flood	$676	$153-$3,007
Quality	$718	$2,177-$2,372
Quantity	$219	$10-$4,425
Recreational Fishing	$614	$163-$2,310
Commercial Fishing	$1,339	$186-$9,669
Birdwatching	$2,086	$909-$4,788
Amenity	$5	$2-$24
Habitat	$527	$163-$1,688
Storm	$408	$19-$8,850
Ecosystem Service	**Native Wetlands**	**Restored Wetlands**
Gas regulation	$128	$93
Disturbance regulation	$15,300	$15,300
Water supply	$1,424	$1,424
Nutrient cycling	$7,706	$5,780
Commodities	$2,907	$2,907
Biodiversity	$185	$163
Recreation	$1,744	$1,744
Total	**$29,394**	**$27,410**

Source: Woodward, R., and Y. Wui. 2001. "The Economic Value of Wetland Services: A Meta-Analysis." *Ecological Economics* 37: 257-270; Dodds, W. K. Wilson, R. Rehmeier, et al. 2008. "Comparing Ecosystem Goods and Services Provided by Restored and Native Lands." *BioScience* 58(9):837-845.

From a cost perspective, a review by the Environmental Law Institute of U.S. Army Corps of Engineers found that the average expenditures per-acre for wetland compensatory mitigation projects in the Portland district is in the range of $19,528–$84,600.[30] This range of values represents a one-time payment for present and future benefits derived from wetland habitat.

To estimate air quality benefits, the *2010 Entrix Report* multiplied WHI's annual pollutant removal (based on a Portland-specific model developed by the U.S. Forest Service) by pollutant-specific values from the literature. Table 7 shows the rate of pollutant removal for five different pollutants, the annual value associated with pollutant removal, and the annual value per acre (for each pollutant) provided by wetlands on WHI. For benefits derived from water purification, the *2010 Entrix Report* applied the results of a meta-analysis of 39 studies looking at water purification in wetlands ($153–$664 per acre per year).

[29] Ingraham, M. and S. Foster. 2008. "The Value of Ecosystem Services Provided by the U.S. National Wildlife Refuge System in the Contiguous U.S." *Ecological Economics*. 67:608-618.

[30] Environmental Law Institute. 2007. "Mitigation of Impacts to Fish and Wildlife Habitat: Estimating Costs and Identifying Opportunities." October.

Table 7. Annual Quantity and Value of Pollutant Removal by Wetlands

Pollutant	Annual Kilograms Removed per Acre	Annual Value per Ton	Annual Value per Acre
CO	2.03	$1,403	$3
NO^2	3.56	$4,039 – $9,875	$14 – $35
O^3	14.58	$2,019 – $9,875	$29 – $144
PM^{10}	10.51	$6,593	$69
SO^2	2.88	$2,418 – $9,546	$7 – $28

Source: ECONW staff estimates with data from Entrix. 2010. "WHI Environmental Foundation Study." City of Portland Bureau of Planning and Sustainability. Portland, Oregon. July.

As with forests and woodlands, the *2010 Entrix Report* did not consider all potential values associated with the ecosystem services wetlands provide. Many wetlands, for example, provide climate change-related benefits by sequestering more greenhouse gases than they emit. For the purposes of this analysis, however, we assume that the ecosystem service values the *2010 Entrix Report* included (including the wildlife benefits

Water-Related Benefits

The *2010 Entrix Report* describes several mechanisms through which ecosystems provide water-related benefits.

- **Water Quality.** Vegetation and woody debris in WHI's forests and woodlands slow water flow allowing biophysical processes to remove pollutants (e.g., regulated pollutants in the Columbia including PCBs and DDT) from the water and improve water quality.
- **Water Temperature.** Shade and physical features provided by riparian forests can help reduce water temperature, improving habitat for aquatic species.
- **Flood Regulation.** Wetlands and riparian vegetation store and convey storm and floodwater, which can decrease the frequency and extent of flood-related impacts on surrounding areas.

All habitat types on WHI, to some extent, provide these services. Furthermore, all of these ecosystem services are valuable insofar as they are each associated with avoided costs and other types of values, which we discuss throughout this section. As stated in the *2010 Entrix Report*, however, these values in the context of WHI and the Columbia River Basin likely are small (with the exception of water-related benefits associated with wetlands). Dams along the Columbia River are managed, in part, to control flooding in the Lower Columbia River. Furthermore, flood storage capacity on WHI is small relative to the size of the river, which means the potential value derived from flood regulation likely is small. Similarly, due to the size of the basin and the volume of water that runs through it, the marginal impact of forests and woodlands on water quality and water temperature likely is small. So, while these are prevalent functions on WHI, their marginal contribution (in monetary terms) in the context of the entire Columbia River Basin likely are small.

The extent of the difference in water-related benefits between the Baseline and Development Scenarios could be greatly exacerbated by water quality degradation from port activities. The discussion above holds primarily in terms of the loss of habitat and permeable land. It does not include the potential introduction of pollutants from port activities. If stormwater runoff from the site is substantially more contaminated than baseline stormwater in the area, or other events such as pollutant spills occur, the decline in water quality and associated habitat could be more dramatic. Such a decline would increase the costs of the Development Scenario relative to the Baseline Scenario.

attributable to wetlands described later in this section) adequately account for the ecosystem services that wetlands on WHI provide.

Shrubland and Grassland

As compared to forests and wetlands, there is less literature available describing the value of ecosystem services provided by shrublands and grasslands. One study, based on the net primary productivity of various landscapes in the U.S. National Wildlife Refuge System, suggests that the ecosystem service values of shurblands, generally, may be about $600–$800 per acre per year.[31] This estimate comes from a meta-analysis of many individual site-specific studies. The same study considered the value of grasslands, and suggests that the value of ecosystem services provided by grasslands may be about $30–$140 per acre per year.

The *2010 Entrix Report* identified three main components of ecosystem service value derived from shrublands and grasslands: wildlife-related benefits, carbon-related benefits, and other air quality-related benefits. We discuss wildlife-related benefits associated with shrublands and grasslands on WHI later in this section, To estimate carbon-related benefits, the *2010 Entrix Report* multiplied WHI's annual carbon sequestration rate (0.6 metric tons per acre of grassland/shrubland) by the social cost of carbon emissions ($41–$149 per metric ton) for a total of $26–$92 per acre per year. To estimate air quality benefits, the *2010 Entrix Report* multiplied WHI's annual pollutant removal (by grassland/shrubland) by pollutant-specific values from the literature. Table 8 shows the rate of pollutant removal for five different pollutants, the annual value associated with pollutant removal, and the annual value per acre (for each pollutant) provided by grasslands and shrublands on WHI.

Table 8. Annual Quantity and Value of Pollutant Removal by ShrubInd per

Pollutant	Annual Kilograms Removed per Acre	Annual Value per Ton	Annual Value per Acre
CO	0.79	$0 – $1,403	$1
NO^2	1.45	$4,039 – $9,875	$6 – $14
O^3	6.05	$2,019 – $9,875	$12 – $60
PM^{10}	4.34	$0 – $6,593	$29
SO^2	1.18	$2,418 – $9,546	$3 – $11

Source: ECONorthwest staff estimates with data from Entrix. 2010. "WHI Environmental Foundation Study." City of Portland Bureau of Planning and Sustainability. Portland, Oregon. July.

The *2010 Entrix Report* did not consider all potential values associated with the ecosystem services grasslands and shrublands on WHI provide. These areas, for example, likely provide water-related benefits similar to those described above. While the water-related benefits these areas provide certainly have positive economic values, they are likely small due to the size of the Columbia River Basin and efforts to control water quantity by dams upstream.

[31] Ingraham, M. and S. Foster. 2008. "The Value of Ecosystem Services Provided by the U.S. National Wildlife Refuge System in the Contiguous U.S." *Ecological Economics* 67:608-618.

Value of Wildlife

Economic research has shown that people place a considerable value on the continued survival of sensitive species, such as those listed as threatened or endangered. Economic studies suggest that the value associated with protecting threatened, endangered, and rare species similar to those found on WHI ranges from an annual payment of $11 per household to a one-time payment of nearly $400 per household (see Table 9).

In most instances, the available research has not considered willingness-to-pay (WTP) values for the sensitive species or other wildlife-related natural resource functions found on WHI. Existing data do, however, serve to provide support for the notion of value attributable to sensitive species in general. There are several sensitive plant species on WHI, but there is little literature describing the economic value of these species. Research suggests that the household WTP to protect sensitive plant species generally is lower than their WTP for mammals and birds, but likely higher than their WTP for insects or reptiles.[32] Furthermore, there are many examples of private and public entities funding efforts aimed at protecting sensitive plant species, providing evidence for a general demand from the public to protect sensitive plant species.

Threats to sensitive species due to development on WHI also may impose higher costs for governments, firms, and households that engage in future activities that affect the species, and higher costs for governments charged with monitoring species status and ensuring their protection.[33] These potential future costs associated with sensitive species serve to demonstrate an avoided cost of pre-emptive efforts to protect sensitive species.

Table 9. Household Willingness to Pay to Protect Threatened, Endangered, and Rare Species

Studies Reporting Annual Values		
	Average Value	**Range of Values**
Bald eagle	$43.51	$23.43-$50.21
Owl	$72.52	$43.51-$145.05
Salmon/Steelhead	$90.38	$11.16-$155.09
Whooping Crane	$62.48	$49.09-$76.99
Woodpecker	$17.85	$14.50-$22.32
Studies Reporting Lump Sum Values		
	Average Value	**Range of Values**
Arctic grayling	$25.66	$22.32-$29.01
Bald eagle	$331.38	$273.36-$390.52
Falcon	$35.70	-

Source: Richardson, L. and J. Loomis. 2009. "The Total Economic Value of Threatened, Endangered and Rare Species: An Updated Meta-Analysis." *Ecological Economics* 68:1535-1548.

[32] Martin-Lopez, B., C. Montes, and J. Benayas. 2007. "The Non-Economic Motives Behind the Willingness to Pay for Biodiversity Conservation." *Biological Conservation*. 139(1-2): 67-82.

[33] Wilcove, D. and L. Chen. 1998. "Management Costs for Endangered Species." *Conservation Biology*. 12 (6): 1405-1407.

Correction to the *2010 Entrix Report's* Analysis of Pollutant Removal

Table B-15 in the *2010 Entrix Report* describes pollutant removal by habitat type on WHI. The table includes, by habitat type on WHI, the number of acres, service level, and pollutant removal for five different types of pollutants. Pollutant removal figures are purported to be in metric tons per acre per year. The values are inconsistent, however, with the total pollutant removal row at the bottom of the table, and result in extremely large volumes of pollutant removal. Using the values as reported in the *2010 Entrix Report* would have increased the value of pollutant removal by a factor of three. We corrected this error and used the resulting values in our analysis.

2. Benefit Values Used in This Analysis

For our analysis of the change in benefits between the two scenarios, we rely on the literature and data described above, and on the analysis presented in the *2010 Entrix Report*. Table 10 summarizes these values. The first three columns summarize values associated with general ecosystem services (air purification, carbon sequestration, and water purification) for each habitat type. These values are expressed in terms of dollars per acre per year. The literature suggests that some of these values may change over time (e.g., the social cost of carbon emissions likely increases by 2–3 percent, in real terms, per year[34]). For our analysis, though, we assume these values remain constant, in real terms. Table 10 also summarizes the values associated with wildlife habitat found within each habitat type. These values represent the existence value of wildlife found in these areas (e.g., society's willingness to pay to protect wildlife on WHI). The final column sums these different values by habitat type.

Table 10. Ecosystem Service and Wildlife Values Used in this Analysis (2011$/Acre/Year)

Habitat Type	Air Purification	Carbon Sequestration	Water Purification	Wildlife Habitat	Total Value
Forest/Woodland	$73–$267	$26–$92	Not Quantified	$309–$516	$408–$875
Shrubland	$30–$110	$24–$88	Not Quantified	$309–$516	$363–$714
Grassland	$24–$89	$24–$88	Not Quantified	$309–$516	$357–$693
Wetland	$74–$266	Not Quantified	$153–$664	$3,095–$11,347	$3,322–$12,277
Shallow Water	Not Quantified	Not Quantified	Not Quantified	$1,037–$15,473	$1,032–$15,473

Source: ECONorthwest with data from Entrix. 2010. "WHI Environmental Foundation Study." City of Portland Bureau of Planning and Sustainability. Portland, Oregon. July.

Notes: While this table suggests that some habitat types provide no value in terms of some ecosystem services (e.g., water purification from forests), the text in this section describes how the values derived from many ecosystem services not included likely are accounted for by those reported here.

Our review of the literature describing the values associated with different ecosystem services provided on WHI suggests that the unit values used in the *2010 Entrix Report* are within the accepted range of values. The specific list of ecosystem services we incorporate into our analysis likely is a subset of all the ecosystem services produced on

[34] Nordhaus, W. 2008. *A Question of Balance: Weighting the Options on Global Warming Policies*. Yale University Press, New Haven, CT. 234 pp.

WHI. As previously discussed, each of the habitat types in Table 10 likely provides additional ecosystem services. The values associated with other ecosystem services, however, are not included in this analysis. These values are, to some degree, accounted for by values attributed to other ecosystem services, and applying multiple values for many different ecosystem services can lead to double-counting. Furthermore, many of the values (especially those associated with water-related benefits from terrestrial areas) likely are small due to their small relative impact on water quality and water quantity in the Columbia River Basin. The values we include in our analysis provide a useful snapshot that allows us to consider the direction (positive or negative) and the magnitude of the net effect of the Development Scenario on the value of ecosystem services provided on WHI.

3. Potential for Improvement on WHI and Elsewhere

To better understand the benefits derived from mitigation associated with the Development Scenario, we first need to understand the potential for improvement on the undisturbed portion of WHI. A team of natural resource experts from Portland BES, who have working knowledge of WHI habitats, discussed and estimated the potential improvement of wildlife and other ecosystem services on the undisturbed portion of WHI for each habitat type (see Table 11). Wildlife-related natural resource function on undisturbed wetlands, for example, has the capacity to improve by 10–25 percent with mitigation while its other ecosystem services have the capacity to improve by 0–25 percent. In other words, each habitat type has two improvement potentials (one for ecosystem services and one for wildlife habitat). To facilitate our analysis we combined the improvement potentials for wildlife and ecosystem services and calculated one range for each habitat type. We weight each improvement potential by the proportion of the total value attributable to wildlife and ecosystem services.

Table 11. Improvement Potential through Mitigation on WHI

Habitat Type	Potential Wildlife Improvement	Potential Ecosystem Service Improvement	Low Values		High Values		Weighted Average Mitigation Potential
			Wildlife	Other ES	Wildlife	Other ES	
Forest/ Woodland	0%	10%	76%	24%	59%	41%	2–4%
Shrubland	0%	85%	85%	15%	72%	28%	13-27%
Grassland	0%	10–15%	87%	14%	74%	26%	1–4%
Wetland	10–25%	0–25%	93%	7%	92%	8%	9–25%
Shallow Water	10–25%	10–25%	100%	0%	100%	0%	10-25%

Source: Potential improvement estimates from *Portland BES*.

Notes: To calculate the weighted average mitigation potential, we weighted potential improvement percentages by shares of total quantified value for each end of the range (low values and high values).

The expert team from Portland BES considered forest/woodland areas differently than other habitat types on WHI. They assume that, under the Development Scenario, undisturbed forest/woodland areas will lose natural resource function, and that even after mitigation, undisturbed forest/woodland areas will function at a level 30 percent below the Baseline Scenario. The reasoning for this loss is that under the Development Scenario, the overall size of the forest area is reduced, making the remaining habitat less

suitable to particular interior species. Furthermore, the intrusion of development impacts (e.g., light, noise, vibration) will reduce functions near the edge of the remaining forest habitat. Said differently, 480 acres of forest/woodland provides significantly more functions than 204 acres of forest/woodland, even if you remove invasive species and add native plantings on the remaining 204 acres. To estimate the potential impact of mitigation on these areas, we assume that development without mitigation reduces natural resource function on forests by 40 percent, so mitigation on these areas improves functionality by 10 percent.

Given the mitigation potentials summarized in Table 11, we assume mitigation on undisturbed areas of WHI will only partially increase the overall value of wildlife and ecosystem services. For example, mitigation efforts on one acre of undisturbed wetland, will generate 0.09–0.25 acres worth of actual improvement. This means that each acre of wetland displaced by the development would require mitigation efforts on about 4–10 acres of undisturbed wetlands (not considering the effects of time preference and

Shallow Water Habitat

BES staff identify two types of shallow water habitat on WHI: (1) shallow water habitat below the low-water mark (typically flooded), and (2) shallow water habitat above the low-water mark but below the high-water mark (occasionally flooded). Each of these areas likely provides a different set of ecosystem services and wildlife benefits (e.g., flooded areas likely provide more salmon habitat than drier areas). Given other data constraints, our analysis groups both sub-types of shallow water habitat into one category. To the extent that mitigation on shallow water habitat can produce greater improvements than those described in Table 11, our analysis potentially under-estimates the benefits from mitigation efforts on shallow water habitat.

success rates) for there to be no net loss in wildlife or ecosystem services. We assume all offsite mitigation will occur on land that currently provides no wildlife or ecosystem service benefits, so mitigation efforts will translate one to one.

4. Benefits Analysis

We analyze the benefits associated with wildlife and ecosystem services in three parts:

- The benefits derived under the Baseline Scenario.
- The benefits derived under the Development Scenario without mitigation.
- The benefits derived under the Development Scenario with mitigation.

For each analysis, we describe the number of acres, by habitat type, the annual value of the benefits derived from wildlife and ecosystem services, how these annual values change over time, and the NPV of the benefits over the next 100 years. Throughout this section, we discount future values (to calculate the NPV) by applying a 3 percent discount rate. We describe additional assumptions as they come up in our analysis.

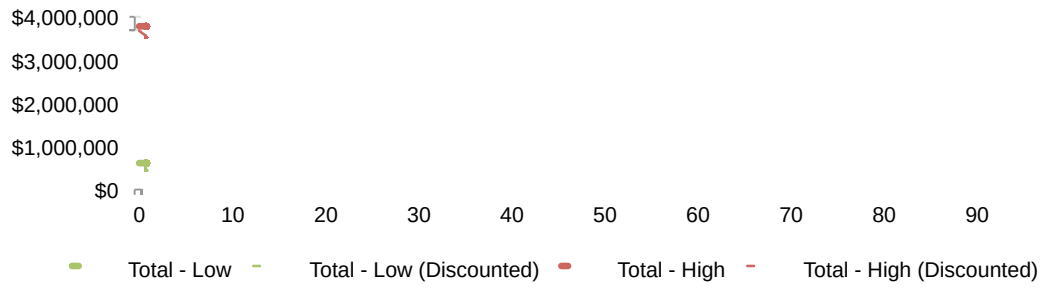
Baseline Scenario

Table 12 summarizes our analysis of the Baseline Scenario. The annual value associated with the benefits from ecosystem services provided by WHI under the Baseline Scenario range from about $0.6–$3.8 million (un-discounted). The 100-year NPV of these benefits

is about $19.3–$119.4 million. The thick red line shows the high-end of the un-discounted annual benefits while the thin red line shows the high-end of the discounted benefits. The green lines show the low-end of the benefits. The areas under the thin red and green lines represent the range of the 100-year NPV under the Baseline Scenario. The range in this case is directly related to the range in per-acre values for ecosystem services and wildlife.

Table 12. Summary of Benefits under the Baseline Scenario

Habitat Type	Acres	Annual Value ($/Year)	100-Year NPV
Forest/Woodland	480	$196,000–$420,000	$6.2–$13.3 million
Shrubland	25	$9,000–$18,000	$0.3–$0.6 million
Grassland	230	$82,000–$159,000	$2.6–$5.0 million
Wetland	45	$149,000–$552,000	$4.7–$17.5 million
Shallow Water	170	$175,000–$2,630,000	$5.5–$83.1 million
Total	950	$0.6–$3.8 million	$19.3–$119.4 million



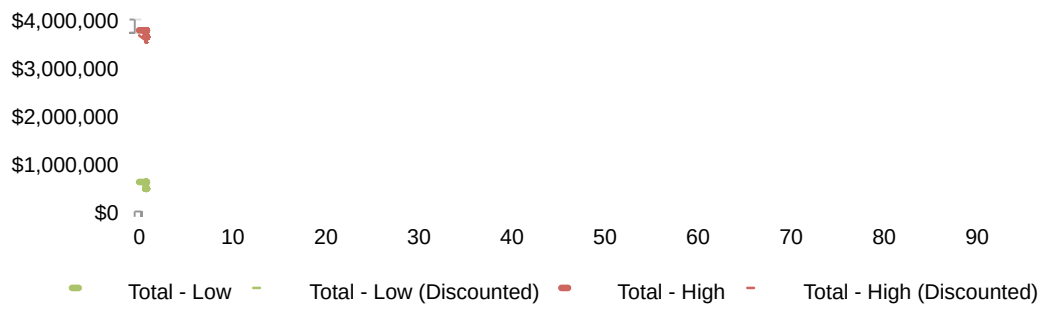
Source: ECONorthwest staff estimates.

Development Scenario without Mitigation

Table 13 summarizes our analysis of the Development Scenario assuming no mitigation. The Development Scenario would displace 283 acres of natural area. It would also decrease the quality of the remaining forest/woodland areas by 40 percent. We consider this reduction in quality by reducing the total acres of forest/woodland in the Development Scenario by 40 percent (this is the acre value presented in Table 13). In this instance, the value of ecosystem services under the Development Scenario parallel those under the Baseline Scenario until development begins in 2023, at which point the value of benefits drops to about $0.4–$3.3 million per year. The 100-year NPV of these benefits is about $14.8–$107.9 million. As in the previous example, the thin red and green lines represent the range of undiscounted benefits as they accrue each year. The areas beneath the thin red and green lines represent the range of 100-year NPVs, discounted at a rate of 3 percent.

Table 13. Summary of Benefits under the Development Scenario (no mitigation)

Habitat Type	Acres	Annual Value after Development ($/Year)	100-Year NPV
Forest/Woodland	204	$83,000–$179,000	$3.6–$7.7 million
Shrubland	20	$7,000–$14,000	$0.2–$0.5 million
Sparsely Vegetated	105	$38,000–$73,000	$1.6–$3.0 million
Wetland	35	$116,000–$430,000	$4.0–$14.6 million
Shallow Water	167	$172,000–$2,584,000	$5.4–$82.0 million
Total	531	$0.4–$3.3 million	$14.8–$107.9 million



Source: ECONorthwest staff estimates.

Development Scenario with Mitigation

Table 14 summarizes our analysis of the Development Scenario assuming the mitigation efforts described by Portland BPS. In this example, benefits from mitigation accrue linearly according to how long it takes each habitat type to achieve full functionality. Annual values are difficult to summarize for this example because they change from year to year as mitigation efforts increase function. The 100-year NPVs of the benefits shown in Table 14 are higher than the values of benefits assuming no mitigation. The increase in value from benefits derived through mitigation are represented by upward slopes in the thick lines beginning in 11 years. The areas beneath the thin red and green lines represent the range of 100-year NPVs. The 100-year NPV of the benefits under the Development Scenario with mitigation is about $16.7–$113.8 million.

Table 14. Summary of Benefits under the Development Scenario (mitigation)

Habitat Type	Acres	Mitigation acres (acres on WHI)	100-Year NPV
Forest/Woodland	204	420 (340)	$4.0–$8.6 million
Shrubland	20	0 (0)	$0.2–$0.5 million
Grassland	105	150 (0)	$2.9–$5.6 million
Wetland	35	25 (25)	$4.2–$16.6 million
Shallow Water	167	5 (5)	$5.5–$82.5 million
Total	531	600 (370)	$16.7–$113.8 million

Surplus Habitat on WHI

The Concept Plan for WHI recognizes the opportunities for additional high value habitat creation in addition to mitigation activities associated with the Development Scenario. These opportunities are highlighted by creation of new shallow water habitat along the south shore. The Concept Plan identifies 180 acres that could be converted to produce shallow water habitat, and it proposes to convert up to 25 acres. Assuming that this conversion would occur on a similar timeline to mitigation activities specific to the Development Scenario, these 25 acres would generate from $1.3–$11.7 million worth of benefits, at a cost of about $20.9 million, both in net present value. The Concept Plan also identifies 18 acres of shrubland and 5 acres of wetland mitigation opportunities remaining.

Source: ECONorthwest staff estimates.

Comparison of Benefits

The objective of our analysis is to shed light on how the value of the benefits associated with wildlife and ecosystem services under the Baseline Scenario compare to the value of the benefits under the Development Scenario. Here, we look at two comparisons:

- **No Mitigation.** In this summary, we look at the 100-year NPV of the benefits under the Development Scenario (assuming no mitigation) minus the NPV under the Baseline Scenario.
- **Mitigation.** In this summary, we look at the 100-year NPV of the benefits under the Development Scenario (assuming mitigation) minus the NPV under the Baseline Scenario.

As shown in Table 15, the NPV of the benefits derived from ecosystem services on WHI, both with and without mitigation, are lower under the Development Scenario than they are under the Baseline Scenario. There are three reasons for this:

- The development scenario reduces the value of the benefits on WHI by displacing 283 acres of natural area and reducing the quality of the remaining forest/woodland area.
- Mitigation efforts on WHI do not fully offset the benefits lost to the development footprint. Since existing areas on WHI can only marginally improve, every acre of mitigation results in a fraction of an increase in benefits.
- Mitigation efforts on and off WHI are slow to develop (particularly for forest habitat). Each year that passes without full benefits from these mitigation efforts, the difference between the NPVs of the Baseline Scenario and the Development Scenario increase.

This type of analysis, because of the direct like-to-like comparisons by habitat type, is not as sensitive to the precise per-acre value used for each habitat type as otherwise. Changing the values would not shift a particular habitat type comparison from positive to negative or vice versa. Using the same per-acre value by habitat type for the costs and the benefits reduces the sensitivity of the results to the per-acre value parameters.

Table 15. Comparison of 100-Year NPV of Benefits (millions of dollars)

Habitat Type	Comparison 1 – No Mitigation	Comparison 2 - Mitigation
Forest/Woodland	($2.6) – ($5.6)	($2.2) – ($4.7)
Shrubland	$0.0 – ($0.1)	$0.0 – ($0.1)
Grassland	($1.0) – ($2.0)	$0.3 – $0.6
Wetland	($0.7) – ($2.8)	($0.6) – ($0.9)
Shallow Water	($0.1) – ($1.1)	($0.1) – ($0.6)
Total	($4.5) – ($11.6)	($2.6) – ($5.7)

Source: ECONorthwest staff estimates.

5. Jobs and Incomes from Mitigation Efforts

Later in this report, we describe costs associated with mitigation efforts on WHI under the Development Scenario. These costs provide benefits in the form of jobs and incomes. To estimate the number of jobs and the value of incomes associated with mitigation efforts, we make a number of assumptions about spending and apply these figures to the *Economic Impacts of Restoration Calculator* created by the Ecosystem Workforce Program, part of the University of Oregon's Institute for a Sustainable Environment. The results are summarized in Table 16. These estimates suggest that about 140 job-years (one year of a job) could potentially be directly generated by mitigation efforts on WHI. Incomes associated with these jobs would total about $9.4 million. The Calculator, using IMPLAN input-output economic impact modeling, also estimates another 133 job-years generated through indirect and induced effects from mitigation activity. It is difficult, however, to assess whether these are net job gains or rather employment of existing workforce. Overall, the jobs are not likely to all occur during one year, but spread over the life of mitigation efforts relative to timing of effort.

Table 16. Jobs and Incomes from Mitigation Efforts on WHI

Mitigation Costs	Cost	% in County
Contracted Work: Equipment Intensive	$6.9 million	100%
Contracted Work: Labor Intensive	$7.8 million	100%
Contracted Work: Technical Services	$4.8 million	100%
In-house Labor Costs	$4.3 million	100%
Materials, Supplies, and Administration	$5.5 million	50%
Total Construction Costs	**$29.3 million**	N/A
Construction Jobs and Incomes	**Jobs**	**Incomes**
Total Construction (full and part-time)	**273**	**$16.7 million**
Direct Jobs and Incomes	140	$9.4 million
Indirect and Induced Jobs and Incomes	133	$7.3 million

Source: ECONorthwest staff estimates with data from *Portland BPS;* Tetra Tech. 2010. *River Plan/North Reach Willamette River Mitigation In-Lieu Fees*. October.; and University of Oregon, Institute for a Sustainable Environment. *Economic Impacts of Restoration Calculator*.
Notes: We used budgets from past mitigation projects (from the above-referenced Tetra Tech report) to estimate the breakdown of the expenses associated with mitigation efforts on WHI.

B. Costs

Our analysis uses estimated mitigation costs as described by BES staff. To provide a context for these cost estimates we reviewed the literature on mitigation efforts across the country similar to those that would happen under the Development Scenario and their associated costs. Below, we briefly describe mitigation costs from the literature the costs reported by BPS staff (Table 17).

Table 17. Summary of Mitigation Costs

Habitat Type	Acres Mitigated	Portland BPS Mitigation Costs ($ / Acre)	Mitigation Costs from Elsewhere ($/Acre)	NPV of Mitigation
Forest/Woodland	420	$45,952	$59,000—$436,000	$16.2 million
Shrubland	-	-	N/A	N/A
Grassland	150	$10,000	$7,000—$434,000	$1.3 million
Wetland	25	$140,000	$0.4—$2.0 million	$2.9 million
Shallow Water	5	$1.0 million	$1.0—$2.9 million	$4.2 million
Total	600	N/A	N/A	$24.5 million

Source: ECONorthwest staff estimates with data from *Portland BPS* and the *2010 Entrix Report*.

Wetlands. Data from the Willamette Partnership, for example, suggests that the value of a wetland mitigation credit in the Willamette Valley is about $50,000–$175,000 per acre, with an average cost of about $60,000 per acre.[35] Likewise, the *2010 Entrix Report* finds that wetland mitigation on and around WHI would fall in line with the costs of the Columbia River Wetland Mitigation Bank, a planned mitigation bank near the Port of Vancouver. According to an official representing that bank, credits would range from $175,000 - $200,000 per acre. The *2010 Entrix Report* reports restoration costs within this range ($55,000 - $182,000 per acre).

Forests. In a 2010 study of the costs to restore riparian forest in the Willamette Basin, the Oregon Department of Environmental Quality estimated the average cost of riparian forest restoration projects conducted by Clean Water Services in Oregon is $14,247 per acre. Likewise, a project manager for a watershed revegetation program in Portland indicated that average cost for site preparation, plantings, maintenance, and program costs are approximately $10,000 - $15,000 per acre.[36] The *2010 Entrix Report* estimates restoration costs per acre of forest/woodland above these levels, at $57,100–$59,500.

Portland BPS provided estimated mitigation costs for efforts associated with the Development Scenario. Table 17 summarizes these mitigation efforts and costs. The first column shows the number of acres of mitigation, by habitat type. The second column shows Portland BPS's mitigation cost estimates, per acre. The third column shows some mitigation costs from the literature. The final column shows the NPV of mitigation costs,

[35] Willamette Partnership. 2006. "Understanding Supply and Demand for Environmental Off-Set Credits in the Willamette River Basin." Accessed 9 February 2012. Available online: http://willamettepartnership.org/publications/MarketplacePubs/UnderstandingSupplyandDemandforEnvironmentalOff-setCredits.pdf.

[36] Michie, R. 2010. "Cost Estimate to Restore Riparian Forest Buffers and Improve Stream Habitat in the Willamette Basin, Oregon." Oregon Department of Environmental Quality. Portland, OR.

associated with the Development Scenario, about $24.5 million. In calculating the NPV of mitigation costs, we assume all mitigation efforts will take place in 2018, and we assume all costs, as reported by Portland BPS, adequately represent these one-year costs. While there may be annual costs associated with mitigation (e.g., maintenance, monitoring), we assume Portland BPS incorporated them into their point estimates.

C. Summary of Costs and Benefits

Table 18 summarizes the benefits associated with the Development Scenario against its costs, relative to the Baseline Scenario. The first four rows present the 100-year NPVs for the benefits and costs associated with the Baseline Scenario and the Development Scenario with and without mitigation. The fifth row presents the 100-year NPV of the loss in ecosystem services under the Development Scenario (without mitigation) and the sixth row presents the 100-year NPV of the lift in ecosystem services due to mitigation. As shown in the bottom row, the overall NPV of benefits minus costs under the Development Scenario, assuming mitigation efforts provided by Portland BPS, is about ($27.1)–($30.2) million. In other words, the Development Scenario would result in a net loss in overall value, despite mitigation efforts.

Table 18. Summary of Results

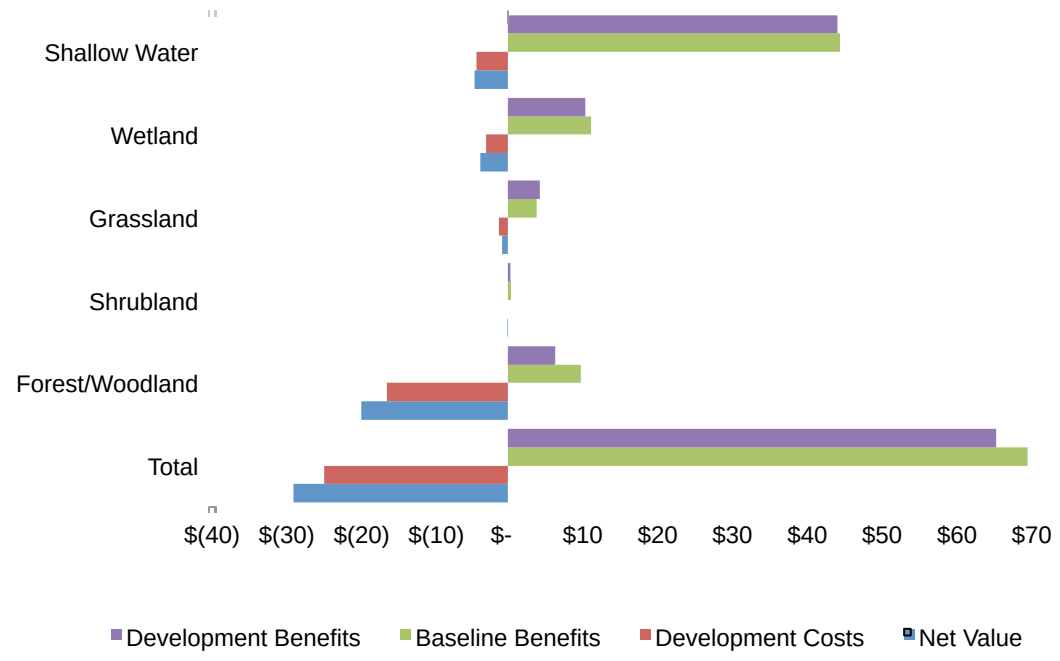
100-Year NPV of . . .	
(A) Baseline Scenario – Benefits	$19.3–$119.4 million
(B) Development Scenario (No Mitigation) – Benefits	$14.8–$107.9 million
(C) Development Scenario (Mitigation) - Benefits	$16.7–$113.8 million
(D) Mitigation Costs	$24.5 million
(E) Ecosystem Service Loss from Development (= B - A)	($4.5)–($11.5) million
(F) Ecosystem Service Lift from Mitigation (= C – B)	$1.9–$5.9 million
(G) Net Value (= C – A – D)	**($27.1)–($30.2) million**

Source: ECONorthwest staff estimates.

1. Summary of Results by Habitat Type

In Figure 3, we present the midpoints of the range of benefits and costs, previously summarized in this report, to demonstrate why the Development Scenario results in a net decrease in overall value. The purple bars represent the NPV of the benefits under the Development Scenario. The green bars represent the NPV of the benefits under the Baseline Scenario. The red bars represent the NPV of the mitigation costs. The blue bars represent the net value under the Development Scenario (i.e., the purple bar, minus the green bar, minus the red bar). As the figure shows, mitigation efforts do not provide full compensation for the natural areas removed or damaged under the Development Scenario (the purple bars are shorter than the green bars). Furthermore, mitigation costs add to the net loss in benefits from natural resources under the Development Scenario, further inflating the overall net loss under the Development Scenario.

Figure 3. Comparison of Benefits and Costs (millions of dollars)



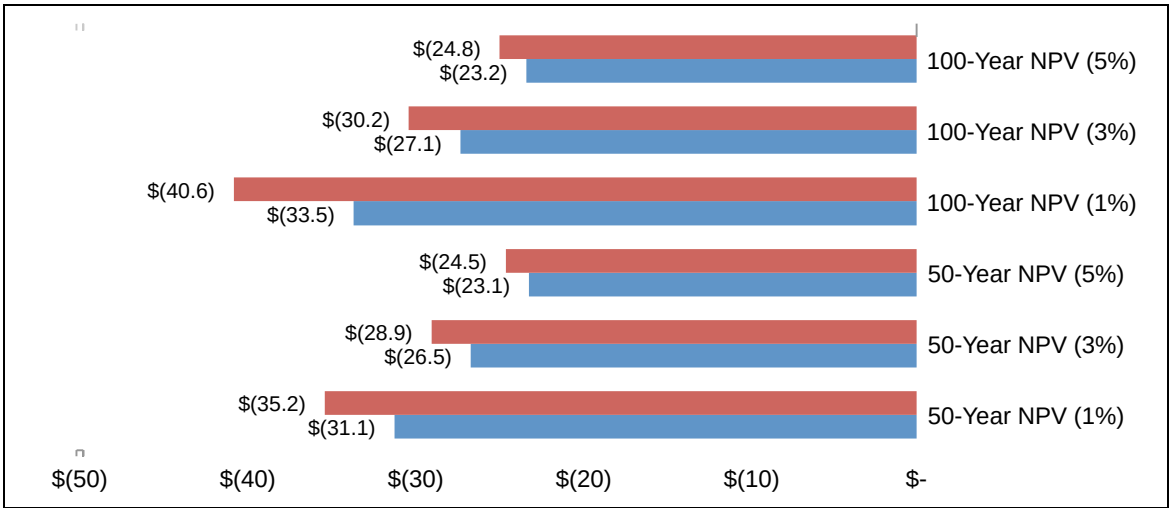
Source: Econorthwest staff estimates.

Notes: In this figure, the benefit values represented by the purple and green bars are equal to the midpoint of the range of benefit values presented in Table 18. Benefits are shown as positive, and costs are shown as negative. In calculating the overall net value, we take the positive value of the benefits under the Development Scenario minus the positive value of forgone benefits under the Baseline Scenario minus the positive value of mitigation costs under the Development Scenario.

2. Sensitivity of Results to Discounting and Time Horizon

Figure 4 summarizes our sensitivity analysis of the results with respect to the discount rate and the time horizon of our analysis. The figure uses the range of benefits under the Baseline Scenario, the range of benefits under the Development Scenario (with mitigation), and the costs of mitigation to show how the time period and discount rates influence the net results. Each bar shows the overall net value under the Development Scenario (equal to the benefits under the Development Scenario minus the benefits under the Baseline Scenario minus Costs). The red and blue bars represent the full range of the net value. As the figure shows, the overall net value under the Development Scenario becomes increasingly negative as the number of years in the analysis increase and as the applied discount rate decreases. In other words, the NPV of the overall net value under the Baseline Scenario, assuming a 50-year analysis period with a 5 percent discount rate, is less negative than the NPV assuming a 100-year analysis period with a 1 percent discount rate.

Figure 4. Sensitivity Analysis – Discounting and Time Horizon (millions of dollars)

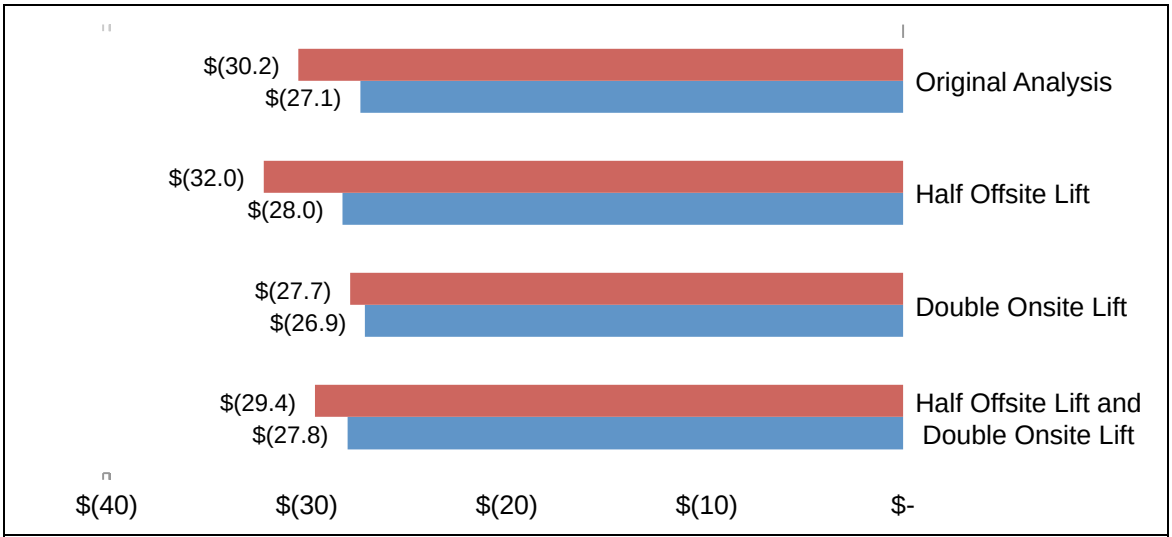


Source: ECONorthwest staff estimates.

3. Sensitivity of Results to Onsite and Offsite Lift from Mitigation

Figure 5 summarizes our sensitivity analysis of the results with respect to the potential lift in ecosystem services and wildlife from mitigation on WHI and elsewhere. The first set of bars represents the 100-year NPV of the net value of benefits minus costs under the Development Scenario with the original set of assumptions regarding lift from mitigation (a net loss of $27.1–$30.2 million). The second set of bars represents the 100-year NPV assuming offsite mitigation provides only 50 percent lift, rather than the 100 percent assumed in the original analysis..

Figure 5. Sensitivity Analysis – Potential Lift from Mitigation (millions of dollars)



Source: ECONorthwest staff estimates.
Notes: The red bars represent one end of the range and the blue bars represent the other end of the range.

This assumption decreases the net value even further (to a net loss of $28.0–$32.0 million) because it generates fewer benefits from offsite mitigation under the Development Scenario for the same costs. The third set of bars represents the 100-year NPV assuming onsite mitigation provides twice the potential lift assumed in the original analysis. This assumption increases the net value (to a net loss of $26.9–$27.7 million) because it generates more benefits from onsite mitigation under the Development Scenario for the same costs. The fourth set of bars represents the 100-year NPV assuming changes in potential lift from mitigation both onsite and offsite. The combined effect of changing these assumptions increases the net value relative to the original analysis (to a net loss of $27.8–$29.4 million). Overall, there appears to be little sensitivity in the results of our analysis with regards to the potential ecosystem service and wildlife lift from onsite and offsite mitigation. The primary reasons for this lack of sensitivity include: (1) the large impact of mitigation costs on the net value, and (2) the slow accumulation of benefits from mitigation, over time, and the impact of discounting future values from those future benefits

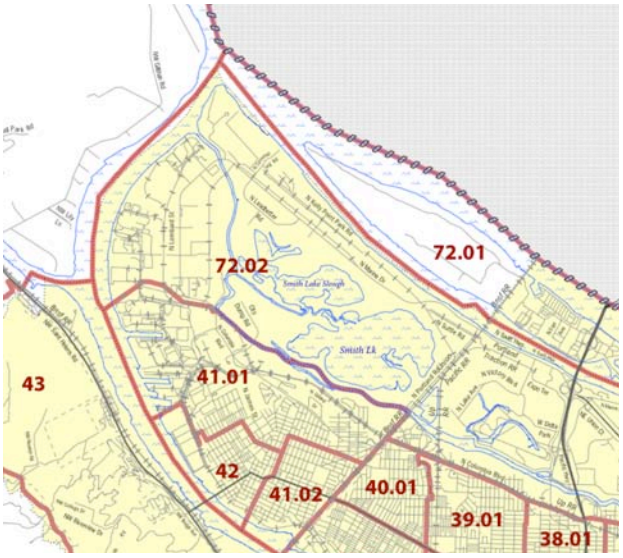
Recreation

I. Introduction

In this section we consider the likely change in recreation-related costs and benefits that would occur as a result of the Development Scenario. The actual recreation opportunities and implementation of recreation-related efforts are not fully defined, and therefore readers should consider our analysis as preliminary. It provides a rough estimate of potential and likely future outcomes as we currently understand them.

An important part of our analysis is considering where potential users of new recreational resources on West Hayden Island (WHI) would come from. We assume most users would live not far from WHI. As we discuss later, parking at WHI will be limited, and there are numerous other recreation options in and around Portland that likely are closer to other houeholds. For that reason, the geographic scope of our analysis includes the two Census Tracts[1] shown in Figure 1. Census Tract 72.01 includes all of Hayden Island. Census Tract 72.02 includes the entirety of the area adjacent to Hayden Island, on the South bank of the Columbia River.

Figure 1. WHI Study Area



We conduct our analysis in three steps. In the first step, we describe the Baseline Scenario for our analysis, which represents the supply of and demand for recreation in and around WHI, now and in the future, without the project. In describing the supply of and demand for recreation under the Baseline Scenario, we discuss public and private recreation facilities, in and around Portland, that provide recreation opportunities similar to, but not necessarily exactly the same as those potentially offered on WHI. In the second step, we describe the supply of and demand for recreation under the Development Scenario. In the third step, we compare the costs, benefits, and economic impacts associated with recreation on WHI under the Baseline Scenario and the Development Scenario.

II. Baseline Scenario

In this section, we describe the recreational opportunities on WHI and factors that may affect recreation on this part of Hayden Island under the Baseline Scenario. Our

[1] A Census Tract is a population region as designated by the U.S. Census for demographic data collection and reporting.

description has two main parts. First, we describe the existing supply of recreational opportunities on WHI and on East Hayden Island (EHI). Given that other, similar recreation sites exist in the Portland area, and these sites compete for users with sites on Hayden Island, we also describe the supply of other similar recreation sites in the Portland area. Second, we describe the demand for recreation in these areas. Comparing supply and demand gives us a context within which to consider the likely future demand for sites on WHI.

A. Baseline Scenario: Supply of Recreation

In this section, we describe the supply of recreation on Hayden Island, and in the Portland area under the Baseline Scenario. Due to access restrictions, supply of recreation on WHI is limited. The rest of Hayden Island offers many water-based recreation opportunities, and the Portland area, as a whole, has many parks that offer various recreational opportunities.

1. Baseline Supply of Recreation on WHI

Currently, fences and signage along the east end of WHI restrict access to the western part of Hayden Island. In spite of the restricted access to WHI by road, recreation does happen on WHI. Boaters in kayaks, canoes, and other non-motorized and motorized boats can put ashore on WHI's beaches and walk the shoreline below the high-water line. People can also access the beaches of WHI by walking along the shoreline from EHI.

2. Supply of Recreation on East Hayden Island (EHI)

Currently there are three main sources of outdoor recreation on Hayden Island:

- **Marinas**. The marinas on EHI provide over 3,600 slips for motorized and non-motorized boats.[2]
- **Lotus Isle Park.** The park lies between two houseboat communities on the south bank of EHI. The 1.7-acre park provides paved paths, picnic tables, and playground equipment. [3]
- **Private Walkways**. The private walkways on EHI do not connect to a broader trail system or to public roads. The *Hayden Island Plan* recommends extending these trails and connecting them to a public system of trails with access to viewpoints along the Columbia River and the Cascades.[4]

In addition to these existing sources of recreation, the *Hayden Island Plan* suggests that a new park may be developed, west of I-5, along the Columbia River. The park would provide access to the river for viewing, swimming, and boating.[5]

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[2] Entrix. 2010. *Recreation Participation, Development Potential, and Current Value on and Around West Hayden Island*. June.

[3] Portland Parks and Recreation. 2011. *Lotus Isle Park*. Retrieved on January 11, 2012 from http://www.portlandonline.com/parks/finder/

[4] City of Portland, Bureau of Planning and Sustainability. 2009. *Hayden Island Plan*. January.

[5] City of Portland, Bureau of Planning and Sustainability. 2009. *Hayden Island Plan*. January.

3. Baseline Supply of Recreation in the Portland Area

There are many parks and other public spaces near WHI and across the Portland Metro area that provide comparable types of recreation opportunities that could potentially exist on WHI. Table 1 summarizes the supply of recreation in the Portland Metro region, as identified in a 2003 inventory.

Table 1. 2003 Park Inventory in Portland METRO

	Number of Parks	Park Acreage
Parks with Public Access	1,106	31,955
With Playground	333	6,025
With Restroom	272	17,940
With Wildlife Viewing	425	28,091
With Interpretive Signage	28	4,710
With Nature Education	57	14,034
With Picnicking	367	15,509
With Camping	8	4,588
With Fishing	61	13,974
With Trails	395	27,178
With Horse Trails	7	3,708
With Boat Launch	32	5,275
With Paddling	26	10,705
With Swim Beach	22	7,648
With Swimming Pool	40	441
With Wading Pool	42	595
With Water Play	16	276
With Baseball	64	1,389
With Softball	124	3,807
With Football	20	490
With Soccer	126	2,322
With Basketball	167	2,137
With Tennis	109	1,983
With Track	7	93
With Volleyball	50	2,750
With Horseshoes	36	981

Source: Woodbury, Max, Metro-Data Resource Center. January 10, 2012. Personal Communication with ECONorthwest.

B. Baseline Scenario: Demand for Recreation

In this section, we describe the baseline demand for recreation on Hayden Island, and in the Portland area. Oregon's demand for recreation has been documented by state-wide surveys, and recreation patterns on specific parks have also been documented, shedding light on specific types of demand in the Portland area.

1. Baseline Demand for Recreation on WHI

The *2010 Entrix Report* includes information on the potential demand for recreation under the Baseline Scenario for WHI as described in our analysis. According to this report, approximately 250–1,000 people would visit beaches on WHI each year (10–40 people per week from May to October). We believe the *2010 Entrix Report's* results are a good starting place for our analysis. We therefore assume that, under the Baseline Scenario, recreation on WHI would range from 250 to 1,000 recreation days per year.

2. Baseline Demand for Recreation on EHI

The *Hayden Island Plan* states that the residents living on EHI desire "access to the river for viewing, swimming, and boating."[6] With access to WHI restricted, this demand likely will require additional recreation development on the east end of the island. Demand for the island's marinas is high with occupancy rates for these slips at 100 percent from April to October (occupancy falls to 25–30% from November to March).[7]

One way in which recreation opportunities supplied on Hayden Island (EHI and potentially WHI) differ from opportunities elsewhere in Portland is the proximity to water access. For example, based on results of a 2008 survey of users of boat ramps, launch sites, and marinas in Multnomah County, users of these sites recorded approximately 165,500 user days at 22 sites throughout the County (see Table 2). Specific to our analysis, five of the sites were on Hayden Island and had approximately 51,400 use days that year. Based on these results, users of sites on Hayden Island accounted for approximately 26 percent of the total users of these types of sites in the County.

Table 2. Use of Boat Ramps, Launch Sites, and Marinas in Multnomah County

Ramp, Launch Site, Marina (origin)	Use Days	On Hayden Island
Chinook Landing Marine Park (Fairview)	48,260	
Gleason Ramp (M. James Gleason)(42nd Street)	21,404	
Tomahawk Bay Moorage	19,916	X
Coverts Landing (The Fishery)	18,727	
Hayden Bay Moorage	17,966	X
Cathedral Park	10,225	
McCuddys Marina (Marine Drive)	8,328	X
Rooster Rock State Park	5,613	
Sundance Marina	4,553	X
Freds Marina	2,631	
Swan Island Ramp	2,360	
Dalton Point	944	
Sauvies Island Ramp	923	
Willamette Park	850	
Harbor 1 Marina	699	
Jantzen Beach Moorage/Fuel Dock	626	X
Rocky Pointe Marina	455	
Lewis & Clark State Park	423	

[6] City of Portland, Bureau of Planning and Sustainability. 2009. *Hayden Island Plan*. January. Pg. 9.

[7] Entrix. 2010. *Recreation Participation, Development Potential, and Current Value on and Around West Hayden Island*. June.

Donaldson Marina	209	
Parkers Marina	184	
Scappoose Moorage	152	
Bartlett Landing	73	
Total	**165,521**	**51,389**

Source: Woodbury, Max, Metro-Data Resource Center. January 10, 2012. Personal communication with ECONorthwest.

3. Demand for Recreation in the Portland Area

The demand for recreation in the larger Portland area provides a context for our analysis of potential demand for recreation on WHI. Table 3 includes information on recreation demand in the Portland area as identified by a 2003 survey conducted by the Oregon Parks and Recreation Department. The data represent recreation demand for individuals living in Oregon's Region 2, which includes parts of Multnomah, Columbia, Washington, Yamhill, Polk, Benton, Linn, Marion, and Clackamas Counties.

Table 3. Demand for Recreation by Oregonians in the Study Area

Recreation Category	Average Number of Trips per Household (per year)	Participation Rate
Trail and Off-trail Activities (hiking, backpacking, mountain biking, cross-country skiing, orienteering, horseback riding)	25	50.5%
Road or Street Activities (running or walking for exercise, walking for pleasure, in-line skating, or skateboarding)	136	82.8%
Fishing, Crabbing, and Clamming Activities	19	30.2%
Boating Activities (canoeing, kayaking, rafting, power boating, sailing, water skiing, windsurfing)	14	19.2%
Swimming and Beach Activities (snorkeling, scuba diving, sitting at the beach)	19	42.9%
Nature Study Activities (bird watching, wildlife observation, outdoor photography)	78	38.7%
Picnicking and Sightseeing Activities	21	60.3%

Source: Oregon Parks and Recreation Department. 2003. *2003–2007 Oregon Statewide Comprehensive Outdoor Recreation Plan*. January.

Comparing survey data in Table 3 from 2003 with results from a previous survey conducted in 1987, indicates that recreation preferences have changed over time. To the extent that changing preferences indicate increased demand for the types of recreation that would be available on WHI, it supports a conclusion of demand at WHI. A declining demand would indicate the opposite result. Some of the most relevant patterns from the survey as they relate to our analysis include:

- Increasing participation rates for nature/wildlife observation (254%), using playground equipment (114%), fishing from a boat (97%), and hiking (21%).
- Stable participation rates for picnicking.
- Decreasing participation rates for sailing (-55%) and beach activities (-65%).[8]

[8] Oregon Parks and Recreation Department. 2003. *2003–2007 Oregon Statewide Comprehensive Outdoor Recreation Plan*. January.

We can estimate the number of days Portlanders spend participating in recreation activities by aligning population data from the U.S. Census with the recreation data in Table 3. We summarize these results in Table 4. For example, individuals living in Census Tract 72.01 (Hayden Island) participate in about 236,700 recreation user days[9] per year and individuals living in Census Tract 72.02 (adjacent to Hayden Island, south of the Columbia River) participate in about 213,200. Individuals living in the rest of Portland participate in about 45.5 million recreation user days per year.

Table 4. Annual Recreation Days by Residents in Three Areas

Type of Recreation	Census Tract 72.01	Census Tract 72.02	Rest of Portland
Trail and Off-trail Activities	16,354	14,731	3,144,463
Fishing, Crabbing, and Clamming Activities	7,507	6,762	1,443,413
Boating Activities	3,471	3,126	667,297
Swimming and Beach Activities	10,520	9,477	2,022,837
Nature Study Activities	38,707	34,867	7,442,501
Picnicking and Sightseeing Activities	16,210	14,601	3,116,720
Total	**236,683**	**213,199**	**45,508,313**

Source: ECONorthwest staff estimates with data from U.S. Census Bureau and Oregon Parks and Recreation Department. 2003. *2003–2007 Oregon Statewide Comprehensive Outdoor Recreation Plan*. January.

As described above, there are many opportunities for water-based recreation on Hayden Island. Table 5 summarizes boating activities in the Columbia and Willamette Rivers as reported in a 2007 survey. To the extent that Portlanders participate in water-based recreation more than other individuals in the region, the summary presented in Table 4 may under-represent the total number of recreation days on Hayden Island and in the rest of Portland.

Table 5. Boating on the Columbia River, the Willamette River, and by Multnomah County Residents in 2007

	Columbia River	Willamette River	Multnomah County Residents
Boat Use Days	524,091	281,176	305,716
Trips	433,248	244,391	262,417
Activity Days	515,236	307,673	302,754
Fishing	273,686	139,531	140,084
Sailing	41,044	1,362	18,700
Personal Watercraft	18,051	26,340	10,655
Waterskiing	32,383	58,512	34,145
Cruising	150,072	81,929	98,989

Source: Oregon Statewide Marine Board. 2009. Boating in Oregon: Triennial Survey Results - 2008.

Notes: **Boat Use Day** – any portion of a 24-hour period in which participant is engaged in boating activities. **Activity Day** – one individual participating in one recreation activity during any reasonable portion or all of one day. **Trip** –

[9] Each occurrence of a recreation activity is counted separately, although only the primary activity for a day is counted. Activities do not need to occur for a full day to be included.

Each time an individual left their residence to go boating.

The *2008–2012 Oregon Statewide Comprehensive Outdoor Recreation Plan* (SCORP) focused on four issues influencing current and future recreation patterns in the state. In Table 6 we identify these issues, summarize some of the SCORP's findings, and list its recommendations. The SCORP's findings shed light on trends and issues associated with recreation around Portland.

Table 6. Oregon SCORP Issues, Summary, and Recommendations

Issue	**Oregon's population is aging rapidly.**
Summary	• By 2030, nearly 20 percent of the state's population will be over 65 years old. • More than half of all Boomers walk (80%), picnic (68%), sightsee (63%), visit historical sites (62%), participate in ocean beach activities (54%), and day hike (52%). • Boomer activity would increase with more trails/parks close to home.
Planning Recs	• Develop a statewide marketing plan to encourage Boomer outdoor recreation participation. • Facilitate the development of local senior walking clubs. • Develop accessible trails in remote settings in close proximity to urban areas.
Issue	**Outdoor recreation (such as camping, fishing, and hunting) is decreasing in popularity among Oregon's youth.**
Summary	• Oregon youth have increased the amount of time they spend watching TV, playing video games, and browsing the Internet. • 10 percent of K–12 students participate in after-school programs while 23 percent of those not participating show interest.
Planning Recs	• Develop a menu of after-school programs linked to education standards that address key objectives of the statewide youth outdoor programming framework. • Provide funding and assistance for innovative park designs to connect youth with nature.
Issue	**Oregon's population is becoming increasingly diverse.**
Summary	• By 2020, about 22 percent of the state's population will be Hispanic, Asian, or African-American. • Hispanic and Asian groups prefer recreation in parks (near home and out of town) over recreation in their yards.
Planning Recs	• Develop group-day use facilities, recreational trails, outdoor sports fields, and close-to-home camping opportunities. • Develop and implement a regional youth framework to encourage under-represented youth participation in outdoor recreation
Issue	**Oregon's population is following national trends of decreasing physical activity, and increasing obesity.**
Summary	• 44 percent of Oregonians are overweight and 20 percent are obese. • Oregonians living in the Portland area are increasing their physical activity.
Planning Recs	• Support close-to-home non-motorized trail development. • Target at-risk people and communities.

Source: ECONorthwest staff estimates with data from Oregon Parks and Recreation Department. 2008. *The 2008-2012 Oregon Statewide Comprehensive Outdoor Recreation Plan*. February.

III. Development Scenario

The Development Scenario would change the supply of recreation available on WHI. It would not change the supply of recreation available on EHI or in the Portland Area relative to the Baseline Scenario. Changes in the supply of recreation likely will change the ways in which demand for recreation are expressed. Here, we assume that as the supply of recreation increases under the Development Scenario, the number of recreation user days on WHI will increase with little impact on recreation elsewhere.

A. Development Scenario: Supply of Recreation

Our analysis assumes that the only difference between the supply of recreation under the Baseline Scenario and the supply under the Development Scenario is the change in supply offered by new recreation opportunities on WHI. These recreation opportunities include:

- Approximately two miles of trails along the south side of the development, and up through the center of WHI to the beach on the north side.
- Improved beach access on the north side of WHI.
- A new non-motorized boat launch with an adjacent small parking lot and public restroom.

B. Development Scenario: Demand for Recreation

Our analysis assumes that recreation preferences do not differ between the Baseline Scenario and the Development Scenario. The only differences in demand between the two scenarios come from how demand is expressed. In other words, individuals that would rather jog than swim in a river will continue to prefer jogging. A change in the supply of recreation, however, likely will influence how individuals choose to participate in recreation activities.

Many parks in the Portland area offer recreation opportunities similar to those proposed as part of the Development Scenario for WHI. The information on recreation demand or use at these sites can provide insights into the potential demand for a similar site on WHI. The sites we studied are Smith and Bybee Wetlands Natural Area and Kelley Point Park (both of which are on the south side of the Columbia River, near WHI), public beaches on Sauvie Island (downstream of WHI on the Columbia River), as well as Willamette Park and Sellwood Riverfront Park (both of which are along the Willamette River in South Portland). Of these five areas, Willamette Park and Sellwood Riverfront Park were the only two with extensive user data we could apply to WHI. These two sites offer similar activities to what could be available on WHI, however, they have slightly better access and are closer to a larger population base then sites on WHI would be. For these reasons, we used data on recreation use at these sites as an upper bound on the potential recreation activity on WHI.

- **Smith and Bybee WNA** covers nearly 2,000 acres between the Columbia Slough and the Columbia River and provides restrooms, wildlife watching, interpretive signage, nature education, fishing, trails, and paddling.[10] While Smith and Bybee

[10] Metro. 2003. Parks Inventory.

does not provide access to the Columbia River, it does provide access to two large lakes that offer recreation opportunities similar to those the river provides, and in very close proximity.

- **Kelley Point Park** covers about 100 acres at the confluence of the Columbia River and Willamette River. The park provides restrooms, wildlife watching, nature education, picnicking, trails, beach access, and a boat ramp.[11]
- **Sauvie Island Wildlife Area** (SIWA) covers about 11,500 acres and is the most popular wildlife area in Oregon.[12] In 2009, there were an estimated 989,361 recreation days spent at SIWA with about 55 percent of recreation days spent on the beach. SIWA provides about 112 acres of beach to the public. Some of these beaches are easily accessible by car, foot, and boat and offer ample parking. Other beaches are more remote and are only accessible by long foot paths or by boat.[13]
- **Sellwood Riverfront Park** covers about 7.6 acres in Southeast Portland along the Willamette River. The park provides a boat dock, canoe launch, off-leash dog area, paved and unpaved paths, and picnic tables.[14]
- **Willamette Park** covers about 30 acres in Southwest Portland along the Willamette River. The park provides playground equipment, restrooms, picnicking, trails, a boat launch, softball, soccer, and tennis.[15]

In the summer of 2004, the Oregon Parks and Recreation Department conducted user surveys in several parks along the Willamette River. Table 7 summarizes the results of the surveys collected in Sellwood Riverfront Park and Willamette Park. To date, there have not been any comprehensive surveys describing user activity at Smith and Bybee WNA or Kelley Point Park (we discuss recreation at SIWA later in this section). The first column lists a series of recreation types. The second and third columns show the number of recreation days associated with each recreation type (June-September) as suggested by survey results. The fourth column in the table identifies how well each recreation category translates to recreation available on WHI. The fifth column shows the estimated annual number of recreation days on WHI under the Development Scenario. We calculated this amount by multiplying the largest number from the second and third columns by the percentages in the fourth column. We assume that summer recreation levels in Sellwood Riverfront and Willamette Parks are representative of the potential full-year recreation levels on WHI, because it is likely that these activities would be much less common on WHI during colder months.[16]

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[11] Metro. 2003. Parks Inventory.

[12] Oregon Department of Fish and Wildlife. 2012. *Sauvie Island Wildlife Area Management Plan*. April.

[13] Oregon Department of Fish and Wildlife. 2012. *Sauvie Island Wildlife Area Management Plan*. April.

[14] Metro. 2003. Parks Inventory.

[15] Metro. 2003. Parks Inventory.

[16] Given data limitations, our analysis relied on user information for Sellwood Riverfront and Willamette Park. Our analysis took into account the differences in intensity of use between these parks and the likely future use of park areas on WHI.

As shown in Table 7, there were about 13,700 recreation days in Sellwood Riverfront Park during the summer of 2004 and about 13,500 in Willamette Park. Many of the recreation opportunities available in those parks, however, will not be available on WHI under the Development Scenario. For example, dogs will not be allowed on WHI, so we exclude those days. There will be no playground equipment for children, no large mowed fields for frisbee, and no paved trails for biking or rollerblading, so we exclude those days as well. Without paved trails, we assume the other parks overstate WHI's potential for running and jogging, so we include only 50 percent of those days. Furthermore, WHI will not have any formal picnic areas, so we include only 50 percent of picnic days. The boat launch will not have the capacity to handle large motorized and non-motorized boats, so we include 5 percent of the boaters Willamette Park attracts. The rest of the recreation categories match up well between the parks, so we assume WHI potentially, at an upper bound, attracts the same number of users. In total, our analysis assumes WHI would attract about 8,300 recreation days, per year, under the Development Scenario.

Table 7. Estimated Recreation Demand on WHI Under the Development Scenario

Recreation Category	Sellwood Riverfront Park (Summer Only)	Willamette Park (Summer Only)	Potential on WHI	Recreation Days on WHI (All Year)
Dock, drift boating, jet skiing, motorboating, sailing	471	10,117	5%	506
Walking with dog	2,642	71	0%	0
Kids, frisbee	262	0	0%	0
Biking, rollerblading	1,465	200	0%	0
Running	26	82	50%	41
Jogging	131	188	50%	94
Walking, path	2,982	870	100%	2,982
Swimming	262	0	100%	262
Canoeing, Kayaking	523	259	100%	523
Fishing	471	0	100%	471
Picnicking	1,936	1,304	50%	968
Scenery, photography	2,067	223	100%	2,067
Reading, relaxing, tanning	419	141	100%	419
Total	**13,656**	**13,454**	**N/A**	**8,332**
Total (Daily Average)	**150**	**147**	**N/A**	**23**

Source: ECONorthwest staff estimates with data from Oregon Parks and Recreation Department. 2004. *Willamette River and Greenway Survey.*

Notes: Data for Sellwood Riverfront and Willamette Parks represent summer recreation days. We assume those numbers could represent annual recreation demand on WHI. Due to its remote location, we anticipate recreation on WHI during non-summer months will be low.

The WHI Concept Plan suggests that there would be one or two parking lots on WHI under the Development Scenario offering a total of up to 20 parking spots. Individuals could also walk or ride their bicycles to WHI, or boat to the beach. The amount of available parking likely would limit the number of people traveling to WHI, especially on weekends during summer months. Assuming that half the annual recreation days

spent on WHI (as shown in Table 8) occur on summer weekends, there would be about 315 users per weekend. If all those users come by car, and each car brings an average of three people, there would be about 105 cars looking for parking on WHI each weekend during the summer. Given that each car likely would stay on WHI for only a few hours, and that some individuals would walk, bike, or boat to WHI, available parking likely would accommodate the projected volume of recreation activity.

As stated above, SIWA attracted nearly one million recreation days in 2009. Some of the recreation opportunities SIWA provides would not be available on WHI (e.g., hunting, trapping, dog training, trap shooting). Other recreation opportunities are more comparable (e.g., wildlife viewing, hiking, beach use). Here, we focus on beach use at SIWA, and how it relates to potential beach use on WHI under the Development Scenario. SIWA attracts about 600,000 beach-related recreation days per year on about 112 acres of beach.[17] There are a number of reasons that WHI, under the Development Scenario, likely will not attract nearly as much recreation:

- SIWA provides 112 acres of beach area. As described in the Concept Plan, WHI would provide about four acres of beach area above the ordinary high water mark and about 40 acres of beach area below the ordinary high water mark under the Development Scenario. With less beach area, WHI likely would attract fewer beach-goers than SIWA.
- SIWA provides ample on-street parking as well as 44 designated off-street parking areas, each providing a range of individual parking spots. Under the Development Scenario, parking on WHI would be limited (up to 20 individual parking spots). With fewer parking options, fewer individuals can participate in recreation activities on WHI than at SIWA at any given time.
- Parking options at SIWA provide easy access to beach areas for individuals coming by car. Under the Development Scenario, parking areas on WHI would be on the far east end, not necessarily near any beach areas (some beach areas would be over one mile away).
- While many individuals live closer to WHI than they do to SIWA, they may still prefer to go to beaches on SIWA for a number of reasons including: scenery, other amenities (e.g., farm stands, picnic tables), the larger size, and past experiences.

Given the characteristics of recreation on SIWA (as listed above), we did not use it as a comparator site for WHI under the Development Scenario. Rather, we used Sellwood Riverfront Park and Willamette Park (see Table 7). Not only do these parks align well with WHI, they also provide extensive survey data describing the demand for recreation in public parks with water access in Portland.

IV. Benefits

In this section, we describe the benefits associated with recreation activities on WHI under the Baseline Scenario and the Development Scenario. We distinguish between two types of benefits: (1) the consumer surplus—or economic value—derived from participating in recreation activities on WHI, and (2) jobs and incomes associated with

[17] Oregon Department of Fish and Wildlife. 2012. *Sauvie Island Wildlife Area Management Plan*. April.

recreation-related construction and management and maintenance activities under the Development Scenario.

A. The Value of Recreation on WHI

One component of a good's total economic value is its consumer surplus value. In general, individuals that purchase a good or service are typically willing to pay more for the item than the market price. The difference between the amount these buyers would be willing to pay and the item's market price is the consumer surplus the buyer derives from the exchange. Consumer surplus is relevant to our analysis because it can describe changes in economic well-being. For example, if someone pays an amount to enjoy fishing, boating, or some other activity that they value at more than they paid, then he or she is economically better off. Recreation activities in particular tend to have low per-use costs, so after initial equipment investments, marginal costs are typically very low and potential consumer surplus can be most of the economic value for the recreational use.

No data exist that directly describe consumer surplus specific to recreation on WHI. Data do exist, however, that describe comparable recreational activities in areas like WHI. For example, staff from the U.S. Forest Service estimated the range of potential consumer surplus values associated with different types of recreation on National Forest and other public lands in 2005. In Table 8 we summarize the average consumer surplus values for different types of recreation in Oregon and Washington, and a range of consumer surplus values reported for different types for recreation along the Pacific Coast. In the last column, we summarize the range of consumer surplus values we apply in our analysis.

Table 8. Consumer Surplus Values by Recreation Type

Recreation Type	Oregon / Washington (average)	Pacific Coast (range)	Values Applied (range)
Fishing	$50	$5–$124	$5–$50
Hiking	$29	$1–$155	$1–$29
Flatboating, rafting, canoeing	-	$30–$35	$30–$35
Picnicking	$42	$18–$171	$18–$42
Swimming	$7	$7–$71	$7
Wildlife viewing	$42	$8–$417	$8–$42
General Recreation	$34	$12–$162	$12–$33

Source: Loomis, J. 2005. *Updated Outdoor Recreation Use Values on National Forests and Other Public Lands*. General Technical Report PNW-GTR-658.
Notes: The consumer surplus value associated with general recreation is the average value of all other recreation types.

The values in Table 8 represent consumer surplus in terms of dollars per person per recreation day. For example, consumer surplus value for fishing on National Forest and other public lands ranges from about $5 to $124 per recreation day in Pacific Coast states, with an average value of $50 in Oregon and Washington. National Forests and other public lands often offer high-quality recreation opportunities not found in more urban settings. In general, the consumer surplus value associated with high-quality recreation opportunities is higher than the value associated with lower-quality recreation opportunities. Since recreation available on National Forest and other public lands likely is of higher quality than the potential recreation available on WHI, we

assume that consumer surplus values for recreation on WHI are on the lower end of the range. We use the minimum value of the Pacific Coast range and the average value from Oregon and Washington to create the range of consumer surplus values we apply in our analysis. For example, we assume the consumer surplus value for hiking on WHI ranges from about $1 to $29 per recreation day.

Previously, we estimated the number of recreation days on WHI under the Baseline and Development Scenarios. We estimate the value of recreation on WHI under the two scenarios by multiplying the range of consumer surplus values from the final column in Table 8 by the number of recreation days reported for each scenario. We report the results of this calculation in Table 9. The total consumer surplus value associated with recreation on WHI under the Baseline Scenario ranges from about $2,900–$34,200 per year. Under the Development scenario, the consumer surplus value ranges from about $78,500–$293,500 per year.

Table 9. Annual Recreation Days and Annual Consumer Surplus Value on WHI

	Baseline Scenario		Development Scenario	
Recreation Type	**Recreation Days**	**Consumer Surplus**	**Recreation Days**	**Consumer Surplus**
Fishing	0	$0	471	$2,500–$23,700
Hiking	0	$0	2,982	$1,400–$85,700
Flatboating, rafting, canoeing	0	$0	1,029	$31,100–$36,500
Picnicking	0	$0	968	$17,600–$40,300
Swimming	0	$0	262	$1,900
Wildlife viewing	0	$0	2,067	$17,500–$86,600
General Recreation	250–1,000	$2,900–$34,200	554	$6,500–$18,900
Total	**250–1,000**	**$2,900–$34,200**	**8,332**	**$78,500–$293,500**

Source: ECONorthwest staff estimates with data presented elsewhere in the report.

The values reported in Table 9 are annual values. We assume that the potential recreation sites on WHI would generate these values each year. For example, we assume that the benefits derived under the Baseline Scenario would continue, at their current levels, for the next 100 years. Under the Development Scenario, we assume the baseline levels of recreation will continue until construction begins in 2023. We assume development-level recreation begins in 2028, after construction is completed. To compare the future streams of values under the Baseline and Development Scenarios we convert all future values to a common year. We do this by discounting future values to dollar values in 2011. That is, we calculate a net present value, in 2011 dollars, of future recreation values under each scenario. We do this by discounting future values using a 3-percent discount rate. We summarize the results of this calculation in Table 10.

Table 10. NPV of Consumer Surplus from Recreation

Recreation Type	Baseline Scenario	Development Scenario	Difference
Fishing	$0	$49,100–$465,500	$49,100–$465,500
Hiking	$0	$28,100–$1,684,000	$28,100–$1,684,000

Flatboating, rafting, canoeing	$0	$610,900–$716,700	$610,900–$716,700
Picnicking	$0	$346,200–$791,800	$346,200–$791,800
Swimming	$0	$37,300	$37,300
Wildlife viewing	$0	$345,000–$1,700,200	$345,000–$1,700,200
General Recreation	$92,100–$1,080,700	$151,700–$664,000	$59,700–($416,600)
Total	**$0.1–$1.1 million**	**$1.6–$6.1 million**	**$1.5–$5.0 million**

Source: ECONorthwest staff estimates with data presented elsewhere in the report.

Note: The change general recreation is shown as potentially negative. Data are insufficient to distribute recreation demand across recreation activities under the Baseline Scenario, so we lump estimated activities into the general recreation category. By lumping recreation like this, our analysis likely understates recreation in other categories and overstates general recreation under the Baseline Scenario. The effect of these assumptions on the total NPV under each scenario likely is small.

B. Jobs and Incomes Associated with Recreation Construction and Management

In addition to the consumer surplus value derived from recreation, the Development Scenario would produce benefits in the form of jobs and incomes associated with spending on construction and management. To estimate the number of jobs and the value of incomes associated with recreation on WHI under the Development Scenario, we rely on a number of assumptions about the costs of developing the recreational resources and managing them once developed. We split our discussion of jobs and incomes into two categories: (1) direct impacts refer to jobs and incomes directly tied to project-related spending (e.g., a laborer that is hired to build the trail), and (2) indirect impacts refer to jobs and incomes associated with spending from individuals directly employed by the project (e.g., a cook at the diner construction workers go for lunch). Depending on a number of factors these jobs and incomes may be net of the background economy without the project or they may be substitutes for other opportunities. Table 11 summarizes our results

Table 11. Jobs (Employment Years) and Incomes from Recreation Construction and Management on WHI

Construction Efforts (One Year)		
Construction Costs	**Cost**	**% in County**
Contracted Work: Equipment Intensive	$300,000–$900,000	100%
Contracted Work: Labor Intensive	$330,000–$990,000	100%
Contracted Work: Technical Services	$131,500–$394,500	100%
In-house Labor Costs	$100,000–$300,000	100%
Materials, Supplies, and Administration	$250,000–$750,000	50%
Total Construction Costs	$1,111,500–$3,334,500	N/A
Construction Jobs and Incomes	**Jobs**	**Incomes**
Total Construction (full and part-time)	**8.9–26.8**	**$0.6–$1.7 million**
Direct Jobs and Incomes	4.7–14.2	$0.3–$0.9 million
Indirect and Induced Jobs and Incomes	4.2–12.6	$0.3–$0.8 million
Management Efforts (Annual)		
Annual Management Costs	**Cost**	**% in County**
Contracted Work: Equipment Intensive	$0	N/A

Contracted Work: Labor Intensive	$28,000	100%
Contracted Work: Technical Services	$0	N/A
In-house Labor Costs	$14,000	100%
Materials, Supplies, and Administration	$10,000	50%
Total Annual Management Costs	**$52,000**	**N/A**
Annual Management Jobs and Incomes	**Jobs**	**Incomes**
Total Annual Management (full and part-time)	**0.8**	**< 0.1 million**
Direct Jobs and Incomes	0.3	< $0.1 million
Indirect and Induced Jobs and Incomes	0.5	< $0.1 million

Source: ECONorthwest staff estimates with data from Worley Parsons. 2012. *Order of Magnitude Cost Estimate – Draft*. 4 March; Roth, Emily. 2012. Personal Communication with ECONorthwest staff. 7 January.; and University of Oregon, Institute for a Sustainable Environment. *Economic Impacts of Restoration Calculator*.

Note: Communication with staff at Portland Parks and Recreation suggests that annual maintenance costs likely will be incurred by existing staff time and that no new jobs will be created.

We calculate the number of jobs and the value of incomes using an input-output tool, the *Economic Impacts of Restoration Calculator* created by the Ecosystem Workforce Program, part of the University of Oregon's Institute for a Sustainable Environment. We summarize our results in Table 11. Based on our analysis, construction efforts associated with recreation on WHI could potentially support approximately 4.7–14.2 direct jobs and 4.2–12.6 indirect jobs associated with incomes totaling $0.6–$1.7 million. These jobs would all occur in one year (the year construction occurs). Some of these jobs may be part time and some may be full time. Management efforts associated with recreation on WHI likely would not support one full-time direct or indirect job, and would generate incomes totaling less than $0.1million. These jobs represent annual employment (beginning the year after construction is completed). These additional management responsibilities likely would be absorbed by existing staff..

V. Costs

Recreation costs have two components: (1) construction costs of recreational assets, and (2) management/operation and maintenance costs. Under the Baseline Scenario, there is no formally administered recreation available on WHI (although use of the shoreline for hiking and boat landings does occur), so we assume no current or future costs.[18] Under the Development Scenario, however, there will be both short-term construction costs and long-term management and maintenance costs, which we discuss in the remainder of this section.

A. Construction Costs

Staff from WorleyParsons estimated the potential construction and capital costs of developing recreation on WHI. We summarize these costs in the top half of Table 12. These costs fall into two broad categories: capital costs and other fees. Capital costs, estimated at about $1.1–$3.3 million, include construction of the trails, parking lot, and other amenities and features in the area. Other fees, estimated at about $0.4–$1.3 million, include engineering, design, construction management, and contingency. Assuming

[18] The Port currently incurs some costs associated with individuals trespassing on WHI, and would continue to incur these costs under the Baseline Scenario. Some of these costs may be related to recreation, and some may also be incurred under the Development Scenario. We do not account for these costs in our analysis.

these costs are incurred in 2025 (shortly after construction begins), and a discount rate of 3 percent, the NPV of recreation-related construction costs is about $1.0–$3.1 million.

B. Management and Maintenance Costs

At this point, it is unclear who would take responsibility for managing and maintaining the land and recreational assets under the Development Scenario. As we understand, the most likely option is for Portland Parks and Recreation (PPR) to manage the recreational resources on WHI. Therefore we use PPR-based cost estimates in our analysis. When PPR acquires a new natural area, it submits a budget request to the City Council. In general, PPR applies a per acre management fee for all new natural area acquisitions of $1,800 per acre per year (see the bottom half of Table 12). The final column in Table 12 shows our assumption of the percentage of each activity unit needed from PPR and the associated management fee. We anticipate the total necessary management fee for PPR's management activities on WHI would be about $340 per acre per year.

Table 12. Construction and Management Costs under the Development Scenario

Construction Costs		
Capital Costs	**Low-end (-50%)**	**High-end (+50%)**
Trails	$244,000	$732,000
Trail parking	$2,500	$7,500
Boat launch	$30,000	$90,000
Comfort station	$300,000	$900,000
Perimeter landscaping	$160,000	$480,000
Amenities	$250,000	$750,000
Terminal gate house	$125,000	$375,000
Subtotal	**$1,111,500**	**$3,334,500**
Other Fees	**Low-end (-50%)**	**High-end (+50%)**
Engineering, design, construction management (8%)	$88,900	$266,800
Contingency (30%)	$333,500	$1,000,300
Subtotal	**$422,400**	**$1,267,100**
Total Construction Costs (not discounted)	**$1,533,900**	**$4,601,600**
NPV of Construction Costs	**$1,044,500**	**$3,133,500**

Source: ECONorthwest staff estimates with data from Worley Parsons. 2012. *Order of Magnitude Cost Estimate – Draft*. 4 March.

Management Costs			
Activity Unit	**Description**	**Annual Cost per Acre**	**Annual Cost per Acre on WHI**
Natural Area	Invasive plant removal, revegetation, trail maintenance, litter removal, amenity maintenance, volunteer support, planning, monitoring, public response, intra/inter bureau project support, illegal camping removal	$1,191	$238 (20%)
Equipment	Mowing, material pick-up/drop-off	$118	$12 (10%)
Structures	Sign repair, kiosk repair, bollards repair, lock	$36	$18 (50%)

	replacement		
Urban Forest	Tree pruning, tree removal, log removal or replacement, chip delivery, tree inspection	$118	$12 (10%)
Horticulture	Plants, IPM support	$36	$4 (10%)
Overhead (20%)		$300	$57
Total		**$1,800**	**$340**

Source: Roth, Emily. 2012. Personal Communication with ECONorthwest staff. 7 January.

Notes: Since the beginning of this analysis, PPR's annual management costs have increased by 2.9 percent, from $1,750 to $1,800 per acre. We assume that the increase in costs was evenly distributed across the six cost categories.

Portland Bureau of Planning and Sustainability estimates that there are 800 acres of natural area on WHI.[19] The Proposed Project would take up 283 acres, and mitigation efforts on WHI associated with the Proposed Project would take up 365 acres, leaving 152 acres for PPR or some other entity to manage.[20] Assuming PPR manages these 152, annual costs for natural area management would be approximately $52,000 per year.[21] Once the recreation facilities are constructed, PPR would incur maintenance costs associated with the built assets. PPR estimates annual maintenance costs would be 1.5–1.75 percent of capital costs associated with the recreation asset, or in this case approximately $17,000–$58,000 per year. Assuming PPR begins incurring management and maintenance costs in 2028 (the year after construction is completed), and a discount rate of 3 percent, the NPV of PPR's management and maintenance costs under the development scenario would be approximately $1.3–$2.2 million.

C. Cost Summary

Recreation costs have two components: (1) construction costs of recreational assets, and (2) management and maintenance costs. We assume construction costs, including capital costs and capital-related fees, will be incurred in 2025, soon after development begins. We assume all these costs are incurred in one year. Management and maintenance costs are annual costs, likely incurred by PPR, beginning in 2028, the year after constructions is completed. Table 13 summarizes the annual value and the 100-year NPV of each cost, assuming a 3 percent discount rate. The 100-year NPV of construction-related costs would be about $1.0–$3.1 million and the 100-year NPV of management and maintenance costs would be about $1.3–$2.1 million for a total of about $2.4–$5.3 million

Table 13. Summary of Recreation-Related Costs under the Development Scenario

Cost Category	Unit Value (not discounted)	100-year NPV
Capital costs (one-time cost incurred in 2025)	$1.1–$3.3 million	$0.8–$2.3 million
Other capital-related fees (one-time	$0.4–$1.3 million	$0.3–$0.9 million

[19] This estimate does not include "wet" habitat (i.e. shallow water habitat) that PPR would not actively manage.

[20] Management costs associated with on-site mitigation efforts are included elsewhere in our analysis.

[21] Some of the land included in the 667-acre estimate likely would below the low water mark and would not be subject to these management costs. To the extent that management costs associated with shallow water habitat are less than those for terrestrial land, our estimates in Table 14 may overstate the management costs under the Development Scenario.

cost incurred in 2025)		
Subtotal	$1.5–$4.6 million	$1.0–$3.1 million
PPR management costs (annual cost beginning in 2028)	$51,700 per year	$1.0 million
PPR maintenance costs (annual cost beginning in 2028)	$16,700–$58,400 per year	$0.3–$1.1 million
Subtotal	$0.2–$0.3 million per year	$1.3–$2.1 million
Total Recreation-Related Costs	**N/A**	**$2.4–$5.3 million**

Source: ECONorthwest staff estimates with data from Worley Parsons. 2012. *Order of Magnitude Cost Estimate – Draft*. 4 March; and Roth, Emily. 2012. Personal Communication with ECONorthwest staff. 7 January.

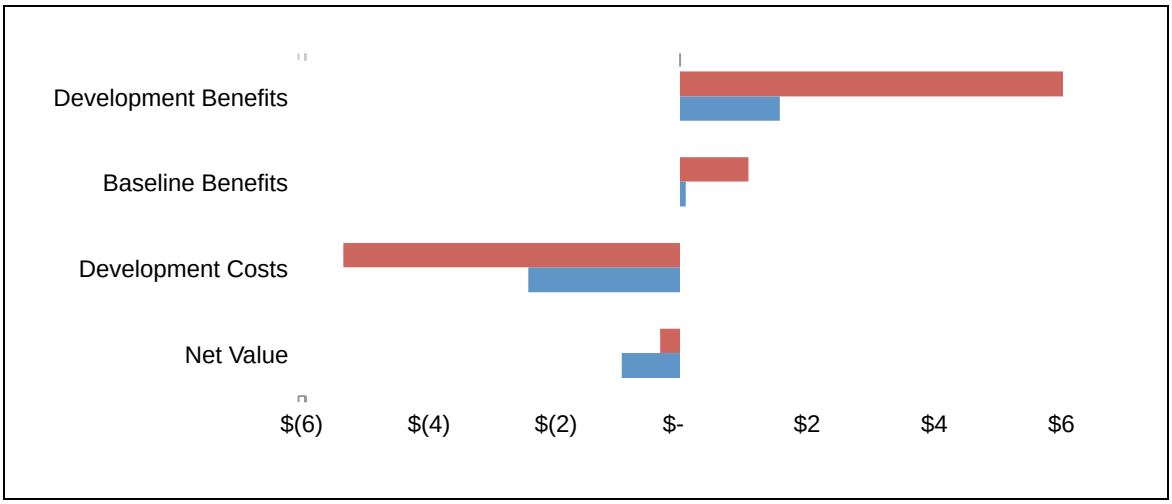
VI. Summary of Costs and Benefits

Overall, the NPV of construction and management costs of recreation on WHI under the Development Scenario is about $2.4–$5.3 million dollars over the next 100 years. The 100-year NPV of benefits derived from recreation on WHI is about $0.1–$1.1 million under the Baseline Scenario and $1.6–$6.1 million under the Development Scenario. Subtracting the costs under the Development Scenario and the forgone benefits under the Baseline Scenario from the range of benefits under the Development Scenario suggests a net loss of about $0.9 million (assuming low-end recreation values and costs) or $0.3 million (assuming high-end recreation values and costs) over the next 100 years. Additional management responsibilities under the Development Scenario likely would fall to existing staff, which would not increase the total number of jobs. There is also the potential for 8.9–26.8 new jobs associated with construction under the Development Scenario (during the year construction takes place).

Figure 2 summarizes these results. The figure shows the range of values associated with each type of benefit and cost under the two scenarios, and the range of the overall net value of benefits minus costs under the Development Scenario. The range of benefits is based on the range of per-day values associated with different types of recreation. The range of costs is based on low and high construction and management costs. To calculate the net value, we assume low-end recreation values and low-end costs (the blue bars) and high-end recreation values and high-end costs (the red bars). The full range of the net value (using high-end costs and low-end recreation values on the one hand, and low-end costs and high-end recreation values on the other) results in a range of about ($0.3)–($0.9) million.

Figure 2. Comparison of Benefits and Costs (millions of dollars)

Development Scenario Benefits	Baseline Scenario Benefits	Development Scenario Costs	Net Value
$1.6–$6.1	$0.01–$1.1	$2.4–$5.3	($0.9)–($0.3)



A. Sensitivity of Results

One way to test the sensitivity of the results it to identify the break-even point, where the 100-year NPV of the benefits under the Development Scenario equal its costs. Table 14 summarizes the results. To summarize, the results show that:

- Assuming low-end recreation values and low-end costs, the Development Scenario would need to generate about 13,259 recreation days per year to break even (about 60 percent more recreation than we assumed in our analysis).
- Assuming high-end recreation values and high-end costs, the Development Scenario would need to generate about 8,788 recreation days per year to break even (about 5 percent more recreation than we assumed in our analysis).
- The full range of recreation days needed to break even is about 4,600–29,000 (assuming high-end recreation value and low-end costs on one hand, and low-end recreation values and high-end costs on the other).

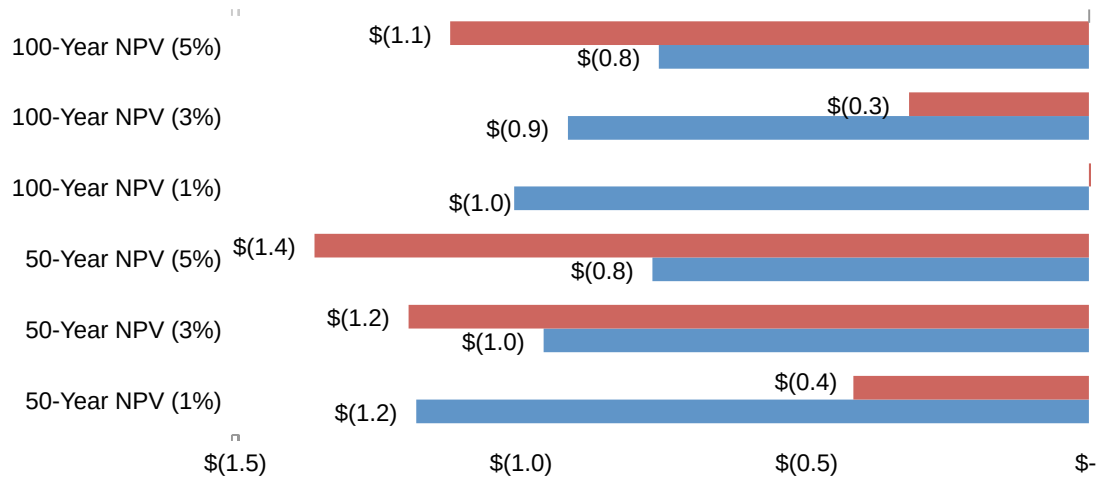
Table 14. Annual Recreation Days Needed to Break Even

Recreation Type	Annual Recreation Days Used in Analysis	Low-End Break-Even Point	High-End Break-Even Point
Fishing	471	749	497
Hiking	2,982	4,746	3,145
Flatboating, rafting, canoeing	1,029	1,638	1,085
Picnicking	968	1,540	1,021
Swimming	262	416	276
Wildlife viewing	2,067	3,289	2,180
General Recreation	554	881	584
Total	**8,332**	**13,259**	**8,788**

Notes: This sensitivity analysis assumes that the distribution of recreation days across different types of recreation remains constant. The low-end break-even point assumes low-end recreation values and low-end costs while the high-end break-even point assumed high-end recreation values and high-end costs. Using the full extent of the range results in a broader range of recreation needed to break even.

Figure 3 summarizes our sensitivity analysis of the results with respect to the discount rate and the time horizon. Each bar in the figure shows the benefits under the Development Scenario minus the benefits under the Baseline Scenario minus costs under the Development Scenario assuming different time horizons and discount rates. These numbers allow comparisons with other potential assumptions for categories of costs and benefits under the Development Scenario. As the figure shows, the net value of the recreation-related benefits under the Development Scenario minus the costs is negative in all instances. The net loss grows as the discount rate decreases (from 5 percent to 1 percent) and as the analysis period increases (from 50 years to 100 years).

Figure 3. Sensitivity Analysis – Discount Rate and Time Horizon (millions of dollars)



Notes: The low estimates (the blue bars) represent low-end recreation values and low-end costs while the high estimates (the red bars) represent high-end recreation values and high-end costs. Using the full extent of the range results in a broader range of net values. Even with the broader range of recreation values and costs, however, the Development Scenario would result in a net loss.

B. Other Objectives for Recreation On WHI

Our analysis assumes residents of Hayden Island and the surrounding area derive most of the recreation benefits, under both scenarios. Table 19 summarizes some demographic characteristics of Hayden Island and the surrounding area. In general, residents living on or near Hayden Island represent some of the SCORP's target communities for recreation-related programs (e.g. low-income populations, older populations, and ethnic and racial minority populations). To the extent that the Development Scenario helps assist the SCORP's objectives, it may provide additional benefits not considered in this analysis.

Table 19. Demographic Characteristics

	City of Portland	Census Tract 72.01 (Hayden Island)	Census Tract 72.02 (Adjacent to Hayden

			Island)
Economic Characteristics			
Percent of population below poverty level	16.3%	17.5%	7.4%
Median household income (2010$)	$48,831	$46,143	$46,184
Age Characteristics			
Population under 18	19%	11%	16%
Population 60 and over	15%	38%	17%
Race and Ethnicity Characteristics			
Racial minority	24%	12%	34%
Hispanic or Latino	9%	7%	12%
Source: ECONorthwest with data from the US Census Bureau.			

Local Effects

I. Introduction

We studied the potential effects of the Development Scenario on the local community of East Hayden Island (EHI) for three reasons. First, residents of EHI have expressed concerns over how the Development Scenario could affect their island community and quality of life.[1] West Hayden Island (WHI) sits in close proximity to EHI, which means residents, workers and business owners in EHI will likely experience the bulk of any significant negative effects of the Development Scenario—to the extent that such effects occur. Second, the experiences of residents of other neighborhoods near port and industrial developments in the Portland area and elsewhere highlight the potential effects of a WHI port on the quality of life in adjacent neighborhoods. These experiences also shed light on measures that could mitigate potential negative effects. Third, the impacts of the Development Scenario on the quality of life in EHI is relevant to our description of the overall distribution of effects of the Development Scenario.

The Development Scenario is the latest in a series of changes that will or have affected life on EHI for residents and businesses. Through community groups such as the Hayden Island Neighborhood Network (HINooN) and the Hayden Island Livability Project (HILT), residents and business owners organize, become informed and express their concerns and comments on a range of developments such as the Columbia River Crossing (CRC) project, the proliferation of video-poker bars, the disposal of dredge material on WHI, and now the proposed port facility on WHI. The eastern edge of the WHI port would sit approximately one-half mile from the western edge of the nearest residential area in EHI.[2] Residents' concerns focus on the close proximity of the development and the potential consequences on their quality of life caused by the construction and operation of a port facility that close to home.

This portion of our analysis focuses on the effects of the Development Scenario on the quality of life (Q of L) in EHI. By quality of life we mean factors such as noise, light pollution, air quality, and traffic concerns. As we explain elsewhere, uncertainty exists regarding the types of development that will take place on WHI and when the development will occur. More information exists about some aspects of the Development Scenario, e.g., the configuration of the rail line, than about other aspects, e.g., what activities will take place on the land set aside for marine-industrial uses and how these activities would affect EHI. These data constraints and uncertainties surrounding the Development Scenario prevent us from quantifying and monetizing the effects on Q of L measures. Instead, we identify the major categories of quality of life concerns (e.g., noise effects), describe the potential effects

[1] Oregon Consensus. 2008. *West Hayden Island Proposed Annexation and Rezoning Assessment Report*. Prepared by Oregon Consensus. November.

[2] As currently depicted by WorleyParsons and Anchor QEA in "Alternative A: West Hayden Island Concept, "January 20, 2010.

as best the available information will allow, and, in some cases, summarize quantified measures of effects from other studies of similar port or industrial developments on local Q of L. We stress that these summaries are *illustrative* and we do not present them as measures for the WHI project.

This portion of our analysis has two parts. In the first part, which is Section II below, we describe the Baseline Scenario for EHI and current Q of L issues. By Baseline Scenario, we mean conditions that exist now and are projected to exist in the near future. This description includes information on trends and developments that will or could affect EHI, but which are unrelated to the WHI port. These developments include the CRC project, and proposed developments on EHI as outline in the Hayden Island Plan.

In the second part, which we describe in Section III below, we describe the potential effects of the WHI port on Q of L under the Development Scenario. In some cases we draw on analyses conducted by City of Portland staff or other consultants specific to the WHI port, e.g., a study of how the Development Scenario could impact traffic on Hayden Island and in surrounding areas. In cases where WHI-specific information was not available, we reviewed the available literature and summarize the literature in the context of WHI. We also conducted a number of key-informant interviews of EHI residents to help us understand the potential effects of the WHI port on Q of L concerns.[3] Our analysis included how the proposed bridge that would connect WHI with Marine Drive could affect the extent to which the Development Scenario would affect the Q of L of EHI residents.

II. Baseline Scenario

Our analysis of the Baseline Scenario of Q of L for EHI has two parts. In the first part, we describe the current conditions in EHI and current Q of L concerns. In the second part, we describe projected future conditions in EHI as described in planning documents and other sources, but which are unrelated to the WHI port. We identify which current Q of L concerns may be mitigated by proposed or planned changes for EHI, which Q of L concerns likely will persist in spite of planned changes, and any new Q of L concerns that planned changes could cause. With this description as background, we describe the potential effects on Q of L specific to the Development Scenario in Section III.

As described in a recent report by the City of Portland, EHI is home to approximately 2,200 permanent residents living in 1,600 housing units that include a mix of single-family residences, condominiums, manufactured homes, floating homes, and boat "live aboards." EHI's population grows in summer when roughly 5,000 boat owners occupy the island's available moorage sites. Approximately 240 business operate on EHI and employ nearly 3,000 workers. Retail businesses range from small convenience shops to big-box retail outlets and includes restaurants,

[3] The key-informant interviews of residents of EHI included: attending a meeting of the Hayden Island Livability Project during which participants raised questions and concerns about WHI, and interviews with Victor Viets, Ron Schmidt, Corky Koiler, Timme Helzer, Tom Dana, and Martin Slapikas. These interviews took place during January and February of 2012.

shops, bars, and marinas. EHI also includes a number of commercial and industrial operations.[4]

Land-use types are not uniformly distributed across EHI, and, as we describe in the next section, this fact influences the potential Q of L effects of the WHI port. The I-5 highway bisects EHI. To the east is a large number of floating homes, the largest system of boat moorages on the Columbia River, single-family homes and condominiums, and much of the small-scale retail and some of the commercial uses.[5] Because of the large number of boat moorages, floating homes and marine-related businesses, some residents who live on the east side of EHI describe the lifestyle as "resort-like" and "easy-going."[6] In general, compared with households west of I-5, households on the east side have higher household incomes (medium household incomes of $53,000 for east EHI vs. $37,000 for west EHI), a smaller percentage of households living in poverty (13% of households in east EHI vs. 22% for west EHI), and a greater percentage of population with a post-secondary education (36% for east EHI vs. 17% for west EHI).[7]

To the west of I-5, land uses include commercial and manufacturing, the Jantzen Beach SuperCenter shopping mall and big-box retail businesses, office buildings, a manufactured-home park (the largest such park in Oregon), floating homes, a commercial marina, and over 190 acres of land zoned for industrial use on the western edge of EHI, which includes a large auto-auction yard that stretches the width of the island.[8] Residents of the manufactured-home park include low-income households, people with disabilities, and those living on fixed incomes.[9] Residential units in the manufactured-home parks and some floating homes are the homes closest to the WHI port. Many are adjacent to North Hayden Island Drive (NHID), which trucks and other traffic would use to travel between the WHI port and I-5 if the bridge connecting WHI and Marine Drive is not constructed.

I-5 provides the only (non-boat) access on or off EHI. The stretch of I-5 a few miles north and south of EHI is severely congested.[10] This creates problems for local residents, workers, and shoppers who can sit in rush-hour type delays at any time waiting to get off the island or on I-5 trying to access the island. Accidents, holidays,

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[4] City of Portland, Bureau of Planning and Sustainability. 2009. *Hayden Island Plan*, August 19, p. 1-3.

[5] Hayden Island Neighborhood Network, http://www.myhaydenisland.com/; City of Portland, Bureau of Planning and Sustainability. 2009. *Hayden Island Plan*, August 19; Google Maps of EHI.

[6] Key informant interviews of EHI residents.

[7] U.S. Census. Census Bureau. 2010. American Community Survey 2006-2010. Block Group 1 and 2, Census Tract 72.01, Multnomah County, Oregon.

[8] Hayden Island Neighborhood Network, http://www.myhaydenisland.com/; City of Portland, Bureau of Planning and Sustainability. 2009. *Hayden Island Plan*, August 19 (*Hayden Island Plan*, 2009); Google Maps of EHI.

[9] Key informant interviews of EHI residents.

[10] Rose, Joseph. 2010. "Daily Beast says Portland's I-5 drivers have nation's 16th worst commute," *The Oregonian*. Thursday, January 21. http://blog.oregonlive.com/commuting//print.html.

sporting events, bridge openings, etc. can compound congestion and delays. The CRC, which we describe in more detail in Section III, is designed to mitigate the I-5 bottleneck and improve access on and off EHI.

The concentration of 12 video-poker and lottery bars in two adjacent strip malls—which locals refer to as "casino row," or "lottery row"—creates a casino-like atmosphere that concerns local residents. The close proximity to Vancouver, WA, and the fact that Washington does not permit video poker, attracts Washington residents to EHI.[11] These bars generated approximately $10 million in lottery commissions in 2010, which does not include food, alcohol, or tobacco sales.[12] Casino row also draws customers by offering low cost alcohol and cigarettes.[13] According to police and news reports, since casino row began operating, robberies, drug dealing in parking lots, and other crimes have increased significantly, which creates safety concerns for some residents.[14] In October of 2011, a Vancouver, WA man was injured in a suspected gang-related shooting on casino row.[15] The proposed CRC will physically displace the two strip malls that make up lottery row. Lottery officials say that changing regulations and required license renewals in 2015 will reduce the number of permitted video-poker and lottery bars that operate on EHI. Some residents, however, have concerns that business owners will find ways around the CRC displacement and any proposed licensing changes to maintain the revenues that these bars generate.[16]

EHI has little open space but residents regularly access the beaches on WHI. Lotus Isle Park, a 1.7 acre park sits on the southern shore of the island, east of 1-5.[17] The key informants we spoke with acknowledged that EHI lacks park space, but noted that EHI residents regularly walk along the beach below the high-water line into WHI. The beaches on WHI are also accessible by boat, which many EHI residents have.[18] According to the Hayden Island Plan, the single developed park in EHI is inadequate and the area is underserved by parks.[19]

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[11] Law, Steve. 2011. "State fumbles 'Lottery Row' fix," *Portland Tribune*. November 17.

[12] Manning, Jeff. 2011. "Problems with Oregon Lottery video poker at shopping center on Hayden Island prod consideration of new rule," *The Oregonian*. November 11.

[13] Law, Steve. 2011. "State fumbles 'Lottery Row' fix," *Portland Tribune*. November 17.

[14] Manning, Jeff. 2011. "Problems with Oregon Lottery video poker at shopping center on Hayden Island prod consideration of new rule," *The Oregonian*. November 11; Law, Steve. 2010. "'Lottery row' a magnet for crime," *Portland Tribune*. December 16.

[15] Reeden, Rim. 2011. "Man injured in Hayden Island shooting," *Portland Tribune*. October 30; Thompson, Jeff. 2011. "Man hit in gang-related Haden Island shooting," *KGW.com*. October 30.

[16] Key informant interviews of EHI residents; Law, Steve. 2011. "State fumbles 'Lottery Row' fix," *Portland Tribune*. November 17.

[17] *Hayden Island Plan*, 2009. Page 2.

[18] Key informant interviews of EHI residents.

[19] City of Portland, Bureau of Planning and Sustainability. 2009. *Hayden Island Plan*. September 18, 2009. Page 3.

Residents of EHI hear noise from planes, trains, and ships. EHI sits in one of the flight paths for Portland International Airport. This places EHI in the Portland International Airport Noise Impact Zone, which limits residential housing to areas that do not exceed a day-night average noise level (ldn) of 68.[20] Roughly the southern half of EHI has ldn measures of between 65 to 68 dB. The northern half of the island has ldn reading of 68 dB or above.[21] Given these noise levels, zoning restrictions prohibit new residential housing in areas that were not already zoned for housing before 1981.[22] According to the key informants we spoke with, residents of EHI can also hear horns from trains on the Washington side of the Columbia River, and horn blasts from ships in the River and in the Ports of Portland and Vancouver.[23]

Some EHI residents have concerns about the toxicity of dredge material deposited on WHI. The proposed site of the WHI port includes an area currently used as a disposal site for dredge material. This material comes primarily from dredging operations that maintain the ship canal and port areas on the Columbia and Willamette Rivers. Some EHI residents have concerns that the dredge materials contain toxic chemicals.[24] According to the Oregon Department of Environmental Quality (DEQ), however, the sediment does not pose a health hazard. DEQ analyzed the dredge material and concluded, "… that contaminant concentrations were at naturally occurring levels for metals or below screening values for people and animals and would not have an adverse impact."[25] Specific to residents of Hayden Island, DEQ concluded, "that there would not be an adverse impact to people or the environment, including concluding that there would be no impact to residents on West Hayden Island."[26]

We summarize the current Q of L concerns or issues of EHI residents and businesses as follows:

- I-5 is the single on-off access for the island. The frequent and extensive congestion on I-5 imposes hardships on residents, business owners and their customers as they travel to and from the island.

- Casino row, and the associated increase in crime, concerns residents because it reduces their sense of personal safety.

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[20] Ldn values are decibel measures weighted by factors for annoyance, for example time of day or other considerations. Pilip-Florea, Shadrach, 20009. "Hayden Island: Strategic Resource for Sustainable Urban Future?" *Quarterly & Urban Development Journal*, 4th quarter. PSU Center for Real Estate. Page 22.

[21] *Hayden Island Plan*, 2009. Page 8-9.

[22] *Hayden Island Plan*, 2009. Page 3.

[23] Key informant interviews of EHI residents.

[24] Key informant interviews of EHI residents.

[25] Oregon Department of Environmental Quality. *Beneficial Use of Solid Waste, Beneficial Use Determinations Port of Portland Post Office Bar, Questions and Answers*. www.dep.state.or.us. (DEQ Dredge Q and A)

[26] DEQ Dredge Q and A.

- EHI has little park or open space areas. Some residents say they access beaches on WHI by walking or boat. City planning documents list EHI as an area underserved by parks.

- EHI sits in the flights path of Portland International Airport and the associated Noise Impact Zone for the airport. Noise levels on the north side of EHI measure at the maximum limit permitted for residential areas. Noise levels on the south side are just below the maximum limit.

- Some EHI residents have concerns about the toxicity of dredge spoils deposited on WHI. DEQ concluded that the dredge materials on WHI pose no health concerns.

Factors unrelated to the Development Scenario will affect EHI in the future. Looking out 30 or 50 years no one can say today what all these factors will be, however we do have information today about two of the likely factors. The first, the Columbia River Crossing (CFC) project, aims to reduce congestion on I-5, improve vehicle access on and off Hayden Island, and bring light-rail to the island. The second, the Hayden Island Plan, describes planning goals and strategies to improve accessibility and livability on the island. Neither of these potential developments are without controversy. For the purposes of our analysis, we look to the CRC for information on the likely future traffic conditions on I-5 and EHI. We look to the Hayden Island Plan for the likely future growth and development of EHI.

As described in a preliminary report by the City of Portland's Bureau of Transportation, the CRC is projected to alleviate the current congestion on I-5 and associated back-ups on to EHI streets.[27] The City's transportation analysis took into account the housing and population increases projected in the Hayden Island Plan. According to the report, the CRC improvements and planned street upgrades on EHI are projected to alleviate congestion on I-5 and EHI through 2035. Press reports describe the CRC as a long, expensive process. Supporters and detractors alike agree that even though the process is moving forward, uncertainty exists as to the ultimate timing, cost or configuration of the final project.[28] Some critics of the project are concerned that projected population increases in the Portland-Vancouver area, and the associated increase in economic activity, will generate traffic that congests I-5

[27] Hillier Bob, N. Zhou, and J. Gillam. 2011. Memorandum: *DRAFT West Hayden Island Transportation Modeling Analysis: Phase I – Planning Level Network Analysis.* December 9.; Personal Communication with Bob Hillier, February 6 and 14.

[28] Damewood, A. 2012, "White House sets aside $39 million for CRC work," *The Columbian*, www.columbian.com, February 14; Manning, J. 2012, "Columbia River Crossing officials suggest significant downsizing to trim $650 million from the controversial project," *The Oregonian*. January 19; Carinci, J. 2010. "Some fear bridge will lead to sprawl," *Daily Journal of Commerce*. February 22; Duin, S. 2011. "In the Columbia River Crossing bridge game, we're the dummies," *The Oregonian*. July 11; Manning, J. 2011. "Columbia River Crossing opponents lose first ruling on bridge project," *The Oregonian*. October 27; Manning, J. 2011. "Traffic estimates on Columbia River Crossing further muddy the financial picture," *The Oregonian*. July 19.

again in the not too distant future. According to these critics, the CRC may only temporarily address the area's traffic problems.[29]

According to the Final Environmental Impact Statement (FEIS), the CRC will displace 35 floating homes, 39 business that currently employ over 600 workers, and the bars on casino row.[30] Local residents express mixed feelings about the project. They welcome the relief from traffic congestion and improved accessibility, but have concerns about the five-year construction period and how the final configuration and operation of the project will affect their lifestyle.[31]

According to the CRC FEIS, "The traffic noise modeling in the Portland area indicates that there would be no traffic noise impacts to any of the noise-sensitive properties identified." The light rail would, however, cause "moderate" noise impacts for some floating homes near Jantzen Beach. Proposed mitigation measures include installing sound barriers, acoustical absorbent sound walls and increasing the height of traffic barriers to act as sound barriers as well.[32]

The City of Portland developed the Hayden Island Plan with input from island residents and business owners. The Hayden Island Plan includes planning goals and strategies to improve accessibility and livability on the island. Major components of the Hayden Island Plan include:[33]

- Maintaining current housing, including floating and manufactured homes, and adding up to 2,800 new dwelling units. The planned new developments include transit-oriented housing adjacent to the proposed light rail stop.
- Maintaining the industrial land uses on the western edge of EHI.
- Modernizing and improving the Jantzen Beach SuperCenter and incorporating mixed-use development on the site.
- Developing a park with beach access to the Columbia River.
- Improving accessibility to and from the island as part of the CRC. This includes a new interchange for I-5 at HI, new bridges across North Portland

[29] Letter from Lillian Shirley, Director, and Gary Oxman, Health Officer, Multnomah County Health Department to Doug Ficco and John Osborn, Co-Directors, Columbia River Crossing, June 9, 2008.

[30] Oregon Department of Transportation, Washington Department of Transportation, U.S. Department of Transportation, et al. 2011. *Columbia River Crossing Final Environmental Impact Statement and Final Section 4(f) Evaluation*. September. Pages 3-88 and 3-94. Colombia River Crossing Final Environmental Impact Statement. 2011. Chapter 3: Existing Conditions and Environmental Consequences.; Manning, J. 2011. "At Hayden Island interchange, the Columbia River Crossing will cast a huge footprint." *The Oregonian*. September 24.

[31] Manning, J. 2011. "At Hayden Island interchange, the Columbia River Crossing will cast a huge footprint.: *The Oregonian*. September 24; Key informant interviews of EHI residents.

[32] CRC FEIS, 2011. Pages 3-297, 3-302, and 3-312.

[33] City of Portland, Bureau of Planning and Sustainability. 2009. *Hayden Island Plan*. September 18, 2009. Page 6-7, 14-20.

Harbor and the Columbia River, a light-rail stop on the island, and pedestrian and bike paths on the light-rail bridge.

- Improving and expanding the local street networks.

The Hayden Island Plan takes into account the new traffic generated by the projected increase in the island's population and visitors. According to past and current traffic modeling, the projected increase in traffic will not congest the Hayden Island I-5 interchange, assuming the current configuration of the CRC.[34]

Some residents of EHI expressed concerns that developments on the island will deviate from the details in the Hayden Island Plan in ways that do not take their concerns into account. They point to modifications of the CRC as one example of how actual developments may occur differently than planned.[35]

Based on the information available today, the CRC and Hayden Island Plan may affect Q of L concerns and issues for EHI. Below, we summarize the information on current Q of L concerns and information on how the CRC and Hayden Island Plan may influence these issues:

- The CRC and associated improvements to the local network of streets on EHI, are projected to alleviate congestion on I-5 and EHI. These developments would also improve accessibility to and from EHI by adding new vehicle brides, a new light-rail stop, and pedestrian and bike paths on the light-rail bridge. This modeling takes into account the growth and development of EHI as described in the Hayden Island Plan, and the associated increase in on-island traffic generated by the projected growth. Some EHI residents have concerns over how the construction activities and the ultimate design and operation of the CRC will affect their Q of L.

- The CRC will displace the casino-row bars in EHI that make up casino row. Lottery officials state that new regulations, and required relicensing in 2015, will ultimately reduce the number and concentration of establishments with video poker and other lottery games. Some EHI residents are concerned that given the large revenues that the casino-row bars generate, the business owners will find ways around the new regulations.

- The Hayden Island Plan includes a new park with beach access to the Columbia River and open space areas that will help address what the City of Portland describes as a deficiency of parks on EHI. Some EHI residents note that they can access the shoreline on WHI by boat and walking from EHI below the high water mark.

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[34] *Hayden Island Plan*, 2009. Page 7; Hillier Bob, N. Zhou, and J. Gillam. 2011. Memorandum: *DRAFT West Hayden Island Transportation Modeling Analysis: Phase I – Planning Level Network Analysis.* December 9; Personal Communication with Bob Hillier, February 6 and 14.

[35] Key informant interviews of EHI residents.

- The CRC will generate moderate noise impacts from the light rail. The CRC FEIS describes measures that could mitigate these impacts. Residents of the manufactured home communities on EHI expressed concerns over noise and air-quality impacts from CRC construction actions.[36] This may exacerbate existing conditions, given that EHI sits in the Noise Impact Zone for Portland International Airport, which limits some development of residential areas.

III. Development Scenario

In this section, we describe the aspects of the proposed Development Scenario that may affect Q of L issues for EHI residents and businesses. In general, these concerns include the impacts of the WHI port on traffic congestion, noise, light pollution, and air quality. As described in Section I, the Development Scenario for WHI includes the following major factors that could affect the Q of L of EHI residents:

- Loading and moving unit trains that transport autos and bulk materials.
- Truck and auto traffic to and from the WHI port.
- Operating some parts of the WHI port 24-hours a day, which requires significant external lighting.
- Developing a new ramp for non-motorized boat access and new hiking trails.

In the following sections we describe our review of available information on the potential Q of L impacts from the WHI port. We base our analysis on information specific to the port, reports and other information from the Port of Portland, City of Portland, and the general literature on port operations. We begin with the potential traffic impacts of the WHI port.

A. Traffic Effects

The Development Scenario would result in increased truck and automobile traffic to and from the WHI port. Currently, the only route available for this traffic between the proposed facility and I-5 is North Hayden Island Drive (NHID). The Development Scenario includes a potential new bridge between WHI and Marine Drive, which, if built, traffic engineers predict would significantly reduce the volume of port traffic that uses NHID through EHI.

According to a preliminary analysis of the traffic impacts of a WHI port, the port would generate an increase in on-island traffic relative to the Baseline Scenario. Because of other planned traffic improvements, however, the City's traffic analysis predicts that port-related traffic would not negatively impact traffic flows on the island or on- or off-island access. According to the City's traffic analysis, the large majority of port-related traffic would be autos rather than trucks—1,534 auto trips and 516 truck trips per day, for a total of 2,050 daily trips.[37] Without a WHI bridge,

[36] CRC FEIS, 2011, Page 3-145.

[37] Hillier, 2011, Page 7. Table 3.

the port facility would increase traffic by an average of 12 percent throughout the network of streets on EHI. The impact on traffic west of the mall, however, would be more significant.[38] As described in the City's traffic analysis, these results reflect the high end of the range of likely traffic impacts. That is, these effects describe a possible worst case scenario of traffic effects. The actual effects could be less.

According to the City's analysis, traffic related improvements included in the CRC and Hayden Island Plan will help mitigate negative impacts of the traffic effects from the port. The City's traffic analysts assumed that the CRC will happen as described at the time of their analysis (December 2011), and that EHI will grow and develop as described in the Hayden Island Plan. The traffic model predicted that growth on EHI unrelated to the WHI port will significantly increase traffic volumes on the island. The on-island road improvements in the CRC and Hayden Island Plan, however, would improve on-island roadways and access so that the projected traffic growth—natural growth from increased on-island development and growth from the port—would not overwhelm EHI roadways. The traffic model predicts no substantive traffic problems associated with the WHI port. This includes no substantive congestion on EHI and no substantive delays accessing or exiting the island from I-5 or the new auxiliary bridge that would be adjacent to I-5 through 2035.[39] Another reason for the limited impact of the WHI port on accessing or exiting the island is that the late afternoon or early evening traffic flow ("PM peak traffic") for the port traffic would be opposite the direction of other on-island traffic at that time.[40]

We understand that the City's traffic analysis of the WHI port is preliminary and meant to generally describe the amount and type of traffic the facility could generate. City traffic engineers have not yet conducted a detailed analysis of how port traffic could interact with other traffic on EHI at specific intersections. What seems more certain, however, is that to the extent that the on-island traffic improvements in the CRC and Hayden Island Plan do *not* happen as assumed in the City's analysis, it will increase the probability that port-related traffic would generate negative traffic impacts. These impacts could include increased congestion on EHI roadways, increased delays and travel times, and increased traffic accidents.

Public comments on the CRC included concerns that the project would prove only a temporary fix for traffic congestion on I-5 and EHI. According to these comments, projected population growth and associated increases in economic activities and roadway traffic could eventually increase congestion equal to or worse than current conditions.[41] Others believe that cost and funding issues will derail the CRC.

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[38] Hiller, 2011 and conversations with City staff.

[39] Hillier Bob, N. Zhou, and J. Gillam. 2011. Memorandum: *DRAFT West Hayden Island Transportation Modeling Analysis: Phase I – Planning Level Network Analysis.* December 9; Personal Communication with Bob Hillier, February 6 and 14.

[40] Hillier, 2011. Page 14.

[41] Letter from Lillian Shirley, Director, and Gary Oxman, Health Officer, Multnomah County Health Department to Doug Ficco and John Osborn, Co-Directors, Columbia River Crossing, June 9, 2008.

If developing the WHI port included a new bridge that connected WHI with Marine Drive, the City's traffic model predicts that 90 percent of the port traffic would use the bridge and connect to I-5 via Marine Drive.[42] This would significantly reduce port traffic and impacts of this traffic on EHI.

The City's traffic analysts also considered the possibility that some travelers would cut through EHI via the new bridge between WHI and Marine Drive to access I-5. According to model results, however, traveling this route takes 2 to 4 minutes longer than accessing I-5 via Marine Drive. Given these results, traffic analysts conclude that a new bridge between WHI and Marine Drive would not attract cut-through traffic between Marine Drive and I-5.[43] Recent news reports, however, describe potential changes to the CRC that may affect the results of the cut-through analysis. Officials with the CRC recently proposed eliminating most planned improvement to the Marine Drive interchange on I-5 as part of a cost-cutting measure.[44] To the extent that this development increases the travel time between the River Gate area and I-5 to the point that traveling this route takes longer than cutting through EHI, the bridge between WHI and Marine Drive could possibly attract cut-through traffic.

The City's traffic analysis predicted that some vehicles from EHI or WHI would travel through neighborhood streets in St. John's via a new bridge connecting WHI with Marine Drive. Results, however, indicate that traffic volumes on these streets would increase by 3 percent above projected baseline traffic counts, which, according to the traffic analysis, would not create congestion or require road improvements.[45]

As described in economics and transportation studies, increasing traffic on a given roadway imposes two types of costs on roadway users. The first is the cost of increased congestion. According to this literature, increased traffic generally increases travel times. Increased traffic also increases the probability of accidents between vehicles, bicyclists, and pedestrians. These costs include foregone work-related benefits and the costs of injury and damage to vehicles and other property.[46] For example, in one study traffic researchers calculated the congestion and accident costs for trucks traveling 9 to 15 mile segments of an industrial corridor in New

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[42] Hillier, 2011. Page 13.

[43] Hillier, 2011. Page 12; Personal Communication with Bob Hillier, February 6 and 14.

[44] Manning, J. 2012. "Columbia River Crossing officials suggest significant downsizing to trim $650 million from the controversial project." *The Oregonian*. January 19.

[45] Hillier, 2011. Page 12.

[46] Ozbay, K. and B. Bartin. 2001. "Estimation and Evaluation of Full Marginal Costs of Highway Transportation in New Jersey." *Journal of Transportation and Statistics* 4(1): 81-104.; Small, K. 1992. *Urban Transport Economics.* Newark, NJ: Harwood Academic Publishers GmbH.; Vickrey, W. 1968. "Automobile Accidents, Tort Law, Externalities, and Insurance: An Economists Critique. *Law and Contemporary Problems* 33:464-87.

Jersey. These researchers estimated a congestion cost, in 2011 dollars, of $0.84 per vehicle, per trip and an injury cost of $1.28 per vehicle, per trip.[47]

According to the City's traffic analysis, the Development Scenario will increase the number of vehicles traveling through EHI to I-5 on NHID. With increased traffic comes the possibility of increased congestion and traffic accidents, and the associated increased costs. Given, however, that the proposed port activities would not begin till approximately 2026, and given that other factors such as the final details of the CRC and future development of EHI neighborhoods that would affect traffic on EHI are unknown at this time, existing data do not allow us to calculate these projected costs.[48] We can, however, illustrate the potential magnitude of the cost of congestion. We do this by applying the costs of congestion reported in the literature to a number of vehicle-trips affected on NHID by the traffic to and from the WHI port. We calculate these illustrative costs for one year of port operations. We stress that the results of this illustrative calculation are not definitive for the WHI port. An analysis of the impacts of port traffic on travel times would require a more detailed traffic analysis.[49] We note that our illustrated cost calculation excludes the costs of traffic accidents associated with the port traffic because that is a more complex calculation that does not lend itself to a simple illustration.

According to the City's traffic analysis of the WHI port, without the bridge between WHI and Marine Drive, the Development Scenario would generate approximately 2,050 vehicle trips per day down NHID between the WHI port and I-5. With the bridge, this number drops to approximately 226. Given these results, we assume in our illustrative scenario that with the WHI bridge there would be no significant increase in travel time on EHI because of the traffic from the WHI port. Without the bridge, we assume that 500 vehicle trips per day on EHI roads are increased by an additional 30 seconds per trip because of the 2,050 additional port vehicles trips on NHID. We assume these 500 trips per day are generated by: workers and customers at the auto-auction yard and other commercial and industrial businesses on the west end of EHI; residents of the manufactured home communities; residents of the proposed residential developments on EHI; and shoppers at the renovated Jantzen Beach SuperCenter mall and other retail shops. As a point of reference we note that the traffic analysis of the CRC FEIS anticipates approximately 6,000 vehicle trips during the most traffic-intensive eight-hour segment of each day for the Hayden Island interchange on I-5.[50] Using these data and assumptions, we estimate the total

[47] Ozbay. and Bartin. 2001. "Estimation and Evaluation of Full Marginal Costs of Highway Transportation in New Jersey." We have converted these figures from 2001 dollars to 2011 dollars using the Consumer Price Index (CPI).

[48] Personal Communication with Bob Hillier, February 6 and 14.

[49] Personal Communication with Bob Hillier, February 6 and 14.

[50] CRC FEIS, 2011, Traffic Technical Appendix.

increase in travel time is approximately 4.2 hours per day, or approximately 1,533 hours per year.[51]

We then multiply this total increase in travel time by the estimated value of time for drivers and passengers. According to transportation planners,[52] at least some transportation analysts in the Portland area use statistics and data on travel time as reported in a study titled, *The Cost of Congestion to the Economy of the Portland Region*.[53] According to this report, the per person value of travel time is $30.73 for on-the-clock (working) drivers of passenger vehicles and trucks, $15.36 for commuters and recreational drivers, and $40.31 for on-the-clock freight truck drivers ($2011).[54] Assuming the data and conditions described above, and assuming all the drivers in our illustrative example are commuters and recreational drivers, the estimated cost of increased travel time for one year on EHI because of port traffic with no WHI bridge is approximately $23,500.[55]

B. Noise Effects

The Development Scenario could generate noise impacts from three sources. The first source is noise produced by unit trains as they travel the elevated railroad tracks that cross the island and as they travel through the new rail yard on WHI. The second source is noise caused by the loading of autos and bulk materials onto rail cars. The third source is noise made by trucks traveling on NHID between the WHI port and I-5. We describe these potential sources of noise impacts, summarize information on the economic costs of these impacts on affected populations, and describe potential mitigation measures. We begin by describing the problems associated with noise impacts and factors that can affect the severity of these impacts.

Noise pollution can have a number of negative consequences. Noise can cause undesired social outcomes by reducing enjoyment of leisure activities. It can contribute to health effects, including hypertension, heart disease, sleep interruption, and hormonal changes.[56] Noise can also negatively affect property values proximate to the noise source. As reported in recent studies, chronic noise has negative

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[51] 30 seconds/trip * 500 trips/day = 15,000 seconds, or 250 minutes, or 4.2 hours/day. 4.2 hours/day * 365 days/year = approximately 1,533 hours/year.

[52] Personal Communication with Bob Hillier, February 6 and 14; Personal Communication with Cindy Pederson, Principal Transportation Modeler, Portland Metro, February 16, 2012.

[53] Economic Development Research Group. 2005. *The Cost of Congestion to the Economy of the Portland Region*. Prepared for the Portland Business Alliance, Portland Metro, and the Port of Portland. November 25.

[54] Economic Development Research Group. 2005. "The Cost of Congestion to the Economy of the Portland Region: Appendix A." Prepared for: Metro and Portland Business Alliance. November. We have converted these figures from 2005 dollars to 2011 dollars using the CPI.

[55] 1,533 hours * $15.36/hour = $23,547.

[56] World Health Organization. 2011. "Burden of disease from environmental noise. Quantification of healthy life years lost in Europe." Available online: http://www.euro.who.int/en/what-we-publish/abstracts/burden-of-disease-from-environmental-noise.-quantification-of-healthy-life-years-lost-in-europe.

environmental impacts for a variety of terrestrial organisms, including changes in foraging behavior, reproductive success, and community structure.[57] Researchers report that because of the growth and close proximities of populations and rail and road transportation systems, noise annoyance is one of the most serious environmental pollutants in industrialized economies.

A number of sources describe permitted or recommended noise levels. The City of Portland's daytime permissible level is 65 decibels (dB), and a nighttime permissible level of 60 dB. The Federal Highway Administration (FHWA) has guidelines that help engineers determine whether or not transportation projects generate sound effects that require mitigation. Engineers express these levels as Equivalent Sound Pressure Level (Leq), which describes levels for complex and fluctuating sounds. The FHWA interior measure is 52 Leq for residences, schools, hospitals, etc. and an exterior measure of 67 Leq. The U.S. Department of Housing and Urban Development (HUD) developed what they refer to as "acceptable" sound levels for residential developments. HUD considers sounds less than 65 dB "acceptable." Sounds between 65 to 75 are "normally unacceptable," and sounds greater than 75 dB are "unacceptable."[58] The World Health Organization (WHO) developed guidelines for community noise that focus on the human health impacts of noise at night. According to the WHO guidelines, interior nighttime sound levels above 45 dB can cause sleep disturbance if experienced 10-15 times during the night. The WHO target threshold for nighttime outdoor noise is 40 dB.[59]

The operations of the Toyota facility at Port of Portland Terminal 4 (T4) and the Kinder Morgan Potash facility at Terminal 5 (T5) provide insights into potential noise impacts of the WHI port, and also potential mitigation measures. The loading of vehicles onto train cars at T4 caused a sharp banging noise that impacted residents of the Cathedral Park neighborhood. Engineers tried mitigating the noise by modifying the train cars, but the modifications proved ineffective. Given that the noise complaints were primarily seasonal—increasing in winter when deciduous trees have no leaf cover—engineers recommended maintaining a vegetative buffer of at least 100 feet. Managers at other ports rely on buffers to help mitigate noise, light and other effects of port operations on adjacent neighborhoods. For example, the Port of Tacoma purchased 31 acres as a noise, visual, and light buffer between the port and neighboring residential areas. At T5, loading and unloading potash into train cars created noise impacts from the train cars bumping into one another. Developing braking techniques that minimized car bumping helped mitigation this noise impact. Another mitigation measure is forming a sound barrier with empty rail cars that helps blocks the noise of loading other cars.[60]

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[57] Barber, J., K. Crooks, and K. Fristrup. 2009. "The costs of chronic noise exposure for terrestrial organisms." *Trends in Ecology and Evolution* 25(3): 180-189.

[58] City of Portland, Bureau of Planning and Sustainability. 2010. *West Hayden Island Planning Process Local Impacts of Industrial Development*. Prepared for the West Hayden Island Community Work Group. April. (City of Portland, *Local Impacts*, 2010) Pages 13, 28-29.

[59] City of Portland, *Local Impacts*, 2010. Pages 10-11.

[60] City of Portland, *Local Impacts*, 2010. Pages 10-14.

Truck traffic is another source of potential noise impacts from the Development Scenario. Research conducted as part of the North Portland Noise Study describe the noise impacts of trucks traveling freight corridors through neighborhoods. The Study focused on three freight corridors in North Portland: North Columbia Boulevard, North Lombard and North Going. Traffic noise along all three freight corridors exceeded the FHWA levels that would require noise abatement, and also exceed the HUD levels considered "acceptable" for residential areas.[61]

Noise walls 12 feet high or greater, are the typical engineering solution to traffic noise. Such barriers, however, would negatively affect views and the character of residential neighborhoods such as those in the North Portland Noise Study, and in EHI. The preferred mitigation measures described in the Noise Study were resurfacing freight corridors with quiet pavement and requiring sound insulation in new residential construction along the corridors.[62] Used more widely in Europe, quiet pavements cost approximately 10 to 25 percent more than traditional pavements.[63] Researchers in Washington state, however, found quiet pavements degrade relatively quickly, and suggested the technology may not be compatible with the Northwest climate.[64] Other research also found that the pavement loses its noise-reducing benefits as it ages.[65]

A number of studies describe the costs of noise impacts on affected populations. Some studies describe costs in terms of the health-care effects and some use surveys to identify the amount that people would be willing to pay for less noise. Other studies describe the costs in terms of reduced values of properties in areas affected by noise or the cost of noise abatement.

In 2007, researchers published a handbook in which they describe their review and summary of current and past studies of the costs of noise and other environmental effects associated with traffic. Based on their review of several case studies of the economic costs of noise, they identified what they considered the most analytically reliable costs of noise impacts. Using data from these case studies they estimated the noise costs for road and rail traffic by type of vehicle and distance traveled. We list their results in Table 1 below.

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[61] North Portland Noise Study, 2010. Pages 12, 60-65.

[62] North Portland Noise Study, 2010. Page 67-68.

[63] U.S. Department of Transportation, Federal Highway Administration. 2005. "Quiet Pavements: Lessons Learned from Europe." FOCUS. April. Publication Number: FHWA-HRT-05-025

[64] Rosenthal, B. 2010. "A lot riding on 'quiet pavement' in Bellevue as testing continues." *The Seattle Times*. January 31.

[65] Rich, S. 2011. "'Quiet Pavement' Being Tested by More State DOTs." *Government Technology*. July 13.

Table 1. Noise Costs for Road and Rail Traffic in Suburban Neighborhood (per vehicle, per mile driven, $2011)

Vehicle	Time of Day	Cost (Low)	Cost (High)
Car	Day	$0.09	$0.26
	Night	$0.14	$0.40
Truck	Day	$0.70	$1.98
	Night	$1.30	$3.60
Freight Train	Day	$37.27	$72.20
	Night	$122.03	$122.03

Source: ECONorthwest staff estimates with data from Maibach, M., et al. 2007. *Handbook on Estimation of External Costs in the Transport Sector*. Internalisation Measures and Policies for All External Cost of Transport, Delft, CE, December 19. Table 111, Page 69.

Other researchers calculate a cost of noise as a function of decibels. One researcher calculated an annual willingness-to-pay to reduce noise of .09% to .11% of per capita income per dB.[66] Other studies describe analyses of property value depreciation due to noise. We present results from two of these studies in Table 2 below.

Table 2. Cost of Noise Annoyance from Railways ($2011)[1]

Decibel Level	Willingness To Pay Estimate	Impacts On Property Value
55-60 dB	$797	$68
60-65 dB	$955	274
65-70 dB	$645	$685
70-75 dB	$353	$1,367
75-80 dB	$163	$2,584[2]
>80 dB	$50	

Source: van Kempen, E.E.M.M. 2001. 2001. Een Schatting van de Baten van Geluidmaatregelen. RIVM rapport 715120004. quoted in Brons, M., P. Nijkamp, E. Pels, and P. Rietveld. 2003. "Railroad noise: economic valuation and policy." *Transportation Research Part D* 8:169-184.; and INFRAS/IWW. 2004. "External Cost of Transport: Update Study." Study for the International Union of Railways. Zurich.

Notes:

[1] We have converted the data from the original studies to 2011 dollars.

[2] This value represents >75 dB effect size estimation.

Researchers also developed the Proximity Depreciation Sensitivity Index (PDSI) to describe the relationship between distance from the sources of transportation-specific noise impacts and reductions in property values. As distance increases from a noise source, the noise impacts decline and so do the negative impacts of noise on property values. The results of one study found that for properties within 100 meters

[66] Maibach. 2011. *Handbook on Estimation of External Costs in the Transport Sector.*

of a rail line, the noise impacts reduce property values by 10.4%, relative to comparable properties further from the rail line. For properties within 200 meters, the reduction in property value attributed to noise impacts was 4.0%.[67] Another researcher found that the discount on sale price attributed to noise impacts terminates approximately 275 meters from a railway.[68]

We expect that the WHI port would likely generate noise effects, however, data are not available at this time that would describe the type, severity or impact areas of those effects. This is especially relevant when calculating noise impacts because site-specific factors affect the severity of noise effects, including the distance from the noise source, topography, metrological conditions of air temperature, wind speed, and direction, and the location of sound blocking or reflection surfaces. Vehicle characteristics also affect the level of noise impacts including speed, frequency, types (rail, auto or truck), state of maintenance, and roadway- or rail-infrastructure characteristics.[69]

Researchers who study Q of L impacts of port facilities on adjacent neighborhoods recommend collecting this type of information as part of a Health Impact Assessment (HIA) of the proposed development.[70] As these researchers describe, a HIA could address a range of Q of L issues including noise, traffic, air quality, water quality, etc. Environmental Impact Statements (EIS) for projects that have a nexus with the Federal government also include sections on socioeconomic impacts of the projects. These impacts can include noise, traffic, air quality, etc. The range of possible Federal nexus include projects that receive Federal funding or projects that may affect Federally protected plant or animal species.

As we did with traffic-related costs, we calculate an illustrative cost of one of the potential noise impacts from WHI port operations—noise from rail traffic traveling the elevated rail line that currently crosses WHI. Again, we stress that these costs are illustrative and not definitive for the Development Scenario. Also, our illustrative cost calculation assumes no mitigation measures that could minimize noise effects from the rail traffic.

We used the PDSI to estimate the illustrative cost of noise effects from the unit trains as they travel the elevated rail line on EHI residents. As we described above, the literature on noise effects of rail traffic on property values includes research that found a 10% reduction in property values for homes within 100 meters of a rail line,

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[67] Brons, M. et al. 2003. "Railroad noise: economic valuation and policy," *Transportation Research Part D 8*. Pages 169-184.

[68] Poon, L. 1978. "Railway Externalities and Residential Property Prices." *Land Economics* 54(2): 218-227.

[69] Brons, M. et al. 2003. "Railroad Noise: Economic Valuation and Policy," *Transportation Research Part D* 8: 169-184; Forkenbrock, D. 2001. "Comparison of External Costs of Rail and Truck Freight Transportation. *Transportation Research Part A* 35:321-337; Jarup, L. et al. 2008. "Hypertension and Exposure to Noise Near Airports: the HYENA Study," *Environmental Health Perspectives*. 116 (3): 329-333; Leon, B., et al. 2007. "Road Traffic Noise and Hypertension," *Occupational and Environmental Medicine* 64(2): 122-126.

[70] Human Impact Partners. 2010. *Los Angeles and Long Beach Maritime Port HIA Scope Working Draft*. Prepared for the US Environmental Protection Agency. May 17.

a 4% reduction for homes within 200 meters, and no effect of noise on property values for residences greater than 275 meters from a rail line. We use these distances and percentage reductions in property values in our illustrative calculation. According to maps of EHI, no homes lie within 200 meters of the existing elevated rail line that crosses WHI, which would be closer to EHI homes than the loop track and other rail lines of the WHI port that would lie further west from the existing rail line. Approximately 8 floating homes with an estimated average value of $209,000[71] lie within the 200 to 275 meter zone. Based on results reported in the literature, the impacts on property values of noise at these distances would be between 4% and 0%. For the purposes of our analysis we assume a 2% reduction in value for these affected homes. Using these data and assumptions, we calculate an illustrative impact of the noise effects of the rail traffic associated with the Development Scenario of $33,440.[72] This is a one-time effect on property values from port-specific rail traffic that crosses the elevated rail line.

Trains currently travel the elevated rail line across WHI. To the extent that the rail traffic associated with the WHI port has no noticeable increase in noise impacts, our illustrative calculation overstates the potential cost of the noise effects attributed to port-specific rail traffic.

In addition to potential noise effects from rail traffic, port operations could potentially produce noise effects from truck traffic along NHID, and from port operations. Data exist on the value of noise effects from truck traffic, however, the environmental and socioeconomic conditions at the study sites for these effects differ substantially from conditions on EHI. For this reason we did not estimate an illustrative cost of noise effects from port-specific truck traffic. As results from the North Portland Noise Study show, however, trucks traveling other freight corridors in the Portland area generate noise effects that exceed FHWA and HUD levels.

According to researchers who developed the PDSI, the greater the noise effects on residential properties, the larger will be the negative impact on property values. Given these results and the proximity of homes to NHID, we assume that trucks traveling this route to I-5 would generate noise effects that negatively affect property values. Given the data constraints on the potential noise effects and that the available research results are not compatible with EHI conditions, we have not estimated an illustrative cost of this noise effect. We note, however, that given the location of the auto-auction yard on the west end of EHI, trucks of the type that would travel to and from the WHI port using NHID currently travel this route. Trucks transporting autos travel NHID between I-5 and the auto-auction yard. As with the noise effects from increased rail traffic across the elevated rail line, to the extent that port-specific truck traffic has no noticeable impact on noise effects, there would be no cost from these effects. Site-specific data collected as part of a HIA or EIS could help determine the marginal impact of port traffic on noise effects.

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[71] Estimated property values from zillow.com, accessed February, 2012.

[72] Estimate average property value for the affected floating homes = $209,000 * 8 affected homes * 2% = $33,440.

Regarding the potential noise effects of future port operations, perhaps the best indications may be the experiences with noise effects and mitigation results at T4 and T5. Activities at these terminals move the types of goods that may move through the WHI port—autos and bulk goods—and move these goods by rail and trucks, which would also transport goods from the WHI port. Based on this experience, mitigation worked better for some noise effects—filling and moving train cars—than for other noise effects—loading autos onto train cars. The distance between residential areas on EHI and the location of the WHI port will provide a buffer that will help mitigate noise and other effects from port operations. It is unknown at this time, however, the extent to which that buffer will sufficiently mitigate noise and other effects so that they have no impact on EHI residents and businesses. A HIA or EIS could help describe such effects.

Some of the specific questions that a HIA of the potential noise effects of the proposed WHI port could address include the following.[73]

- To what extent would the distance and topography between the WHI port and residences in EHI provide an effective buffer that would mitigate noise effects from the operation of the facility or the rail traffic to and from the facility?

- To what extent would port-generated rail traffic on the elevated rail line that currently crosses WHI cause a noticeable increase in noise effects over current rail traffic? For example, the time of day, duration, or both of port-generated rail traffic may cause a noticeable increase in noise effects.

- To what extent would port-generated truck traffic on NHID cause a noticeable increase in noise effects over current or projected truck traffic? For example, the time of day of truck traffic may cause a noticeable increase in noise effects.

- If a HIA determines that port-generated traffic would cause a noticeable increase in noise effects, what types of measure could mitigate these effects?

C. Light Effects

The WHI port could generate light impacts due to the large expanse of work area outdoors and the possibility of loading and unloading operations continuing 24-hours a day. Worker safety regulations require a minimum amount of illumination. The experiences at the Port of Portland and other port facilities provide insights into potential light impacts from the WHI port, as well as mitigation measures that help reduce light impacts. We begin with a description of the problems associated with light impacts from industrial areas, and then summarize the experiences at the Port of Portland and other ports with light impacts and mitigating measures.

[73] For more details on specific questions that a HIA of noise effects could address see: Heller, J. et al. 2010. *Lost Angeles and Long Beach Maritime Port HIA Scope Working Draft*. Prepared by Human Impact Partners for the U.S. EPA. May 17; and, UC Berkeley Health Impact Group, 2010. *Health Impact Assessment of the Port of Oakland*. University of California, Berkeley, CA. March.

Researchers at the Lighting Research Center at Rensselaer Polytechnic Institute define light pollution as "an unwanted consequence of outdoor lighting [that] includes such effects as sky glow, light trespass, and glare."[74] Light pollution can affect humans by disturbing sleep patterns. Some researchers use the term "photopollution" to describe the adverse effects of artificial light on wildlife. Photopollution can interfere with feeding, biological growth processes, reproduction, and migration.[75]

The light effects of T4 and T5 at the Port of Portland provides insights into the possible light effects of the WHI port. The Toyota facility at T4 offloads cars that are shipped throughout the region, and the Kinder Morgan Potash Facility at T5 loads potash onto ships. Both of these facilities are similar to those anticipated for WHI. After Toyota upgraded their facility in 2004, residents from the adjacent Cathedral Park neighborhood and the Linnton Community across the Willamette River complained of the light effects from the new development. Toyota managers responded by removing some lights, shielding other, redirecting lights down and away from residents, and turning off lights when not in use. Managers at the Kinder Morgan facility also receive complaints about light effects from their operations and responded in ways similar to the Toyota managers.[76]

Increasingly, port managers across the country are taking steps to minimize light pollution from their operations. Light pollution is now among the list of light-related factors that port managers consider when selecting lighting products.[77] Other port facilities have addressed the light effects of their operations by developing lighting management plans or relying on buffers between the port and neighboring residential areas. The Canaveral Port Authority developed a light management plan to address the light effects of the port's operation on wildlife. The Authority developed the management plan in cooperation with the U.S. Fish and Wildlife Service. The plan relies on shielding and directing lights, installing timers, and using appropriate light levels for tasks at hand. The Port of Los Angeles will incorporate "Dark Sky" compliant lighting in their 30 acre public access buffer areas around the Port.[78]

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[74] Simpson, S. 2007. *Willingness to Pay for A Clear Night Sky: Use of the Contingent Valuation Method.* Masters in Science, Technology, and Public Policy Thesis, Rochester Institute of Technology, Rochester, New York. October. Page 8.

[75] Gallaway, T. 2010. "On Light Pollution, Passive Pleasures, and the Instrumental Value of Beauty." *Journal of Economic Issue*s 44 (1): 71-88; Simpson, 2007; Kempenaers, B. et al. 2010. "Artificial Night Lighting Affects Dawn Song, Extra-Pair Siring Success and Lay Date in Songbirds." *Current Biology*, published on line September 16.

[76] City of Portland, *Local Impacts*, 2010. Page 18-19.

[77] Bensalhia, J. 2011. "Lighting the Way." *Portstrategy* Available Online: www.portstrategy.com. January 5.

[78] City of Portland, *Local Impacts*, 2010. Appendix A Pages 5-6.

According to marine industry sources, the issue of light pollution is especially relevant in cases of existing ports expanding operations by adding new terminals.[79] In some cases, residents have sued ports that did not adequately address the light pollution from new facilities. For example, homeowners near the Port of Houston on Galveston Bay sued the Port after the Port expanded by developing a new terminal. Even though a half mile separated the new terminal from the residential area, homeowners complained that the bright lights from the terminal interfered with their right to enjoy their homes.[80]

The experience at T4 and T5 at the Port of Portland, and at the Canaveral Port Authority and Port of Los Angeles, demonstrates that unmitigated light effects from port activities can negatively affect area residents. These experiences also demonstrate, however, that effective mitigation measures can help limit these negative effects. To the extent that the Port of Portland develops WHI without taking light effects into consideration, the resulting light pollution could negatively affect local residents. We found no studies of the economic costs of light pollution in situations comparable to the WHI port. We note, however, that among the potential negative impacts of port or industrial areas on Q of L of adjacent neighborhoods, light effects seem the easiest to mitigate.

D. Air Quality Effects

The Development Scenario could produce two sources of air-quality impacts. The first is particulate matter from diesel exhaust. Operations at port and rail facilities involve a number of diesel-powered engines including those on ships, trains, and heavy trucks that move cargo within the port and transport cargo on roadways throughout the region. The second potential source of air-quality impacts is dust from loading and unloading bulk materials such as potash or grain. We describe each of these sources and experiences with air impacts at the Port of Portland and other ports. We then summarize the literature on the economic costs of air-quality impacts from port operations. We begin by describing the problems associated with air-quality impacts from port and rail facilities.

Port activities, including construction, operations and transport, can emit harmful air pollutants including particulate matter (PM) and diesel exhaust. Oceangoing ships that call on ports can emit sulfur dioxide (SO_2) and nitrogen oxide (NO) and cargo-handling equipment like cranes and trucks are major sources of PM and NO_x. For example, researchers found that traffic generated by and activities in the ports of Los Angeles and Long Beach contribute to over 20% of all NO_x emissions in the Los Angeles area. [81]

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[79] Maritime Journal. 2006. "Tackling Light Pollution in Ports," Maritime Journal. Available Online: www.maritimejournal.com. MJ Information No. 22412. November 1.

[80] Pitman, D. 2010. "Homeowners Sue Port Authority Over Noise, Light Pollution," *KUHF Houston Public Radio*. March 23.

[81] Moretti, E. and M. Neidell. 2009. "Pollution, Health, and Avoidance Behavior: Evidence from the Ports of Los Angeles." National Bureau of Economic Research. Working Paper 14939. May.

Air pollutants emitted by port and rail operations can negatively impact human health by increasing the incidence of asthma, respiratory diseases, cardiovascular disease, lung cancer, pre-term and low-birth weights, and premature death. Researchers who conducted a 2007 study of the Port of Oakland concluded that the life expectancy of residents living near the port is more than ten years shorter than residents of other nearby areas.[82] In another study of the Port of Oakland, analysts with the American Lung Association calculated that one in five children living near the port has asthma and the area has the highest asthma hospitalization rate in California.[83] Other researchers found that exposure to ozone near the ports of Los Angeles and Long Beach contributes to the ozone-related hospital costs of nearly $2 million per year.[84]

Staff from the California's South Coast Air Quality Management District found that residents of Los Angeles and Long Beach had one of the nation's highest lifetime risks of cancer from toxic air pollution. They attributed 84 percent of this high region-wide cancer risk to diesel exhaust emissions, 94 percent of which come from mobile sources, including port operations.[85] Diesel exhaust from port activity is of particular concern in the Portland airshed because diesel emissions are the number one source of toxic air pollution in the metropolitan area.[86]

We note that much of the literature on the impacts of port operations on air quality comes from research conducted in the Los Angeles area. This region has some of the worst air quality in the United States. While existing research support the conclusion that port operations contribute to air-quality impacts, ports are but one among other sources of pollution in this region. For this reason we must be careful when interpreting research results from the Los Angeles area for insights into air-quality impacts of ports elsewhere.

Dust from ports can be an annoyance and also pose serious health risks, including eye irritation and infection, digestive system diseases, and occasionally skin disease, bronchitis, tracheitis, and pneumonia.[87] Increases in ground-level ozone from seaports can affect respiratory morbidity by irritating lung airways, decreasing lung function, and exacerbates existing respiratory symptoms, such as asthma.

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[82] East Bay Alliance for a Sustainable Economy. 2007. "Taking the Low Road: How Independent Contracting at the Port of Oakland Endangers Public Health, Truck Drivers, and Economic Growth." Oakland, California.

[83] Cannon, J. 2009. "Container Ports and Air Pollution." Energy Futures, Inc.

[84] Moretti, E. and M. Neidell. 2009. "Pollution, Health, and Avoidance Behavior: Evidence from the Ports of Los Angeles." National Bureau of Economic Research. Working Paper 14939. May.

[85] South Coast Air Quality Management District. 1999. "Multiple Air Toxics Exposure Study II." November.

[86] City of Portland. 2010. "Sustainable Procurement Evaluative Criteria Emissions Reduction and Construction Waste Recycling for Use in Construction Services." August.

[87] Baltrénas, P., K.D. Fröhner, M. Pranskevičius. 2007. "Investigation of Seaport Air Dustiness and Dust Spread." *Journal of Environmental Engineering and Landscape Management* XV(1): 15-23; Clean Air Task Force. 2005. "An Analysis of Diesel Air Pollution and Public Health in America." Boston, MA. February.

Regulatory officials expect that projected changes in air-quality regulations will reduce air-quality impacts from ports, rail yards and other industrial areas relative to current conditions. State and federal regulations already target harmful air pollutants from seaport operations, and regulatory staff predict that the continued phasing-in of air-quality standards will significantly reduce some air pollutants over the next 25 to 30 years. For example, phasing-in federal standards for diesel fuels and engines will continue reducing PM from diesel exhaust by up to 90% by 2030, relative to 2010.[88] EPA regulations specifically target the types of diesel engines and fuel used in port operations. According to the EPA:

- beginning in 2006, "…refiners began producing ultra-low sulfur diesel fuel … for use in heavy duty highway diesel engines. Nonroad diesel engines were required to use low sulfur … diesel fuel beginning in 2007 and ultra-low sulfur diesel fuel beginning in 2010."

- "Locomotives and smaller marine engines required low sulfur diesel fuel beginning in 2007 and ultra-low sulfur diesel fuel beginning in 2012. In addition emission standard for large commercial marine diesel vessels like cruse and container ships will be phased in beginning in 2011."

- "In addition to reducing emissions from existing diesel fleets, these cleaner fuels enable the use of advanced after-treatment technologies on new engines. Technologies like particulate traps, capable of emission reductions of 90% and more, are required under new standards which began phasing in for the highway sector in 2007, and will begin taking effect in the nonroad sector in 2010."

- "These programs will yield enormous long-term benefits for public health and the environment."[89]

Actions taken by port managers also help mitigate air-quality effects of port operations. For example, all of the 10 largest U.S. container ports have environmental departments that ensure compliance with government regulations and create environmental protection strategies.[90] Most strategies focus primarily on reducing emissions from diesel by switching to cleaner diesel engines, installing pollution-control equipment, and switching to cleaner grades of diesel fuel that have lower sulfate contents. Many of these ports have a long-term plan to switch to alternative fuels, including natural gas, electric vehicles, and biodiesel. For example, the Port of

[88] CRC FEIS, 2011. Page 3-276; Environmental Protection Agency. 2011. "Regulations and Standards." Available Online: http://www.epa.gov/otaq/highway-diesel/regs.htm. June 29.

[89] http://www.epa.gov/cleandiesel/reg-prog.htm

[90] It is worth noting, however, that the largest contributors of particulate matter at these container ports may be large truck volumes. Other types of ports, for example the one proposed for the WHI port, may not have a similar impact.

Los Angeles debuted the first ever 100% electric vehicle deployed at a U.S. container port.[91]

Motivated by the fact that port operations contribute to air-quality effects, managers at the Ports of Seattle, Tacoma and Vancouver, BC (the Ports) partnered with regulatory agencies to identify and implement changes that would reduce air pollution from port operations. This partnership produced the Northwest Ports Clean Air Strategy (Strategy) in 2007. The Ports report annually on their progress toward achieving specific performance milestones for reducing "… port-related air quality impacts on human health, the environment, climate change, and the economy."[92] To reach these milestones, the Ports' staff developed performance measures for major operations including ocean going vessels, cargo handling equipment, trucks, rail, harbor vessels, and port administration. The Ports' staffs' first assessment of performance milestones in 2010 found progress in all operations, but not all the milestones were met. Staff will continue refining and improving their actions and report the next round of milestone results in 2012.[93]

The Port of Portland also has a program of environmental objectives and targets. Air-quality targets for fiscal year 2011-2012 include reducing diesel PM from Port-controlled operations by 25 percent below year 2000 levels by 2015, and reducing Port direct and indirect emissions of greenhouse gases 15 percent below year 1990 levels by 2020.[94]

The air-quality effects at Port of Portland T4 and T5 provide some insights into potential air-quality effects of the bulk terminal proposed for WHI. Kinder Morgan moves soda ash through T4 and Columbia Gran moves grain through T5, the bulk terminal currently anticipated for WHI could process either or both of these commodities. Kinder Morgan received complaints about dust produced from their operations at T4. Kinder Morgan responded by setting up air monitors at the perimeter of their facility to track dust movement and improved the efficiency of their bag house and dust collectors. Columbia Grain took actions to mitigate the air-quality impacts of their operations including hiring a consultant who provides ongoing monitoring at the facility, upgraded some of their bag houses, and began applying food-grade oil to grain to reduce dust produced with grain movement.[95]

At this time, no data exist on the magnitude or geographic extent of any potential air-quality effects of the WHI port. As we noted above in our discussion of potential noise impacts, researchers who study the impacts of ports on Q of L suggest developing a HIA, which could include air-quality effects. According to these

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[91] Cannon. 2009. "Container Ports and Air Pollution."

[92] Port of Seattle, Port of Tacoma, and Port of Metro Vancouver (The Ports). 2010. *Northwest Ports Clean Air Strategy 2010 Implementation Report*. Draft 1. April 8. Page, iv.

[93] The Ports, 2010, Page v.

[94] Port of Portland. *2011-2012 Environmental Objectives and Targets*. Available Online: www.portofportland.com.

[95] City of Portland. 2010. *Local Impacts*. Pages 6-9.

researchers, the air-quality portion of a HIA for a port similar to the one proposed for WHI could address a number of questions associated with potential air-quality effects including the fillowing.

- What is the geographic extent of the affected airshed and what populations, schools, employment centers, etc. are located in this airshed?
- How will port-related activities affect air quality in the affected airshed?
- What other sources of air pollution are present near the WHI port and what is their contributions to air pollution in the affected airshed?
- What is the current prevalence of asthma and other respiratory diseases, cardiovascular disease, cancer risk, low birth weight babies in the affected airshed?[96]

The economics and air-quality literature includes reports on the cost of the types of air pollutants produced by ports, railroads and other industrial areas. For example, in one study researchers estimated the per ton costs for the following pollutants: NO_2= \$10,248; PM_{10} = \$6,842; SO_2 = \$2,508; and CO = \$1,456.[97] The Oregon Department of Environmental Quality likewise estimates that each ton of diesel PM imposes \$395,425 in environmental damage and health costs to Oregonians.[98]

As we did with traffic- and noise-related costs, we calculate an illustrative cost of air pollution for one year of port operations using information from the literature on air-pollution costs and data specific to WHI. Again, we stress that these costs are illustrative and not definitive. Also, our illustrative cost calculation assumes no mitigating measures that could minimize air pollution effects from the WHI port. We factor in the phase-in of federal standards for diesel fuels and engines that analysts estimate will reduce PM emissions from diesel exhausts by 90%.

We can illustrate the cost of air pollution as a result of the additional traffic generated by the WHI port using a model developed by researchers from the Bureau of Transportation Statistics (BTS). Using results from the City's traffic analysis of WHI, our calculation assumes the port would generate 2,050 additional vehicle trips, of which 516 are trucks and 1,534 are cars. We assume 35 mpg for cars and 8 mpg for trucks. The BTS model includes the following costs per ton of pollutant type: VOC = \$4,455, NO_x = \$10,349, CO = \$15.21, and PM_{10} = \$132,616.[99]. The model also assumes

[96] .For more details on specific questions that a HIA of air-quality effects could address see: Heller, J. et al. 2010. *Lost Angeles and Long Beach Maritime Port HIA Scope Working Draft*. Prepared by Human Impact Partners for the U.S. EPA. May 17; and, UC Berkeley Health Impact Group, 2010. *Health Impact Assessment of the Port of Oakland*. University of California, Berkeley, CA. March.

[97] Nowak, D.J., D. Crane, and J. Stevens. 2006. "Air pollution removal by urban trees and shrubs in the United States." *Urban Forestry and Urban Greening* 4: 115-123. Converted from 1994 dollars to 2006 dollars using the CPI.

[98] Oregon Department of Environmental Quality, Bureau of Planning and Sustainability. 2012. "Clean Diesel Efforts." Available Online: http://www.portlandonline.com/bps/index.cfm?a=247878&c=42402.

[99] Based on the morbidity and morality cost per ton of each pollutant.

the emission rates of each pollutant in (grams/gallon) are: 69.9 for CO, 13.6 for NO_x, 16.2 for VOC, and 0.0825 for PM_{10}.[100]

Table 3 below illustrates the potential air pollution costs of truck and car traffic generated by the WHI port per vehicle mile traveled. Since we do not have information on how far each vehicle would travel, we cannot illustrate the total cost of the vehicle trips. We therefore calculated the costs of all 2,050 port-specific vehicles traveling one mile.

Table 3. Costs of Air Pollution Generated by Proposed Port Facility Traffic, per Vehicle Mile Traveled

	Trucks	Cars	Total
Cost of air pollution, per vehicle	$0.04	$0.02	
Cost of air pollution, all port traffic	$18.69	$26.06	$45.61

Source: ECONorthwest staff estimates with data from Ozbay and Bartin. 2001.

Notes: While the fuel consumption of trucks (8 mpg) is higher than that of cars (35 mpg), the proposed port would generate significantly more car traffic and so the total cost of air pollution from cars is higher than that from trucks.

Not all air-quality effects of the WHI port would be negative. To the extent that the port improves the efficiency of ship, rail, and truck traffic, it would help reduce regional air-quality effects below what they would be in the Baseline Scenario. One impact of improved port and transportation efficiencies is moving comparable amounts of freight with lower emissions of carbon and other air pollutants.

E. WHI Bridge

The Concept Plan for the proposed annexation and development of WHI includes a bridge that connects WHI with Marine Drive (WHI bridge). Given the preliminary nature of the Concept Plan, no detailed engineering or cost studies of the bridge exist at this time. The Concept Plan includes a very preliminary cost estimate for the bridge of $50 million to $100 million.[101] According to the City's traffic analysis of the Development Scenario, the WHI bridge would significantly reduce the amount of port traffic that would travel through EHI to I-5. According to this study, with the bridge, approximately 226 vehicle trips per day, including trucks and cars, would travel NHID to and from I-5. Without the bridge, the daily number increases to 2,050 trips.[102] These results represent the high-end, or worst case estimate of the potential impact of port operation on traffic. The actual impacts may be less.

[100] These rates are based on expected emissions rates for passenger vehicles in New Jersey. Since we also include trucks in our analysis, which likely exhibit higher emissions rates, these values are likely an understatement. We also adjusted the estimates to account for the anticipated 90% reduction in PM_{10} emissions that likely will result from new federal regulations by 2030.

[101] WorleyParsons. 2012. Order of Magnitude Cost Estimate —Draft. Memo to Eric Engstron, City of Portland from Bill Dunlap, WorleyParsons. January 4. Table B Infrastructure Estimate Page 8.

[102] Hillier, 2011. Pages 7, 13.

One of the benefits of the WHI bridge would be travel-time savings for the 89 percent of port traffic that would use the bridge. Based on the City's transportation study, and our interview with one of the City transportation engineers who worked on that study, we estimate that traveling over the WHI bridge and down Marine Drive to I-5 saves at least 2 minutes compared with traveling NHID between WHI and I-5. Assuming these conditions, we calculate the value of travel time saved because of the WHI bridge as follows. We begin with the City's traffic projections for the port traffic that would use the WHI bridge of 500 truck trips and 1,325 car trips per day, each trip saving 2 minutes. This equals approximately 16.7 hours of time savings per day for trucks and approximately 44.2 hours of time savings per day for cars.[103] Next, we multiply these time savings by the value of time as reported in the report on the cost of congestion in the Portland region.[104] We use time values per hour of $40.31 ($2011) for truck trips and $15.36 ($2011) per hour for car trips. We calculate the annual value of travel time saved by multiplying hours saved per day by 365, and multiplying the result by the value of time for trucks and cars.[105] Using this method, data and assumptions, we calculate that trucks and cars using the WHI bridge save travel time valued at $493,480 ($2011), for one year.

The WHI bridge would also benefit the Q of L of EHI residents by minimizing the amount of port-related traffic that travels through or near their neighborhoods, and by offering another route on or off the island when I-5 becomes congested. Minimal truck traffic on NHID would also be more compatible with the proposed growth and development of EHI as described in the Hayden Island Plan. According to the Hayden Island Plan, EHI will grow and develop over the next few decades. This growth is projected to include 2,800 new housing units, with part of this growth occuring in a new transit-oriented development adjacent to the new light rail stop. The Jantzen Beach SuperCenter will be redeveloped and modernized and include mixed-use developments. To the extent that NHID is the main access for the WHI port and industrial-type development on WHI, it may limit the interest of prospective developers to make the investments that would support the types of growth and development envisioned in the Hayden Island Plan. The risk is that because of the port traffic, EHI develops a feel and reputation of an industrial area, rather than residential or retail area. As a result, future types of development in EHI may not reflect those envisioned by the Hayden Island Plan, and would be less desirable and of lower valued.

The uncertainty regarding the types of goods or materials that could pass through the WHI port in the future, and possibly through their neighborhood, also concerns residents of EHI. As we describe in the section of this report on port effects, we cannot be certain today about the goods or materials that would pass through the WHI port 20 or 30 years from now. The best guess anyone has now about materials

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[103] 500 truck trips * 2 minutes = 1,000 minutes/60 minutes per hour = approximately 16.7 hours. 1,325 car trips * 2 minutes = 2,650 minutes/60 minutes per hour = approximately 44.2 hours.

[104] Economic Development Research Group, 2005. Appendix C, Page 8.

[105] 16.7 hours/day saved for trucks * 365 days * $40.31 = $245,645; 44.2 hours/day saved for cars * 365 days * $15.36 = $247,836; total savings = $493,480.

that could possibly pass through WHI and travel through EHI on NHID to I-5 is large trucks transporting autos to car dealers up and down I-5. The concerns of EHI residents is that if NHID is the only access to the WHI port from I-5, that at some point in the future more hazardous or traffic-intensive materials will travel this route, which would negatively affect their Q of L.

IV. Summary

Experiences at the Port of Portland and at ports elsewhere show that port operations can negatively affect the Q of L of those living in neighborhoods adjacent to ports. Negative Q of L effects include increased traffic, noise, light, and air pollution. Given these experiences, we expect that the Development Scenario would cause negative Q of L effects for those living in and traveling through EHI. Data do not exist, however, that would allow us to calculate the economic cost of these negative effects. Using data reported for Q of L effects at other ports we illustrate the potential magnitude of some of these effects.

Experiences at the Port of Portland and ports elsewhere also show the range of options that can help mitigate port-specific Q of L effects. Based on these experiences, mitigation works better for some effects than others. Light effects seem the easiest to mitigate. Changing work practices mitigated noise effects of loading rail cars with bulk materials. Likewise, improved filtration proved effective at mitigating air quality effects of transferring bulk materials. Loading autos onto rail cars, and the noise and air quality effects of truck and rail traffic to and from the port seem the effects most challenging to mitigate.

While the Development Scenario may generate negative local Q of L effects, there may be some positive effects at the regional level. To the extent that the WHI port improves the efficiency of ship, rail and truck traffic, it would help reduce negative air-quality effects below what they would be without it.

Some researchers suggest conducting a HIA as a means of identifying Q of L effects of the Development Scenario. In this case, a HIA could help characterize noise and air quality effects. Regarding noise effects, one of the unknowns is the extent to which the distance between the WHI port and residences on EHI—and the topography and other features of the landscape—will buffer potential noise effects of port operations. Another unknown is the extent to which port-specific rail and truck traffic will cause noticeable increases in noise effects over conditions in the Baseline Scenario. Specific to air quality, a HIA could help characterize marginal increases in air pollutants above baseline levels, and describe the relationship between increases in air pollutants and health effects on local populations. These measures could include, for example, the estimated number of missed days of school and work for residents and workers in the impacts area, or any increased incidence of asthma attaches and required medical treatments. If the port development includes a nexus to the Federal government, e.g., receives Federal funding, it could require an EIS, which could include an assessment of local Q of L effects similar to that of a HIA.

Port Effects

I. Introduction

The port facility is a key element of the development scenario. In this section, we investigate how the development and utilization of additional port capacity would affect the economy, particularly the local economy. Specifically, we explore several questions that help policymakers assess the benefits of port development, including:

Who might benefit from the development of additional port capacity?

Under what circumstances will benefits from port development be realized?

Will benefits be large or small?

What share of benefits will be enjoyed locally?

However, benefits alone do not determine the desirability of the development scenario. Benefits must be weighed against costs, and economists consider costs beyond simply the costs of building infrastructure, etc. An evaluation of port development must also account for opportunity costs. That is, it must address how the economy would develop if the resources devoted to developing the port were employed in their next best use. If the resources employed in developing and operating the port facility would find productive uses elsewhere in the local economy in the absence of development, then the net local benefits from port development may be small; on the other hand, if the resources employed in developing and operating the port would be otherwise un- or under-employed, then the net benefits of port development may be large.

As we discuss in greater detail later in this section, economists cannot precisely describe the future evolution of Portland's economy with and without the development of an, as yet un-designed, port facility on WHI. In recent years, ports' role in local economies changed and thus the economic effects associated with port development have become more uncertain. Given these uncertainties, we cannot precisely calculate the potential economic effects of port development. Instead, in this section, we outline key relationships, trends, and data that will help decisionmakers and stakeholders understand the costs, benefits, and economic tradeoffs of investing public funds in a WHI port facility. Specifically we emphasize the following:

(1) Many of the benefits created by port development are enjoyed globally – by firms and consumers outside of Portland; however, many of the costs of developing and operating the report remain concentrated locally.

(2) Historically, ports played a significant role in local economic development – firms found it advantageous to locate near ports because locating near a port meant substantially lower transportation costs; however, significant declines in

transportation costs have diminished the effect of ports on firm location and local economic development.

(3) A successful port facility is a large traded sector entity (that is, it sells services produced in Portland to consumers outside the region). As such, it likely generates local economic benefits similar to those generated by the development of a large factory (or other traded sector entity). Such benefits may include more jobs and higher incomes for local workers, higher property values for homeowners, greater tax revenue for local government, and greater productivity in related industries.

(4) In the absence of the development of WHI, the resources that would have been devoted to WHI may have been used to invest in other projects that promote local economic development. Developing WHI produces net benefits to the extent that the port facility (and other aspects of WHI development) generates larger local economic benefits than these alternatives.

(5) The existence of economic benefits from port development hinge on the existence of demand for the facility. An un- or under-utilized facility produces few local economic benefits.

We describe each of these points in more detail in the remainder of this section.

II. Potential Beneficiaries of a WHI Port

A. Port users

Ports generate economic value by facilitating the movement of goods across long distances. A better, more efficient, port system lowers the cost of moving goods from producer to consumer. These cost savings provide benefits to consumers, who may pay lower costs for goods, and to producers, who may enjoy higher profits. The potential benefits to producers and consumers explain why demand for ports exists.

B. Port and other inputs to the production of port services

Demand begets supply. The existence of demand encourages parties to produce port services. The central player in the production of port services is the port itself, but many other parties directly participate (e.g., other transportation firms (rail/truck), terminal operators, ILWU and its workers, towing, pilots, agents, surveyors/chandlers/maritime services, forwarders, warehouse container repair, government, maritime equipment/construction, barge, related banking/insurance/law, shippers/consignees).[1] Each of these parties may profit (or benefit) from the development and utilization of port facilities. Entities that provide other inputs into the production of port services and entities that sell goods and services to those who earn port-related income also may benefit from port development (these effects are commonly referred to as multiplier effects).

[1] This list is based on the categories of direct impacts in Martin and Associates economic impact analyses for the Port of Portland.

C. Owners of Local Land, Labor, and Capital

Finally, ports may generate additional local benefits by spurring local economic development that would not otherwise occur.[2] Such effects stem from both the boost in local demand created by the port operations and from any firms that may invest in an area because they value proximity to the port (or that value proximity to the firms attracted by the port).[3] To the extent that these firms would have located elsewhere and economic activity would diminish without the port, the port creates economic benefits by creating additional demand for land, labor, and capital throughout the region.

III. Role of Ports in Regional Economies

A. Historic Role

Historically, many port users were local and firms highly valued proximity to ports. Thus, ports could produce substantial local economic benefits. Economists Amy Helling and Theodore H. Poister effectively summarize the traditional benefits that ports provided to their local economies, stating:

> "Historically, urban areas hosting maritime ports benefited directly from investment and local employment at the port and in port-related industries, from access to a wider supply of imported goods at lower prices than elsewhere, and from ready access to extended markets for their exports. In addition, there are indications that the wide and sophisticated array of maritime service businesses serving urban ports enhanced the economic development of nearby areas because they were well suited to innovation and diversification."[4]

In short, the people or firms in a port's immediate vicinity captured much of the value produced by a port. When land transportation was relatively expensive, producers seeking access to wider markets wanted to locate as close to the port as possible to minimize transportation costs and expand their access to markets. For similar reasons, retailers of imported goods wanted to locate close to the port. Thus, many of the goods shipped out of or into a port did not travel a great distance from the port (i.e., each port had a limited hinterland). The advantages of locating near a port increased the demand for (and thus the value of) nearby land, workers, and

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[2] Yochum, G.B. and V.B. Agarwal (1987) "Economic Impact of Port on a Regional Economy: Note" *Growth and Change* 2: 74-87; Eberts, Randall W. (1998) "Principles for Government Involvement in Freight Infrastructure." From Special Report 252: Policy Options for Intermodal Freight Transportation, Transportation Research Board, National Research Council, Washington, DC: National Academy of Sciences, pp. 117-152.

[3] Yochum and Agarwal (1987).

[4] Helling, A. and T.H. Poister (2000) "U.S. Maritime Ports: Trends, Policy Implications, and Research Needs." *Economic Development Quarterly* 14(3): 300-315. citing to Campbell, S. (1993) "Increasing trade, declining port cities: Port containerization and the regional diffusion of economic benefits." In H. Noponen, J. Graham, and A.R. Markusen (eds.) *Trading industries, trading regions: International trade, American industry, and regional economic development* (pp. 215-255). New York: Guilford. and Corbett, KS. (1996) "Double or nothing: The big stakes of hub ports." *The Journal of Urban Technology* 3(2): 1-10.

other capital and furthered economic development. Through this process, ports catalyzed the growth of many of the largest cities in the United States (e.g., New York, Boston, Philadelphia).[5]

B. Recent Changes

In recent decades, however, the relationship between ports and their local economies changed.[6] Over the 20th century, the cost of moving manufactured goods declined over 90% in real (or inflation adjusted) terms.[7] As a result, ports serve larger geographic areas. The growth of each port's hinterland spread the benefits created by the port over a larger area. For instance, because the share of the goods flowing through a port that come from local producers or go to local consumers declined,[8] the (large) share of port-related benefits that accrue to port users have leaked further into the port's hinterland.[9]

The WHI port, as currently envisioned, illustrates this change. The goods currently expected to flow through West Hayden Island (autos, grain, or dry bulk) will not come from local firms or end up in local stores. Instead, West Hayden Island (WHI) would serve as a convenient transshipment point in part of a much longer supply chain. For instance, if a Canadian firm ships potash from Saskatchewan to China through Portland, the user benefits from this transaction will be captured by the Canadian company or the Chinese consumers (or other middlemen). While the benefits to these parties are real, they are global in scale. Important for our analysis, most of these benefits do not occur in the Portland metro area.

In addition to declining local user benefits, changes in the port industry also reduced the profits earned by ports and related port producers. First, competition between ports increased (in part due to the fact that port hinterlands now frequently overlap), and greater competition typically reduces port profits (while increasing user benefits).[10] Given that port owners are local, but users are frequently global, more

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[5] O'Sullivan, A. (2010) *Urban Economics.*

[6] Helling and Poister (2000), Luberoff, D. and J. Walder (2000) US Ports and the funding of intermodal facilities: An overview of key issues. Cambridge: Massachusetts Institute of Technology, New England University Transportation Center; Ferrari, C., M. Percoco, A. Tedeschi (2010) "Ports and Local Development Evidence from Italy" International Journal of Transportation Economics 37(1): 9-30; Benacchio, M., C. Ferrari, H.E. Haralambides, and E. Musso (2000) "On the economic impact of ports: Local vs. national costs and benefits." *Forum of Shipping and Logistics, Special Interest Working Group on Maritime Transport and Ports International Workshop*, Genoa June 8-10, 2000.

[7] Glaeser, Edward L. and J.E. Kohlhase. (2004) "Cities, Regions and the Decline of Transport Costs." Papers in Regional Science 83(1): 197-228

[8] Helling and Poister (2000), Luberoff and Walder (2000),

[9] Helling and Poister (2000), Luberoff and Walder (2000), Ferrari et al (2010), Benacchio et al (2000)

[10] Benacchio et al (2000), Helling and Poister (2000),

competition may increase the share of port-generated benefits accruing to parties outside the port's community.[11]

Second, technological change has decreased the labor intensity of port activities and increased the capital intensity.[12] The work of moving goods between ship and shore used to be done predominantly and sometimes exclusively by many workers, but technological changes have reduced the number of workers required to provide port services. Given that benefits enjoyed by workers typically remain in the port community but benefits to capital owners frequently leak outside the port community (because capital owners can live anywhere), this change has potentially reduced the benefits of ports to their local economies.[13]

Port changes also reduce the local economic development spillovers from port activity.[14] The growth of port hinterlands and the decline in overland transportation cost have reduced the attractiveness of locating near ports for many potential port users. Many firms no longer are willing to pay higher prices for land, labor, and capital near ports because they can ship their goods long distances at low cost. As a result, many economists argue that "the localized, indirect economic development benefits to … cities hosting a port are far smaller than they once were."[15]

The spread of port benefits across a larger area creates tension around port development. The benefits created by ports are increasingly global, but the costs remain concentrated locally.[16] Many of the costs associated with investment and operation (particularly those paid by public ports), the environmental costs, and other negative local spillovers remain concentrated in the port's local community. The decline in local benefits generates more scrutiny for port developments as members of the port's community want to know if the local benefits of port development are sufficient to justify the local costs.

IV. Local Benefits from a WHI Port

A. Background

A port facility like the one envisioned for WHI does not generate the same local economic benefits as a 19th century port. The local economic benefits created by a WHI port resemble those generated by a factory (or other traded sector entity). The port employs local resources (labor and capital) to produce port services that it sells primarily to consumers outside the region. The money brought into the region helps

[11] Benacchio et al (2000)

[12] Benacchio et al (2000)

[13] Benacchio et al (2000)

[14] Glaeser and Kohlhase (2004), Helling and Poister (2000), Luberoff and Walder (2000), Ferrari et al (2010), Benacchio et al (2000), Musso, E., C. Ferrari, and M. Benacchio (2006) "Port investment: Profitability, Economic Impact, and Financing" *Research in Transportation Economics* 16: 171-218.

[15] Helling and Poister (2000); see also Luberoff and Walder (2000), Benacchio et al (2000)

[16] Benacchio et al (2000)

support other local businesses, potentially increasing income and employment in the local sector. Greater economic activity may increase tax revenues, population, and/or property values. To the extent the port affects the success and location of other firms (e.g., perhaps due to greater local economic efficiency and agglomeration effects), these effects will be magnified.

Below, we describe the potential local economic benefits generated by a WHI port in more detail for each of the potential beneficiaries outlined above—port users, the port entity, and indirect beneficiaries of port attracted or induced investments.

1. Port Users

As currently envisioned, a WHI port will generate few local user benefits. The current plan envisions WHI as a convenient transshipment point for far away producers shipping goods to far away consumers. Local user benefits could materialize if the auto terminal allows local auto dealers and consumers to get cars at lower costs. Local user benefits could also stem from the 14-acre marine industrial facility. The magnitude of local user benefits from the marine industrial facility will depend on (a) whether the firm is locally owned and (b) where its consumers are located.

It is also possible that a WHI port would increase overall port efficiency (perhaps due to economies of scale) so that port users throughout region—more of whom are local companies—benefit.

Ultimately, the magnitude of local user benefits will likely be small, but that could change as facility users change over the 50–100 years covered in this analysis.[17]

2. Port and Other Inputs to Production of Port Services

The inputs involved in providing port services (e.g., the port and the other inputs used to supply port services) collect a substantial share of the local economic benefits generated by port facilities.

One potentially large locally beneficiary is the Port of Portland. However, whether or not the Port of Portland (the Port) will financially benefit from the Development Scenario is a tricky question. As a public enterprise, the Port is not required to make profits on its investment. The Port's mission is "to enhance the region's economy and quality of life by providing efficient cargo and air passenger access to national and global markets," not make profits.[18] As such, the Port could be willing to lose money on the investment (either by pricing below costs and accepting a higher risk of losses than private investors might accept) in order to achieve some larger, perceived

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[17] The Greater Portland Metro Export Strategy describes a plan to help *local* businesses access global markets and increase local employment. That Strategy does not, for the most part, affect the commodities at issue in this analysis—autos imported from Asia and exports of bulk materials and grain. These commodities do not originate or benefit local businesses, except for the possibilities described above. www.greaterportlandinc.com

[18] Port of Portland (2010) Strategic Plan and Budget 2010-2015.

public benefit.[19] The existence of a public mission, though, does not mean that the Port does not care about the profitability of its investments. Public ports typically have dual missions – the private one to maximize profits and the public one to promote local economic development.[20]

In part, the magnitude of local economic benefits generated by the Port itself will depend on whether or not the Port evaluates the investment from a private or public perspective. If the Port focuses on its private mission, the Port will *only* invest in the Development Scenario when it expects to earn profits at least as large as its next best investment opportunity. In this scenario, assuming the Port correctly forecasts demand, the costs of developing and operating the WHI port (including mitigation costs paid by the Port) will be paid from Port revenues and the Port will still earn profits at least as high as its next best investment. If the Port focuses on its public mission, then the Port itself may lose money on the investment, and some other party would be responsible for covering some of the costs of development, mitigation, and operation.

Regardless of the perspective it uses to evaluate the investment, the benefits or costs incurred by the Port will ultimately be determined by actual market conditions. If demand is strong, the Port may profit, but if demand falls it may not. We describe demand forecasts in Section E below.

Another group of potential beneficiaries of the WHI port are the other inputs to port production, including port workers. Throughput production requires more than port facilities. Moving goods between ocean-going vessels and barges, trains, and trucks requires the following types of inputs: other transportation firms, including rail and truck; terminal operators; ILWU and its workers; towing companies; pilots; agents; surveyors, chandlers, and maritime service providers; forwarders; warehouse container repair service providers; government entities; maritime equipment and construction companies; barges; and related banking, insurance, legal, and consignee services. Each of these groups provides some good or service that complements a marine facility. As such, when port development allows for greater port activity, these groups benefit to the extent that they earn higher profits or wages than they would have earned in the absence of the port.

Ultimately, how much these groups add to local economic benefits created by the WHI port depends on:

(a) How much throughput will flow through the WHI port?

(b) How the marginal change in throughput will affect demand for each potentially affected group?

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[19] The port economics literature debates whether or not ports should be willing to price below cost or accept higher risk. On the one-hand, if ports generate positive spillovers for the economy, then private markets may undersupply port services. On the other hand, below cost pricing could lead to an oversupply of ports (which in turn leads to inefficient expenditures.), see Musso et al (2006), Luberoff and Walder (2000)

[20] Luberoff and Walder (2000), Musso et al (2006)

(c) How much profit (or economic surplus) each group would collect as a result of expanded activity?

Addressing each of these issues for a not-yet-designed WHI port more than a decade away from operation is difficult. The WHI port's capacity and actual utilization could, in reality, differ substantially from anything we can currently imagine. Similarly, the inputs required to move throughput through the WHI port will likely differ from what we can currently imagine. Finally, the difference between what these inputs can earn from port operations and their next best alternative will also depend on distant economic conditions.

3. Owners of Local Land, Labor, and Capital

Finally, a WHI port could generate additional local benefits if it spurs local investment and economic activity that would not otherwise occur. The likelihood and magnitude of such benefits is an outstanding question and the subject of much debate. As noted previously, spillover economic benefits have declined in recent decades, but decline does not necessarily imply that such benefits do not exist or will not exist in the future. Research results reported in economics and development literature do not provide definitive answers. Some argue that port development does not efficiently foster local economic development because it provides benefits to faraway firms that may compete with local producers, and, if funded with tax dollars, requires higher taxes that may make the area less attractive.[21] In addition some research has found that modern ports do not significantly affect firm location decisions.[22] Others, though, argue that ports attract and induce significant investment and stimulate local economic activity or that these effects may increase in the future if gas prices substantially increase overall transportation costs.[23]

A WHI port may also generate local economic benefits in the form of tax revenues for the city. To the extent that the WHI port increases economic activity in the region, the city will enjoy increased tax revenues. City tax revenues, though, will only constitute a local economic benefit if the taxes are paid by non-local entities. Taxes paid by local parties reflect transfers from one local entity to another and thus do not generate net economic benefits for the region. To the extent, however, that the money the city receives ultimately comes from a non-local entity (e.g., a global shipper), city tax revenues reflect economic benefits.[24]

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[21] Goss, R.O. (1990) "Economic policies and seaports. The economic function of ports." *Maritime Policy and Management* 17: 207-220.

[22] Gripaios, P. and R. Gripaios (1995) "The impact of a port on its local economy: the case of Plymouth" *Maritime Policy and Management* 22: 13-23.

[23] Yochum and Agerwal (1987), Martin and Associates (2010), Hall, P.V. (2004) "`We'd have to sink the ships': Impact studies and the 2002 West Coast port lookout" *Economic Development Quarterly* 18(4):354-367.

[24] Note that for the purposes of this discussion, the party who pays the tax does not need to be the party who hands money over to the government. Producer X may be the one who pays the city; however, if X simply raises their prices to pay the tax, then X does not ultimately pay the tax, X's consumers do.

In short, a WHI port, as currently envisioned, will likely benefit the Port and the other resources involved in the production of port services. It also may produce some spillover benefits, but such effects have diminished over time. Finally, a port development on WHI will not likely produce substantial local user benefits.

B. Empirical Analysis

The precise magnitude of the net benefits created by investment in port facilities is difficult to determine. To assess the benefits of a WHI port, policymakers need to be able to quantify the effects of the port and this entails somehow describing the world with the WHI port and comparing it to the world without the WHI port. That is, policymakers want to know how much value the port creates for the local economy that would not exist otherwise. Relevant questions include: how much profit the port and other firms involved in the production of port services will earn that they would not otherwise earn; how will wages for port workers differ from wages at the jobs they would otherwise hold (if any); how much employment at the port reduces un- or under-employment in the region (both for workers directly and indirectly affected by port activities)?

Answering these questions – particularly for hypothetical future projects covering very long time horizons – is difficult. Indeed, one economist, Randall Eberts, argues that "[e]mpirical research on the benefits of freight transportation does not offer estimates of the benefits and costs with sufficient precision to be of much help" in evaluating potential projects.[25] Existing data and analysis, however, provide some information about the potential economic activity associated with a port facility like the one envisioned for WHI. We summarize this information in the following subsections. We must interpret this information with caution because any calculation of the economic benefits of a WHI port will rely on several layers of assumptions, many of which have relatively weak empirical support—weaknesses that will only be exacerbated by the passage of time between now and the assumed commencement of port operation in 2026.

1. Port Impact Studies

Researchers commonly describe the economic activity created by ports using something known as a Port Impact Study (PIS). PIS attempt to flesh out the relationship between port activity and the rest of the economy in order to quantify the economic benefits (typically measured in jobs or incomes) created by the port.

While there are a number of slightly different methods one can use to complete a PIS, the consulting firm Martin and Associates employs one of the most common approaches in reports they regularly complete for the Port.[26] The Martin and Associates' reports start by using a survey to measure the direct impacts of the port, which capture the effects generated by cargo moving through the port facility. Then, building from the estimate of direct jobs and incomes, Martin and Associates use a

[25] Eberts (1998)

[26] Martin and Associates (2006, 2010), Bennachio (2000)

input-output model to calculate indirect impacts, which result from directly affected firms purchasing inputs for their production, and induced impacts, which result when them employees of directly affected firms purchase goods and services in the local economy.

In the second column of Table 1, *Total Portland Harbor*, we present the results from the most recent Martin and Associates report on the economic impacts of the Portland Harbor area as a whole. According to these analyses, activity at the Port generates 7,011 direct jobs, 17,512 total jobs, and a total personal income of over $1.4 billion. To place these values in context, these values amount to 0.7 percent, 1.7 percent, and 1.6 percent of total employment and personal income in the Portland-Vancouver metropolitan area.

In 2010, Martin and Associates reported the results of a Port of Portland analysis specific to WHI, based on a slightly different development concept than the current Development Scenario in our analysis. Rather than a port expansion of 300 acres total for bulk, auto and marine industrial uses, this analysis assumes that the Development Scenario would include 250 acres of port and 100 acres of marine industrial uses, for a total port-expansion of 350 acres. This analysis does not present results based on the commodities expected to flow through WHI. Instead, it assumes that impacts from the port would equal the average per-acre impacts from all of Portland Harbor. We modified the results reported by Martin and Associates to adjust for the smaller development footprint in the Development Scenario in our analysis. We scaled down the estimates for a 350-acre port facility to reflect a 300-acre facility by simply multiplying all values by .857 (or 300/350). We report the results in the third column of Table 1, *West Hayden Island Estimate #1*.

Table 1. Summary of Results from Recent Economic Impact Analyses

	Total Portland Harbor	West Hayden Island Estimate #1	West Hayden Island Estimate #2
Jobs (Employment Years)			
Direct	7,011	1,175	937
Induced	6,668	1,591	891
Indirect	3,833	847	512
Total	17,512	3,613	2,340
Personal Income ($1,000s)			
Direct	$355,907	$64,003	$47,566
Induced	$871,367	$192,764	$116,456
Indirect	$193,015	$39,441	$25,796
Total	$1,420,288	$296,208	$189,818
Business Revenue ($1,000s)	$1,481,570	$240,324	$198,008
State and Local Taxes ($1,000s)			
Oregon	$80,998	$19,977	$10,825
Washington	$55,221	$10,292	$7,075
Total	$136,219	$30,269	$17,900

Source: ECONorthwest staff estimates with data from Martin and Associates (2010).

We also calculate the potential impact of a WHI port using information from the 2010 Martin and Associates analysis of WHI, and from our recent harbor lands analysis.[27] We take Martin and Associates' estimates for the relationship between direct jobs and commodity throughput, and multiply these figures by the number of direct jobs per 1,000 tons of capacity shortfall in the "most likely" scenario in the ECONorthwest (ECONW) harbor lands report. We report the results in the fourth column of Table 1, *West Hayden Island Estimate* #2. Table 2 presents the assumptions we use in our calculation of the number of direct jobs for our analysis of *West Hayden Island Estimate* #2.

Table 2. Assumptions Used in Illustrative Calculation for Direct Jobs Created by the WHI Port

	Portland Capacity Shortfall (1,000s tons)	Direct Jobs per 1,000 Tons of Commodity	Direct Jobs per Marine Industrial Acre	Estimated Direct Jobs Associated with WHI Port
Automobiles	410	1.34	–	549
Grain	2,930	0.09	–	215
Dry Bulk	2,960	0.03	–	89
Marine Industrial	–	–	6	84
Total Direct Jobs				**937**

Source: ECONorthwest staff estimates.

We caution that readers should not interpret the results in Table 1 as precise calculations of the expected economic impacts of the WHI port. They are best viewed as providing a rough baseline order of magnitude of impact. Based on these results, we recommend that readers assume that the WHI port will generate the direct employment of approximately 900–1,200 people and associated personal income of $45–$65 million. Including multiplier effects, the WHI port may be associated with 2,000–4,000 jobs, $200–$300 million in personal income, and approximately $18–$30 million in state and local tax revenue. This range roughly reflects the range between our *West Hayden Island Estimates* #1 and #2.

2. Limitations of Economic Impact Studies

Port impact studies do not precisely describe the impact of port facilities on economic activity. Results of the port impact analyses must be interpreted with caution for a variety of reasons. First, measuring direct impacts is inherently subjective. How researchers identify direct effects varies from study to study, and what researchers choose to include will affect the results.[28] Second, researchers have

[27] Moore, T. and N. Popenuk. 2012. *Portland Harbor: Industrial Land Supply Analysis*. ECONorthwest. Prepared for the City of Portland: Bureau of Planning and Sustainability. In association with Maul Foster & Alongi, Inc. and Bonnie Gee Yosick. March.

[28] Davis, C.H. (1983) "Regional Port Impact Studies: A critique and suggested methodology" *Transportation Journal* 17:61-71.

employed several different methods to calculate total impacts and different methods may produce different results.[29] Third, port impact studies only describe the immediate relationships. Such studies are "especially unreliable as time passes" because they "typically assume fixed technology, industrial structure, and demand."[30] Over time these relationships change. For example, several authors have noted that the relationship between throughput and local economic activity has declined in recent decades.[31] Also, port impact studies do not capture all of the potential spillover benefits of port developments, e.g., improved efficiency at the port or improved transportation efficiencies. As such, we cannot say today how closely the results above will represent outcomes that would exist between 2026 and 2126, the period considered in this analysis.

Given these difficulties, we do not find it surprising that many economists argue that using port impact studies to justify port investments is "especially controversial" because they "fail to provide reliable guidelines in determining whether or not port facilities should be expanded."[32] Economic impact analyses do not account for all potential benefits (or costs) and not all (or even most) of the impacts on jobs and income they describe qualify as economic benefits for purposes of benefit cost analysis.

3. Economic Impacts vs. Economic Benefits

More important, the economic impacts described in Table 1 are not equivalent to the net economic benefits considered in a benefit-cost analysis (BCA). While many people believe that the jobs and incomes associated with a project adequately describe the benefits of the project, economists disagree. First, economic impact analyses do not describe many of the potential benefits described above. For instance, economic impact analysis does not capture any of the benefits to port users. Since many of these benefits likely accrue to entities outside the local area, this flaw has minimal effects on this analysis. However, economic impact analysis also does not capture a variety of potential effects that could be relevant, e.g., any effects on property values, any effects on port/transportation efficiency, any effects on the location decisions of other firms, etc.

Second, in the area of potential benefits most closely related to economic impact analyses – impacts on producers and workers, economic impact analyses do not, by themselves, describe economic benefits. Economic impact analyses describe the number of jobs and amount of income that may by traced back to port activity; however, the jobs and incomes created by port activity may not constitute *net* economic benefits.

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[29] Benacchio et al (2000)

[30] Hall (2004)

[31] Hall (2004), Luberoff and Walder (2000)

[32] Hall (2004), Benacchio et al (2000)

Whether or not the jobs created by port development generate net economic benefits depends on conditions in the relevant labor markets and the geography of interest to decisionmakers and stakeholders. Regarding local labor markets, the extent to which the results of an economic impact analysis characterize net economic benefits of port development depends on the extent to which workers would remain under- or un-employed in the absence of development. When unemployment is high, some workers may enjoy large benefits from projects that increase employment; however, when unemployment is low, workers will enjoy relatively small benefits.

In general, economists argue that, over the long-run, resources are fully employed.[33] This argument is grounded in the belief that, in general, productive resources do not sit idle for long periods of time. Temporary events, like the current economic slump, may cause some resources to go un- or under-utilized for some period, but, over the long-run, economists believe that the market will figure out how to employ most idle resources productively.[34] Historical data support the notion that the economy tends to operate close to full employment when measured over the long run and across relatively large geographies.[35]

Based on this view, BCA guidelines recommend ignoring secondary economic impacts such as jobs and employment income altogether.[36] For instance, the Office of Management and Budget's guidance on performing BCA states:

> "Generally, analyses should treat resources as if they were likely to be fully employed. Employment or output multipliers that purport to measure the secondary effects of government expenditures on employment and output should not be included in measured social benefits or costs."[37]

As such, under this assumption, the economic impacts of a project could be large, but net economic benefits could be small.

Regarding the geography of interest in an analysis, some argue that projects, like port investment, can generate net economic development benefits within specific regions because greater potential exists for some resources to be un- or under-employed in a local context.[38] This may occur because some resources (including

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[33] Benefit-cost analyses also frequently assume that resources are perfectly mobile (which helps ensure that, over the long-run, resources are fully employed at their opportunity cost).

[34] Hamilton et al (1991), Eberts (1998), Boardman et al (2006)

[35] See, for instance, Congressional Budget Office and Bureau of Economic Analysis discussions of the output gap.

[36] Office of Management and Budget (1992) Circular No. A-94 Revised, Boardman, A.E., D.H. Greenberg, A.R. Vining, and D.L. Weimer (2006) *Cost-Benefit Analysis: Concepts and Practice Third Edition*. Upper Saddle River New jersey: Pearson Prentice Hall, Hamilton, J.R., N.K. Whittlesey, M.H. Robison, and J. Ellis (1991) "Economic Impacts, Value Added, and Benefits in Regional Project Analysis" *American Journal Agricultural Economics* 73: 334-44.

[37] OMB (1992)

[38] Hughes, D.W. and D.W. Holland (1993) "Economic Impacts, Value Added, and Benefits in Regional Project Analysis: Comment" American Journal of Agricultural Economics 73: 759-762; Eberts (1998)

many people) cannot or do not want to move to the places where they could be more fully employed. If that were the case here, the assumption of full employment would not hold and some of the jobs and incomes generated by the port would represent net economic benefits.

The magnitude of the benefits created depend on the wages workers would earn in the absence of port development and the value people enjoy if they do not work. For instance, the benefits from development for workers equal the difference in the earning at their job with the port versus their earnings in the job they would hold without the port (e.g., a worker who would earn $60,000 if the port were developed, but only $50,000 if the port were not developed would enjoy $10,000 of benefits from development). Alternatively, if the worker would not work at all in the absence of port development, benefits equal the difference between the wages earned (e.g., $60,000) and the value the worker places on not working (e.g., $40,000). Economists do not have consensus estimates for the wages workers might earn in the absence of development or the value they place on not working. The range of plausible estimates for the economic benefits from job creation spans from zero to more than 100 percent of the direct employment effects.[39] Ultimately, while projects can generate net economic benefits, they do so not by stimulating economic activity, but by creating a situation where people can earn more than they would otherwise, or by employing otherwise under-utilized resources. One of the key challenges to completing a benefit-cost analysis of a WHI port entails determining what value the port generates that would not otherwise exist in the region. Rather than try to quantify the future net value of the WHI port—for the reasons mentioned above—we describe the net benefits the port would have to generate to cover the relevant costs. We describe this comparison in the final section of this report. One of the key factors in making this comparison is understanding the extent to which demand will exist in the future for the proposed port facility. We address this question in the next subsection.

V. Will Demand for a WHI Port Exist?

Without sufficient demand for the WHI port, the Port is unlikely to devote scarce resources to developing the property and the rest of the potential benefits will never materialize. Thus, the existence of a sufficient level of demand is a necessary condition for the WHI port to generate any benefits.

Since 2004, forecasters have completed 5 forecasts for port demand in Portland and other Lower Columbia River ports.[40] Each of these forecasts predicts that regional trade volumes will grow into the future; however, each forecast presents a different picture of the volumes and commodities expected to flow through regional ports over the next 30 years.

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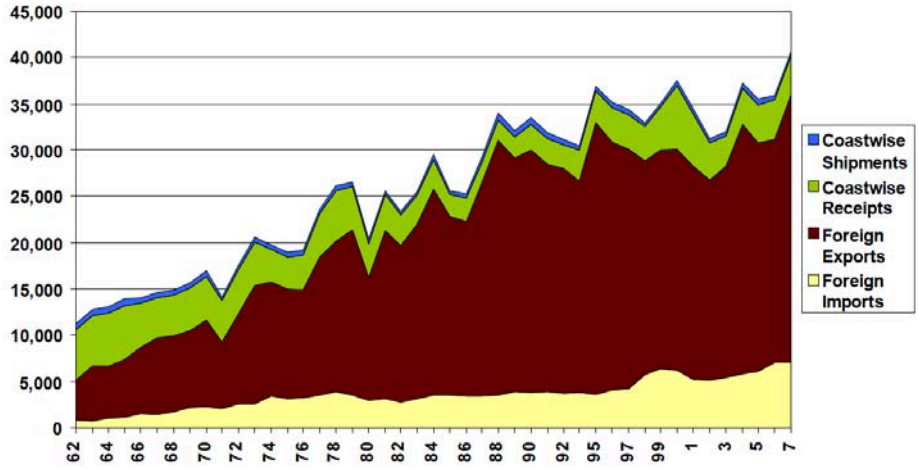
[39] Bartik, T. (2011) "Including Jobs in Benefit Cost Analysis" Upjohn Institute Working Paper

[40] "2004 Marine Cargo Forecast." BST Associates. 19 May 2004.; "West Hayden Island Economic Foundation Study." Entrix. July 2010.; "2009 Marine Cargo Forecast." BST Associates. 23 March 2009.
"West Hayden Island Marine Cargo Forecasts & Capacity Assessment Final Report." BST Associates. 2 April 2010.; "Portland and Vancouver Harbor Forecast Update Draft Report." BST Associates. January 2012.

Figure 1. Lower Columbia River Marine Cargo Trends (1,000 metric tons)

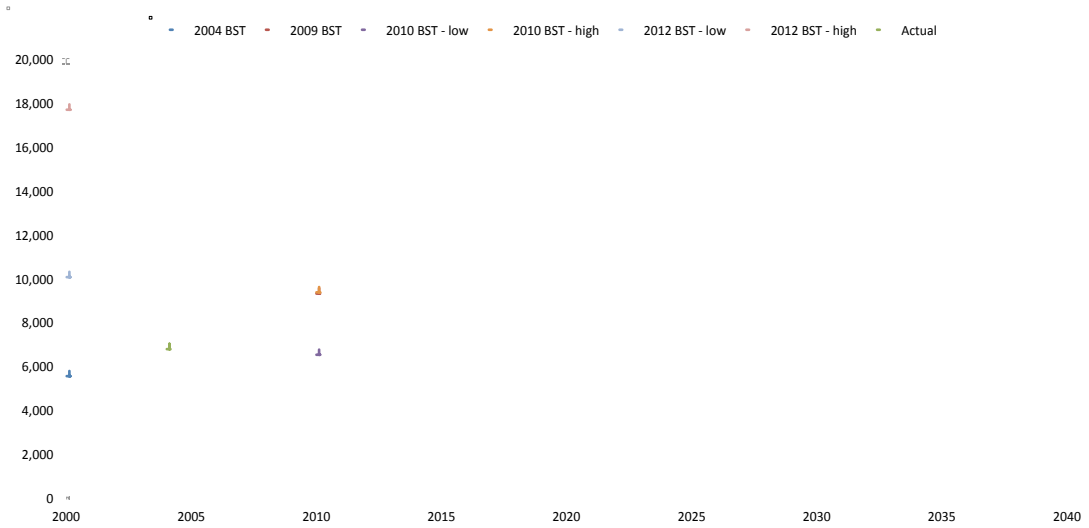


Source: BST Associates; U.S. Army Corps of Engineers Waterbourne Commerce Statistics

Figure 1 presents the trend in Lower Columbia marine cargo since 1962. Over the 45 years covered in this figure, cargo volumes nearly quadrupled. In simple terms, this long-run growth trend provides the foundation for the forecasted growth. Forecasters expect volumes to grow because they have grown over a long period of time.

The magnitude of the expected growth presented in the various forecasts varies. Figure 2 illustrates the wide range of forecasted throughput values for a single commodity, dry bulk, for the Port (or, in some forecasts, all Oregon ports on the Lower Columbia of which the Port is the dominant provider). In 2004, BST Associates projected that dry bulk throughput at Oregon's Lower Columbia ports would equal 5.8 million tons by 2025. By 2009, BST was forecasting dry bulk throughput equal to 9.5 million tons by 2025. In 2010, BST projected that throughput at the Port would fall between 6.2 million and 8.6 million tons by 2030 (and between 6.7 and 9.6 million tons by 2040). Finally, most recently, in 2012, BST projects that dry bulk throughput at the Port will range between 9.5 million and 15.9 million tons in 2030 (and 10.3 and 17.9 million tons in 2040). These forecasts indicate significant changes in expected throughput for a single commodity, from a single forecasting firm, over a relatively short period of time. In particular, the high end of the most recent forecast is substantially different than previous forecasts.

Figure 2. Forecasts of Throughput Values for Dry Bulk, 2004-2040



Source: BST Associates (2004); BST Associates (2009); BST Associates (2010); BST Associates (2012)
Notes: 2004 and 2009 BST are forecasts for the lower Columbia and all others are forecasts for the Port of Portland.

The forecasts for other commodities exhibit similar variation. Table 3 presents the range of forecasts for each specific commodity as well as the results from the most recent forecast completed by BST Associations in January 2012. While the variation across forecasts differs, the projected future volumes for each commodity have fluctuated significantly over a relatively short period and the high end of the most recent BST forecast for the commodities most likely to flow through WHI has increased substantially. BST explains the change in its forecasts by noting that "a key effort in this update was to consider the potential market opportunities that are being evaluated by individual ports in the PNW."

Table 3. Forecast Range by Commodity Group

	Breakbulk	Dry Bulk	Liquid Bulk	Grain	Total Bulk & Grain	Containers	Autos
Overall Low	1,000,000	4,650,000	2,089,000	5,600,000	5,647,000	379,000	925,000
Overall High	1,493,000	17,909,000	8,011,000	11,470,000	24,567,733	2,876,000	1,400,000
2012 Low	1,251,000	10,278,000	6,912,000	6,686,000	N/A	2,162,000	1,030,000
2012 High	1,493,000	17,909,000	8,011,000	11,470,000	N/A	2,876,000	1,281,000

Source: BST Associates

These forecasts suggest that volumes will grow and that additional port capacity in the Lower Columbia may be utilized in the future; however, growing volumes do not necessarily imply that a WHI port will be utilized. Other capacity exists to satisfy some potential demand elsewhere in the region. For example, the *2010 Entrix Report* concluded, "If WHI is not developed, it appears that the existing and planned

terminals at ports located on the Washington side of the Lower Columbia River may be able to meet forecasted cargo demand."[41] A more recent study conducted by ECONW that relied on the most recent BST forecast found that if demand falls in the low end of the range, Portland/Vancouver Harbors will require one additional auto terminal and one additional dry bulk terminal by 2040; however, at the high end of the range, demand would support three auto terminals, three grain terminals, and ten dry bulk terminals (as well as one terminal each for containers, breakbulk, and liquid bulk).

Thus, as described by the available forecasts, demand for a WHI port may or may not exist by 2040. The forecasts described above project trade volumes based on long-run macroeconomic forecasts and then assume that specific ports will keep attracting approximately the same share of traffic as it has in the past. Both volumes and shares flowing to specific ports, however, could deviate from current expectations and deviations could be both up or down.

Economist H.E. Haralambides effectively summarizes the difficulty forecasting port demand, stating:

> "As a result of intertwined and extended hinterlands; abundant land infrastructure and short-sea feedering networks; continuously evolving liner shipping networks; and the infamous `mobility' of the container, demand is very volatile and unpredictable. Port market shares are unstable; investments in one region or country have an impact on another … In such a `fluid' environment, how could one forecast port demand with any degree of credibility?"[42]

The Port acknowledges several of the factors that make forecasting port demand difficult in its Strategic Plan. The Port notes:

> "The Port and the carriers that call its facilities operate in highly competitive and volatile industries. Freight shipments and air travel directly reflect economic activity levels and other market dynamics such as exchange rates, oil prices and income levels."

Shipments of individual commodities can fluctuate, sometimes significantly, over time for the reasons mentioned above. Long-run trends in overall demand for port services, however, have increased relatively consistently, and reflect overall growth in the global economy. So, while past forecasts may not have accurately predicted the types of commodities shipped today, the overall volumes of total goods shipped has increased at relatively predictably rates. Ultimately, whether or not demand for additional port facilities on the Lower Columbia materializes will depend on the factors that affect both the demand for and supply of port services, including:

- Demand for exports (e.g., grain, dry bulk, etc.) produced in Port's hinterland

[41] Entrix (2010)

[42] Haralambides, H.E. (2002) "Competition, Excess Capacity, and Pricing of Port Infrastructure" *International Journal of Maritime Economics* 4:323-347.

- Demand for imports (e.g., autos) consumed in Port's hinterland
- Investments at competing ports
- Investments in rail and road networks that connect to regional (and competitor) ports
- Advances in port and/or shipping technology

In brief, factors that affect the price or competitiveness of the WHI port relative to other ports or affects the volume of trade flowing through the Pacific will change demand. Given that many such events have not (and will not) be incorporated into forecasts until they occur in the future, the available forecasts should be interpreted with these caveats in mind.

Conclusions

In this section, we summarize the results from the previous sections and present our conclusions in the forma of a framework intended to help policymakers address the fundamental question: are the local economic benefits from the Development Scenario likely to exceed the costs? We also summarize results on the distribution of the major economic effects of the Development Scenario

I. Local Economic Benefits and Costs

As we describe in the section on Port Effects, any calculation of the economic benefits of a WHI port would necessarily rely on several layers of assumptions, many of which would have relatively weak empirical support—weaknesses that would only be exacerbated by the passage of time between now and the assumed commencement of port operations in 2026. Rather than present a calculation of port benefits based on many assumptions that lack a solid foundation, we reverse the question. Instead of asking "are benefits larger than costs," we ask, "how large would local port benefits need to be to justify the local costs?

We begin by describing the net economic costs and benefits of the Development Scenario. In Table 1 we summarizes the net costs and benefits for the natural resource and recreation effects, and the costs of port-specific development, including the WHI bridge. In effect, the totals in Table 1 represent the net quantifiable costs of the Development Scenario relative to the Baseline Scenario.

The costs and distribution of costs between the City and Port of Portland for the WHI infrastructure and WHI bridge come from WorleyParsons' estimates of the costs of implementing the Concept Plan for WHI, and from estimates and assumptions by BPS staff. Natural resource and recreation net costs come from those sections of this report. The distribution of these costs between the City and Port of Portland come from estimates and assumptions by BPS staff.

The cost of developing port infrastructure to the City and the Port equals $71 million without a new bridge and $87.25 million including the cost the new bridge and street improvements. The net *cost* (benefits minus costs) of resource mitigation equal $27.1-$30.1 million, (costs exceed benefits) and the net *cost* of developing recreation facilities equal $0.3-$0.81 million. In addition, development would impose some unspecified amount of costs on local residents. In sum, developing WHI would cost between $115 and $118 million, in 2011 dollars. Some of these costs will be paid by the city (and thus taxpayers), some will be paid by the Port, some will be paid by other local entities.

We exclude from Table 1 development costs that will be paid by port tenants based on the assumption that, as private actors, tenants will not incur those costs unless they expect to earn a sufficient rate of return.[1] We also exclude costs that will be paid by state and federal governments because those reflect costs to entities outside the local area.

Except for the costs associated with developing recreational resources and mitigating natural resources, we assume that the costs of the Development Scenario are incurred immediately and thus they are not discounted. This leads us to slightly overestimate costs, but given that we do not know the timing of costs, we conservatively assume that these costs are incurred immediately.

Table 1. Net Costs of the Development Scenario, in 2011 dollars

Cost Category	City of Portland	Port of Portland	Change in NPV of Ecosystem Services	Total
Developing WHI Infrastructure	$6.5 million	$64.5 million		$71 million
WHI Bridge[1]	$5 million	$11.25 million		$16.25 million
NPV of Natural Resource Mitigation Costs (100 years)[2]		$24.5 million	$2.6–$5.6 million	$27.1–$30.1 million
NPV of Recreation-Related Costs (100 years)	$1.2-$2.65 million	$1.2-$2.65 million	($1.59) – ($5)[3] million	$0.3-$0.9 million
Local Effects	*Not Quantified*			
Total	**$12.7–$14.15 million**	**$101.45–$102.9 million**	**$1.01– $0.6 million**	**$115–$118 million**

Source: ECONorthwest staff estimates with data from elsewhere in the report.
Notes:
[1] Total cost of the bridge estimated at $100 million. BPS staff estimate that in addition to the funds paid by the City of Portland and the Port of Portland, port developers would pay $25 million and State and Federal transportation funds would provide the remaining $58.75 million.
[2] Including value of ecosystem services.
[3] Dollar amounts in parenthesis are benefits, not costs.

Ultimately, for the Development Scenario to prove worthwhile, the net present value of the WHI port and port-related benefits should exceed $115 to $118 million plus the amount of the negative local effects.

Stated slightly differently, given that benefits from port activities will occur as a stream over time, we estimate the average annual benefit the port facility would need to generate for benefits to exceed costs. If we rely on assumptions similar to those used to calculate the NPV of recreation and natural resource effects (e.g., extend analysis through 2112, assume a discount rate of 3 percent), and we assume that the WHI port earns sufficient revenue to cover all operation, maintenance, and replacement costs, the port

[1] The general assumption used by economists is that private firms will not invest in a project unless the expected rate of return exceeds the rate of return on other investments (see for instance Eberts (1998).

must generate an average of approximately $5.5 million dollars of net benefit each year it operates to produce a sufficient level of benefit to cover this level of costs.[2] Changing the assumptions would change this value. For instance, performing the calculation using 50 years of port operation changes the average, annual net benefit to approximately $6.5 million.

Thus, the question facing policymakers regarding the economic differences between the Development and Baseline Scenarios boils down to whether or not they expect the WHI port, other port inputs, any local users, and other local owners of land, labor, or capital to benefit by approximately $5.5 million per year, on average. If the Port or any other party suffers losses (including local residents), the benefits to remaining parties must cover these losses in addition to the $5.5 million described above.

As described in the Port Section of this report, we cannot precisely calculate the expected economic effects of port development. While we are confident that port investment could increase regional economic activity in the future, data do not exist that can describe (a) the relationship between future demand for port services in general and the amount of throughput that would pass through a WHI port, and (b) how much of port related income would have been earned regardless of the proposed WHI port. Thus, we cannot estimate what the likely benefits of a WHI port with a reasonable degree of certainty. We can, however, help illustrate the key assumptions that one would need to make to accept or reject the idea that the benefits of port investment will exceed the costs.

As we describe in the Port Section, we use existing port economic impact studies to project the potential impact of a WHI port facility on local economic activity. We re-present the results from our analysis in Table 2 below. Applying existing economic impact estimates to the expected development of WHI, we project that a WHI port facility may directly employ 900–1,200 people who may earn associated personal income of $45–$65 million. Adding in multiplier effects, the WHI port may be associated with 2,000–4,000 jobs, $200–$300 million in personal income, and approximately $18–$30 million in state and local tax revenue.

[2] We reach this conclusion as follows. Assume the Port and related entities earns approximately $5.8 million per year through 2112. Discount those amounts to current dollars assuming a 3% discount rate. The present value of this future stream of revenues equates to approximately the average of the Total Costs listed above in Table 1.

Table 2. Summary of Results from Recent Economic Impact Analyses

	Total Portland Harbor	West Hayden Island Estimate #1	West Hayden Island Estimate #2
Jobs (Employment Years)			
Direct	7,011	1,175	937
Induced	6,668	1,591	891
Indirect	3,833	847	512
Total	17,512	3,613	2,340
Personal Income ($1,000s)			
Direct	$355,907	$64,003	$47,566
Induced	$871,367	$192,764	$116,456
Indirect	$193,015	$39,441	$25,796
Total	$1,420,288	$296,208	$189,818
Business Revenue ($1,000s)	$1,481,570	$240,324	$198,008
State and Local Taxes ($1,000s)			
Oregon	$80,998	$19,977	$10,825
Washington	$55,221	$10,292	$7,075
Total	$136,219	$30,269	$17,900

Source: ECONorthwest staff estimates with data from Martin and Associates (2010).

As we discuss in more detail in the Port Section, these economic impacts do not reliably describe local economic benefits. First, the actual impacts may differ from these projects due to different throughput volumes or changing port technology. Second, economic impact studies do not describe the effects of port development on all potential beneficiaries (e.g., they do not account for potential user benefits, effects on overall port efficiency, or effects on firm location decisions). Third, economic impact studies do not describe the benefits that local residents would have enjoyed in the absence of port development.

In order to adjust the economic impact estimates to more closely reflect potential economic benefits, we need to account for the potential limitations described above. Specifically, there is some chance that the direct and multiplier effects associated with port activity will be smaller than the amounts presented in Table 2. There is also a good chance that some of the activity generated by port development and utilization would have occurred in the absence of port development.

Given that the available data do not provide precise values for how to adjust the economic impact estimates, in Table 3 below we present a range of assumptions that decision-makers can use to adjust the results of the economic impact analysis in order to determine whether or not annual port related local economic benefits will likely exceed the threshold ($5.5 million) required for local economic benefits to exceed local economic costs.

The rows in Table 3 present different assumptions that one could make about what share of the potential economic impacts described in the column *West*

Hayden Island Estimate #1 of Table 2 would represent net economic benefits. The columns present different assumptions that one could make about how much of the personal income calculated for this estimate would have been earned regardless of the WHI port. For instance, if one assumes that the actual impact of a WHI port will be 50 percent of the approximately $300 million estimated under *West Hayden Island Estimate #1* and that only 5 percent of that income would not have been earned in the absence of the WHI port, then the net income created by the WHI port will exceed $7.5 million per year.

Table 3. Impact of Alternative Assumptions for Net Benefits from the Development Scenario (millions of dollars)

		Share of impact on personal income that would not have been earned without the Development Scenario			
Share of Martin & Associates (2010) estimated impact that will actually be realized local		**0.05**	**0.1**	**0.2**	**0.3**
	1	$15.00	$30.00	$60.00	$90.00
	0.75	$11.25	$22.50	$45.00	$67.50
	0.5	$7.50	$15.00	$30.00	$45.00
	0.25	$3.75	$7.50	$15.00	$22.50

Source: ECONorthwest staff estimates with data from Martin and Associates (2010).

Thus, for net port benefits to fall below the net costs of the Development Scenario, one must assume that impacts will be *significantly* lower than the amount estimated by Martin and Associates and one must assume that *nearly all* of the income related to the WHI port would have been earned even without port investment.

Comparing the figures above from Table 3, with the estimated annual income and revenues to cover expected costs of $5.5 million, we see that for incomes not to cover costs in this illustration, we have to assume that the WHI port would provide less than 50 percent of the economic activity described in *West Hayden Island Estimate #1*, and that between 5 and 10 percent of personal incomes in this estimate would not otherwise exist without the WHI port.

We conclude that, given the relatively small annual value that would need to be created to offset the costs, it is likely that the Development Scenario will generate net local economic benefits relative to the Baseline Scenario. Our conclusion assumes demand for the WHI port is sufficient to justify port investment.

When using Table 3 to compare potential benefits to the potential net costs described elsewhere in this report, it will be helpful to remember that the economic impact estimates may understate the local benefits created by the WHI port for a variety of reasons:

- Local user benefits are assumed to equal zero. To the extent that, for example, car dealers in the Portland metro area benefit from the port,

or shippers that use the WHI port open offices in Portland, these types of developments would increase the benefits in our illustrative comparison.

- The WHI port is not assumed to earn profits higher than its next best investment.
- The WHI port is not assumed to trigger other regional investments that benefit local producers and consumers (e.g., improved rail or road networks or greater overall port efficiency).
- The local tax revenue generated by the economic activity related to the WHI port (approximately $20–$30 million) are levied on and paid by local residents (that is, none of these tax revenues are directly or indirectly collected from distant port users)[3] To the extent that non-local port users pay local taxes, the benefits in our illustrative comparison would increase.

Similarly, the values described above may overstate benefits for the following reasons:

- The WHI port may lose money on the investment and not be able to pay for the costs of development out of port revenues. Any port losses would be added to the other costs (while many public ports earn sufficient profits to cross a "self-sufficiency" criterion development by the federal government, others, including the Port in recent years, do not).[4]
- The negative spillovers from port operations on the local community are not quantified and could be significant.

To the extent that these unquantified costs and benefits exist, one would need to further adjust the benefit value obtained from Table 2 or the cost values obtained from Table 1.

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[3] Economists typically view taxes as a transfer from one party to another. Local tax revenue may be a benefit to the region if it is paid by non-local parties; however, if it represents income that would otherwise have been kept by local residents and businesses, then tax revenues reflect a transfer of money from one local party to another. How much tax revenues are collected from non-local entities depends on the incidence of the taxes. That is, it depends on how much the party who ultimately writes the check to the government can increase the price in collects (or decrease the price it pays) to offset their tax payments.

[4] The self-sufficiency criterion requires that a port earn enough in operating and interest revenue to cover its operating expenses and depreciation without counting tax revenues or other extraordinary payments (see U.S. Department of Transportation Maritime Administration (1997)). Applying this criterion to the Port of Portland's marine and other operations, we found that the Port has not been self sufficient over the past several years.

II. Distribution of Economic Effects

In this subsection we describe the distribution of the total costs and benefits of the Development Scenario and compare the local benefits with local costs.

Beginning with recreation effects, the Development Scenario would provide new recreation amenities and benefits not available in the Baseline Scenario. We expect residents local to the Portland area would enjoy the large majority of these benefits. The City and Port of Portland would share the costs of developing these facilities. Thus, the large majority of costs and benefits associated with the recreation effects would be local.

For the reasons we describe in the Natural Resource section of this report, the Development Scenario would reduce the supply and value of ecosystem services relative to the Baseline Scenario. We expect that the reduced value of ecosystem services would mostly affect those in the Portland area. The Port of Portland would pay the costs of natural resource mitigation. Given these conditions, the costs of the natural resource effects would happen locally, with no offsetting net benefits locally or otherwise.

For the reasons we describe in the Port section of this report, a large portion of benefits of the new port facility would accrue to port users located outside the Portland area. Some benefits, though, would happen locally (e.g., at the Port of Portland and for workers at the port). The Port of Portland would pay the large majority of the infrastructure costs of developing the facility. The City of Portland would pay a small portion of these costs. Port tenants and State and Federal taxpayers would pay the remainder. Given these conditions, some benefits and some costs would happen locally and some would happen nationally or globally.

Residents of EHI would enjoy the benefits of the new recreation facilities described above, but could experience significantly negative impacts on their quality of life. As we describe in the Local Effects section of this report, we recommend studying more closely the potential quality-of-life impacts as part of a Health Impact Assessment or as part of an EIS, should one be required for the new port facility.

As we describe in subsection I. Local Economic Benefits and Costs, if the port facility generates $5.5 million per year in net economic benefits, it would justify the expenditure of costs incurred by the City and Port of Portland. We conclude that it is likely that this would be the case. Thus, we expect that the local benefits of the Development Scenario would exceed the local costs.