3.0 ALTERNATIVES

In considering NorthernStar's applications, the FERC will review both the environmental and non-environmental record in deciding whether it is in the public convenience and necessity to issue any authorization for the project. The EIS addresses alternatives to the proposed actions before the FERC, the COE, and the Coast Guard. The FERC must consider whether or not to approve the facilities proposed by NorthernStar.

The COE will review permit applications submitted by NorthernStar in October 2006 under section 10 of the RHA and section 404 of the CWA. The Coast Guard will consider issuing an LOR under its regulations at 33 CFR 127.009 regarding the suitability of the waterway for LNG marine traffic.

3.1 FERC ALTERNATIVES

In accordance with the NEPA and Commission policy, we have evaluated a number of alternatives to the Bradwood Landing Project to determine if any are reasonable and environmentally preferable to NorthernStar's proposed action. Alternatives considered by the FERC, described in more detail below, include no action or postponed action, system alternatives, LNG terminal site alternatives, LNG terminal layout alternatives, vaporization technologies, power line route alternatives, pipeline route alternatives, and dredging and dredged material placement alternatives.

Alternatives were evaluated against the objectives of the Bradwood Landing Project, as described in section 1.1. The primary objective of the project is to deliver competitively priced natural gas to meet the growing demands of gas consumers in the Pacific Northwest. To achieve this objective, NorthernStar would: 1) construct and operate an LNG import terminal with docking/unloading facilities capable of berthing one LNG ship, an LNG storage capacity of 320,000 m^3, and LNG vaporization facilities; and 2) construct and operate a pipeline with a peak natural gas sendout capacity of 1.3 Bcfd. The sendout pipeline would serve the target market by delivering natural gas to the Georgia-Pacific paper mill at Wauna, Oregon and the PGE Beaver Power Plant at Port Westward, Oregon, interconnecting with Northwest Natural's existing bidirectional intrastate pipeline facilities capable of transporting gas to their Mist underground storage facility, and interconnecting with the Williams Northwest interstate pipeline system.

The FERC's evaluation criteria for selecting potentially reasonable and environmentally preferable alternatives include whether they:

- are technically and economically feasible, reasonable, and practical;
- offer significant environmental advantage over the proposed project; and
- meet the objectives of the project, as described above.

With respect to the first criterion, it is important to recognize that not all conceivable alternatives are technically and economically feasible and practical. Some alternatives may be impracticable because they are unavailable and/or incapable of being implemented after taking into consideration costs, existing technologies, and logistics in light of the overall project purpose. In conducting a reasonable analysis, it is also important to consider the environmental advantages and disadvantages of the proposed action and to focus the analysis on those alternatives that may reduce impacts and/or offer a significant environmental advantage.

The Commission has three possible courses of action in processing NorthernStar's proposal. The Commission may: 1) deny the proposal, 2) postpone action pending further study, or 3) authorize the proposal with or without conditions. In arriving at a course of action, the Commission considers a range of alternatives in light of the project's objectives, evaluation criteria, and environmental comparisons. Each alternative is considered until it is clear that the alternative is not reasonable or would result in greater environmental impacts that could not be readily mitigated. Those alternatives that appear to be the most reasonable with less than or similar levels of environmental impact are reviewed in the greatest detail.

3.1.1 No Action or Postponed Action

If the Commission denies NorthernStar's proposal or postpones action on the proposal, the short- and long-term environmental impacts identified in this EIS would not occur. If the Commission selects the no action or postponed action alternative, the objectives of the proposed project would not be met and NorthernStar would not be able to import LNG to provide natural gas to markets in the Pacific Northwest. It is purely speculative to predict the resulting effects and actions that could be taken by other suppliers or users of natural gas in the region as well as any associated direct and indirect environmental impacts. However, since the NWGA projects that existing gas supplies and infrastructure will fall short of meeting peak demand conditions by 2010 (NWGA, 2005), customers would have fewer and potentially more expensive options for obtaining natural gas supplies in the near future. For example, the Energy and Environmental Analysis Foundation, Inc. completed a study in July 2004 that determined natural gas consumers in the United States would pay an extra $200 billion (in constant 2003 dollars) by 2020 if LNG terminals and other natural gas pipeline infrastructure projects being proposed at that time were delayed by a period of 2 years (Interstate Natural Gas Association of America (INGAA), 2004). Higher natural gas prices could adversely influence the regional economy by reducing realized household incomes and business profits (Greenspan, 2003).

Higher natural gas prices (or the threat of higher gas prices) could also lead to alternative proposals to develop natural gas delivery infrastructure, increased efficiency and conservation or reduced use of natural gas and/or the use of other sources of energy. The effect of high natural gas prices on the increased demand for other fuels is supported by the energy consumption projections provided in the EIA's Annual Energy Outlook 2006 Report. Under the scenario of rising natural gas prices, coal-fired power plants are projected to make up most of the new plants added for capacity through 2030. Higher natural gas prices were also cited as a reason for the projected increased demand for total renewable fuels (EIA, 2006).

3.1.1.1 Alternative Natural Gas Infrastructure Proposals

The adoption of the no action alternative could result in the expansion of other existing interstate natural gas pipeline systems or LNG facilities to meet the increasing demand for natural gas in the Pacific Northwest. This might include constructing or expanding regional pipelines as well as LNG import and storage systems. In section 3.1.2 we examine system alternatives. Any expansion of existing systems or construction of new facilities would result in specific environmental impacts that could be less than, similar to, or greater than those associated with the Bradwood Landing Project.

3.1.1.2 Increased Efficiency and Conservation of Natural Gas

Denying or postponing a decision on NorthernStar's application could limit access to new supplies of natural gas in the future, which could in turn contribute to higher natural gas prices. Higher prices could potentially result in customers conserving or reducing the use of natural gas. There is no doubt that both conservation and increased efficiency have an important role to play in the future energy needs of the Pacific Northwest. Energy conservation and the increased use of renewable resources have increased dramatically in the Pacific Northwest in recent years and will continue to have an increasing impact on overall energy demand and supply. This increase has been driven in part by the electricity crisis of 2000-2001 and continued volatility in energy costs in the region, combined with government programs designed to help consumers reduce the use of energy (ODE, 2005).

The ODE offers both Business and Residential Energy Tax Credits and an Energy Loan Program designed to help businesses and residential consumers invest in energy efficiency through such actions as the purchase of more efficient appliances, heating and air conditioning systems, and building renovations. These programs have seen dramatic results in the last 5 years. According to the 2005 Oregon Energy Plan (ODE, 2005), in 2000 the combined residential and business energy tax credit programs stimulated savings of 58.9 kilowatt-hours (kWh). By 2003, savings had reached 860.3 million kWh.

Additional energy conservation is achieved through other federal and state programs as well as utility sponsored and regional programs. These conservation efforts are expected to continue and grow throughout the region. In its recently released Fifth Power Plan, the Northwest Power and Conservation Council (which covers Oregon, Washington, Idaho, and Montana) recommended conservation targets of 700 average MW between 2005 and 2009 and 2,500 average MW during the 20-year planning period.

It is important to recognize that projections for energy demand in the region incorporate the savings achieved and anticipated from planned energy conservation measures. While it is possible that continued high natural gas and electricity prices may result in some increase in the rate of conservation, the incremental increase will not have a material effect on the regional demand for new sources of natural gas supply. Additional regional natural gas supplies are needed to compensate for declining United States production and Canadian imports as well as the increasing regional demand from economic growth. Furthermore, energy conservation is not, in itself, an energy source and cannot ultimately replace the natural gas needed by end users such as industrial and residential customers (see section 1.1). Therefore, increased conservation does not provide an alternative to the proposed project, but rather a complementary component of the overall energy demand and supply mix.

3.1.1.3 Other Sources of Energy

It is also conceivable that adoption of the no action alternative could promote the development of other (non-LNG) sources of energy. In order to assess the alternative fuels and energy sources that would potentially be available to replace the needed natural gas supplies to be provided by the proposed project, it is necessary to understand how natural gas is used by consumers in Oregon. According to the 2003 Oregon Energy Plan (ODE, 2003), excluding natural gas used for electrical generation, the industrial sector is the primary consumer of natural gas, using more than both the residential and commercial sectors combined. Further, natural gas accounts for approximately 30 percent of total industrial sector energy use. The primary use of natural gas in the industrial sector is for process heating. During the 1990s, industries shifted to natural gas from wood, heating oil, and electricity. Therefore, in the absence of increasing supplies of competitively-priced natural gas, the industrial sector would likely need to return to these alternative sources to meet demands for energy supplies in the future. However, this may not be possible for all users, as the shift to natural gas in many cases may have required changes in equipment. In these cases, the economic implications of reverting to alternate energy sources may be too great and the users may have no choice but to curtail production.

Commercial and residential use of natural gas is primarily for space and water heating. Again, the shift to natural gas in both the commercial and residential sectors during the 1990s to meet space and water heating demands has meant a shift away from the use of wood, heating oil, and electricity (ODE, 2003). Therefore, in the absence of increasing supplies of competitively-priced natural gas, the commercial and residential sectors would likely return to these alternative sources to meet demands for energy in the future.

For all sectors, the recent shift to the use of natural gas in place of wood, oil, and electricity has led to significant environmental benefits for Oregon and the Pacific Northwest. It is widely recognized that natural gas is the fuel of choice with respect to air emissions. The 2005 Oregon Energy Plan notes that energy use and production have significant impacts on the environment, in particular on air and water resources. With respect to air emissions, the same document notes that natural gas as a fuel for generating electricity produces significantly less CO_2 and nitrogen oxides (NO_x) than existing coal-fired power plants, and virtually no volatile hydrocarbons, sulfur oxides (SO_x) or particulate matter. Coal-fired power plants produced 42 percent of Oregon's 2003 fuel mix for generating electricity. When used directly for space and process heating by consumers, natural gas is also cleaner in air emissions than wood or heating oil. As an alternate to hydropower, which accounted for delivery of approximately 44 percent of Oregon's power generation supply in 2003, natural gas avoids the impacts on endangered salmonids and their habitats in the Pacific Northwest associated with hydropower dams.

As noted above, in the absence of additional supplies of natural gas to meet increasing consumer demand, users would be forced to seek alternate fuels and energy sources. To the extent that users returned to the use of traditional fuels (wood, oil) this shift would result in increased environmental impacts compared to the use of the natural gas that would be provided by the proposed project. With respect to the potential increased demand for electricity as an alternate energy source, the environmental implications are somewhat more difficult to define as discussed below.

As indicated in the 2005 Oregon Energy Plan, the state's electric generation fuel mix varies with weather, specifically water and snow conditions, which dictate the availability of hydropower. For example, in 2003, natural gas generation accounted for approximately 7 percent of total generation, whereas in 2001, it was approximately 15 percent (ODE, 2003). This demonstrates the response of the generation system to variations in availability of supply sources as well as demand. As a result of the recent development of new gas-fired generation in the region in response to the electricity crisis of 2000-2001, sufficient generation capacity is available to meet increases in demand in the region in the foreseeable future. However, the bulk of this new generation is gas-fired and, as a result, highly vulnerable to the volatile price fluctuations of recent years. Thus, to the extent that consumers revert to electricity in the absence of increased availability of competitively-priced natural gas, it is likely that a significant portion of that electricity will come from existing coal-fired generation sources during non-peak periods, resulting in greater environmental impacts than the proposed project.

Renewable Energy

The Pacific Northwest has been at the forefront nationally in terms of the use of renewable energy resources, in large part due to the historic prevalence of hydropower resources in the region. Hydropower provided 44 percent of the total electric generation mix in 2003 and an additional 4 percent was provided by wind, geothermal, biomass, and municipal solid waste (ODE, 2005). With respect to energy use other than for electric generation, the 2003 Oregon Energy Plan states that approximately 12 percent of total energy use was supplied by renewable resources (consisting primarily of wood in homes and wood waste in lumber mills and pulping liquor in paper factories). Renewable energy resources represent an alternative to the use of natural gas depending on the type of use and type of renewable resource. For example, hydro and wind resources represent alternatives for electricity generation, whereas biomass, solar, and geothermal resources can be used to generate heat as well as electricity. The environmental implications of the use of renewable resources vary as well. The potential to generate additional electricity by constructing new dams is severely limited due to laws that prevent adverse impacts on protected species of fish in the region. In fact, in some areas, efforts are underway to remove existing dams to restore habitat damaged in the past. Further, increased environmental scrutiny of existing dams has, in some instances, resulted in increased release of water for fisheries protection purposes, which has significantly reduced the availability of hydropower in the region. Thus, the development of additional hydropower resources is not considered to be a reasonable or environmentally preferable alternative to the proposed project.

Geothermal and ocean wave resources provide opportunities for development in the region; however, cost, technical maturity, and commercial viability all influence the degree of potential for these resources. While significant long-term potential may exist for development of these resources on a large scale, at present they represent only a marginal fraction of the energy resource mix and are not capable of providing a reasonable alternative source of energy to the proposed project.

Biomass resources, which produce electricity and heat or steam from wood, wood waste, or waste gas, generated 79 trillion British thermal units (Btu) of energy in Oregon in 2003 (ODE, 2005), with the majority generated at industrial sites burning wood wastes for steam, process heat, and electricity, and from the combusting of pulping liquor at pulp mills. In addition, limited amounts of electricity have been produced from tapped methane gas and cow manure. However, the use of biomass resources to supply the energy needs of industry has declined significantly since the early 1990s (ODE, 2003). This decline has been due largely to a shift to natural gas as an energy source for heating, process uses, and electricity generation across all sectors. As discussed above, a return to the use of biomass resources for these purposes by these end users would not be an environmentally preferable alternative to the proposed project. Development of additional uses for waste methane gas to generate electricity and heat will continue to a limited degree based on opportunity and economics; however, these do not represent reasonable alternatives to the proposed project due to the limited number of resource development opportunities available.

Solar power, while very clean, is not a reliable energy source in the project area. An assessment of solar power potential was done for the proposed Georgia Strait Crossing (GSX) Project in northwest Washington using data from the Seattle area (FERC, 2002), which has similar weather conditions to the Bradwood Landing Project area. National Weather Service data collected at the Seattle-Tacoma International Airport showed the average annual possible sunshine for the area is about 47 percent. Data presented by the Renewable Energy Power Project indicated that the daily average is 2.9 kWh per square meter (m^2) for Seattle. At this rate, in excess of 1,000 acres of solar collector surface would be required to provide a level of energy similar to what would have been provided by the GSX Project, which was approximately 7 percent the size of the Bradwood Landing Project. The large area of solar collector surfaces that would be needed, more than 14,000 acres, coupled with the fact that the project area has extended periods with little or no sunshine, indicate that there is limited potential to develop solar energy on a scale similar to that of the proposed project.

The primary renewable resource available as an alternative to natural gas for electricity generation in Oregon and the Pacific Northwest is wind power. The costs of wind-generated electricity are declining and new projects are under development throughout the region and nationally. According to the 2005 Oregon Energy Plan (ODE, 2005), Oregon currently has five large wind projects with a total capacity of 259 MW. In addition, several new projects and expansions are underway or being planned for a total capacity of more than 400 MW. This is equivalent to how much electricity could be generated from 0.03 Bcfd of natural gas (about 3 percent of the average sendout capacity of the Bradwood Landing LNG terminal). It would take 24,800 wind turbines operating at peak capacity to produce an equivalent level of energy that could be generated by the natural gas from the Bradwood Landing LNG terminal.

In assessing the potential for wind generated electricity to provide a significant energy resource for a region, it is important to recognize that wind machines generate, on average, only approximately one-third of their capacity due to variability in wind conditions. Further, due to the variability in generation available from wind resources, as with hydropower resources, there must be sufficient additional generation resources available in the overall mix to provide supplies during periods when the wind sources are not generating to capacity. Finally, even with the expected development of new wind resources in Oregon and the region, the need for natural gas supplies for electricity production as well as direct use by consumers in the residential, commercial, and industrial sectors will remain and continue to grow as the development of wind resources is anticipated in the underlying resource projections that form the basis of the energy demand forecasts for the region. Therefore, wind power does not represent a reasonable alternative to the proposed project.

Nuclear Energy

The Trojan Nuclear Power Plant on the Columbia River in Columbia County, Oregon was closed in 1993, 18 years earlier than its scheduled 35-year life. This early closure of Oregon's only nuclear power plant was due in large part to strong public opposition to nuclear power based on environmental and safety issues. The only currently operating commercial nuclear power plant in the Pacific Northwest is the Columbia Generating Station, located at the Hanford Nuclear Site in southeast Washington. The Hanford Nuclear Site, which encompasses 586 square miles, is owned by the U.S. Department of Energy (DOE) and was used for more than 40 years to produce plutonium for nuclear weapons. The Hanford Nuclear Site includes more than 1,800 waste sites, and radioactive contamination was also spread off-site by wind to the east and by the Columbia River as far as the Pacific Coast. Cleanup at the Hanford Nuclear Site is ongoing and will take decades to complete (ODE, 2005).

Although nuclear power is another potential energy alternative, in our opinion, any proposal for a nuclear plant would generate considerable public opposition based on the experience with the Trojan Nuclear Power Plant and the legacy of the contamination at the Hanford Nuclear Site. In addition, a nuclear power plant would likely take longer to plan, study, and construct than the proposed project. New nuclear facilities are unlikely to be built in the region given public opposition, environmental issues, and regulatory hurdles. Additionally, cost overruns that occurred during nuclear facility construction in the 1970s and 1980s make financing new nuclear facilities problematic (EIA, 2004).

Other Fossil Fuels

As indicated above, compared to other fossil fuels such as coal or oil, natural gas is a relatively clean and efficient fuel that can reduce the emission of regulated pollutants (e.g., NO_x, sulfur dioxide (SO_2), and particulate matter) or unregulated greenhouse gases (GHG) (e.g., CO_2). Given there are emissions associated with producing, processing, transmitting, and distributing natural gas and other fossil fuels, it is difficult to accurately quantify the impact of an LNG import project on air quality. However, credible estimates of air emissions can be developed based on reasonable assumptions regarding burning natural gas delivered by the project compared to burning fossil fuels that would likely be utilized if the gas from the project was not available. Table 3.1.1-1 lists the emissions that would result from the Bradwood Landing Project assuming it provides about 1.3 Bcfd of natural gas to the Pacific Northwest market and the corresponding emissions that would result if an equivalent amount of energy were generated using coal or fuel oil in lieu of natural gas. It is clear from the table that the use of either fuel oil or coal would increase emissions significantly. Additionally, to comply with current air emission regulations, emission control technologies could be required that could limit the economic viability of any new oil- or coal-fired facility.

In addition to the increased emissions associated with the burning of coal or fuel oil, each of these fuels would also have to be imported into the project area and stored, similar to the proposed LNG. The distribution of these fuels to market would require more truck, barge, and train trips than the distribution of an equivalent amount of energy derived from natural gas, which would increase emissions and traffic congestion.

TABLE 3.1.1-1

Comparison of Air Emissions from Burning Fossil Fuels [a]

Fossil Fuel	SO_2 (tpy)	NO_x (tpy)	PM_{10} (tpy)	CO_2 (tpy)	C (tpy)
Natural Gas	143	21,522	1,723	23,833,333	6,500,000
Fuel Oil	112,636	43,047	2,441	34,558,333	9,425,000
Coal	301,321	150,661	6,673	45,283,333	12,350,000

[a] The emissions generated by coal, fuel oil, and natural gas were estimated using the most recent Best Available Control Technology (BACT) analyses identified on the EPA Reasonably Available Control Technology/BACT/Lowest Achievable Emission Rate Clearinghouse for boilers with heat input ratings between 100 and 250 million Btu per hour. The emissions from each fuel source are estimated based on a fuel use of 1.3 Bcfd, 365 days per year, 1,000 Btu/cubic foot.

PM_{10} particulate matter less than 10 microns in diameter

C carbon

tpy tons per year

3.1.1.4 No Action or Postponed Action Conclusions

As described in section 1.1, the NWGA warns that existing gas supplies and infrastructure are adequate in the short term, but will fall short of meeting peak demand conditions by 2010 under a high-growth demand scenario (NWGA, 2006). For its base case forecast, the NWGA predicts that natural gas use in the Pacific Northwest (British Columbia, Washington, Oregon, and Idaho) will increase 8.1 percent through 2011. Much of the demand growth in the NWGA forecast is driven by power generation. Although not expected, it is conceivable that this demand could be reduced by increasing use of other energy sources and/or conservation. Because natural gas is the cleanest of the fossil fuels, the increased use of other fossil fuels would result in higher air emissions that can contribute to climate change, acid rain, and smog. The economic, ecological, and human health benefits of reduced air emissions have been well documented (EPA, 1999). It is also conceivable that increasing energy efficiency and use of renewable sources of energy could reduce the projected future demand for natural gas. However, neither conservation measures nor renewable energy sources are expected to replace the need for additional future natural gas supplies in the Pacific Northwest (ODE, 2005). In addition, competition is increasing from Canada and other parts of the United States for the supplies of natural gas in western British Columbia and the Rocky Mountain region – areas that have been the traditional sources of natural gas for the Pacific Northwest (NWGA, 2006).

As noted above, if the no action or postponed action alternative is adopted there are two likely outcomes: 1) negative environmental and economic impacts associated with more limited supplies of natural gas; and/or 2) the development of other natural gas infrastructure projects that meet some or all of the project objectives identified by NorthernStar.

3.1.2 System Alternatives

System alternatives are options that would make use of other existing LNG or natural gas facilities to meet the stated objectives of the proposed project. A system alternative would make it unnecessary to construct all or part of the proposed project even if some modifications or additions to the existing facilities are necessary. These modifications or additions would result in environmental impacts that could be less than, similar to, or greater than those associated with construction of the proposed project. Ultimately, the purpose of identifying and evaluating system alternatives is to determine whether potential environmental impacts associated with construction and operation of the Bradwood Landing Project could be avoided or reduced by using another system.

3.1.2.1 Existing Pipeline Systems

The Pacific Northwest receives supplies of Canadian natural gas from British Columbia and Alberta and supplies of domestic gas from sources in the Rocky Mountain region. Two existing interstate natural gas pipelines, the Williams Northwest pipeline system and TransCanada's GTN pipeline system, currently serve the Pacific Northwest (see figure 3.1.2-1). Williams Northwest pipeline is a 4,158-mile bi-directional transmission system crossing the states of Washington, Oregon, Idaho, Wyoming, Utah, and Colorado. This system provides access to British Columbia, Alberta, Rocky Mountain, and San Juan Basin natural gas supplies. The GTN pipeline system includes 1,350 miles of pipeline beginning at the Idaho/British Columbia border, traversing through northern Idaho, southeastern Washington and central Oregon, and terminating at the Oregon/California border, where it interconnects with two other pipeline systems. Natural gas for the GTN pipeline originates primarily from supplies in Canada. To meet the objectives of the project, we assume that a viable system alternative would need to be able to interconnect with one or both of these interstate pipeline systems for distribution. Alternatively, expansion of these pipeline systems could bring additional supplies of natural gas to the region.

As an alternative to developing a new LNG import terminal in the Pacific Northwest, we considered the feasibility of accessing existing or proposed sources of natural gas outside of the region. Natural gas currently used in the Pacific Northwest comes from existing production areas in Canada and the Rocky Mountain region of the United States. Most Canadian production originates in the Western Canadian Sedimentary Basin. However, net natural gas imports from Canada are projected to decrease from 3.3 trillion cubic feet in 2005 to 1.2 trillion cubic feet in 2030 (EIA, 2007). This decrease will be due primarily to an expected decline in conventional natural gas resources in Alberta and increases in Canada's domestic consumption.

On the other hand, the Rocky Mountain region is expected to increase its production of natural gas over the next 20 years, primarily from unconventional sources such as tight sands, shale, and coalbed methane. The portion of natural gas contributed by the Rocky Mountain region to the total of the lower 48 states' onshore natural gas production is expected to increase from 27 percent (in 2003) to 38 percent in 2025 (EIA, 2005a). Part of this predicted gain in share of total onshore production is due to the fact that some regions (onshore Gulf Coast, midcontinent) are expected to experience declining production rates. However, much of the additional new production in the Rocky Mountain region is targeted for markets in the eastern United States. For example, a joint venture by Kinder Morgan Energy Partners L.P. and Sempra Pipelines and Storage has proposed the Rockies Express Project to transport natural gas from the Rocky Mountains and San Juan Basin to major markets in the Midwest and East. The FERC recently authorized construction of the western portion of the Rockies Express Project, in Docket No. CP06-354-000, consisting of about 718 miles of 42-inch-diameter mainline pipeline extending from Colorado to Missouri.

The growth of cross-border pipeline capacity from Canada to the United States has slowed significantly (EIA, 2005b). In the past 2 years a total of only 274 MMcfd of capacity has been added. The only major expansion of an existing pipeline system currently planned for the future that would bring significant additional supplies of natural gas from Canada or the Rocky Mountains to the Pacific Northwest would be the Palomar Pipeline Project.

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Figure 3.1.2-1 Existing Interstate Pipelines in Pacific Northwest

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The environmental impacts associated with the expansion or modification of an existing pipeline system to be able to deliver volumes of natural gas to the Pacific Northwest equivalent to the Bradwood Landing Project would depend on the project size, length, and design. Such a project would result in impacts on water resources, upland vegetation, wetlands, wildlife habitats, land use, and air quality. For example, the Palomar Pipeline Project would consist of 220 miles of 36-inch-diameter pipeline, over the Cascade and Coast mountain ranges, crossing segments of lands administered by the U.S. Department of the Interior Bureau of Land Management (BLM) and National Forest lands administered by the U.S. Department of Agriculture Forest Service (FS), with potential habitat for federally listed threatened and endangered species such as the northern spotted owl and marbled murrelet, and across numerous waterbodies, including the Deschutes River, Clackamas River, and Willamette River.

3.1.2.2 Existing LNG Facilities

Three LNG storage facilities currently exist in the Pacific Northwest (see figure 3.1.2-2). All three are peakshaving plants that liquefy and store natural gas to be vaporized during periods of peak demand. In Oregon, Northwest Natural owns and operates two peakshaving LNG storage plants. One is located in Portland and has a liquefaction capacity of 2 MMcfd, a storage capacity of 300,000 m^3, and a vaporization capacity of 120 MMcfd. The other is located in Newport and has a liquefaction capacity of 5 MMcfd, a storage capacity of 50,000 m^3, and a vaporization capacity of 100 MMcfd. In Washington, Williams Northwest owns and operates a peakshaving LNG storage plant in Plymouth with a liquefaction capacity of 19.7 MMcfd, a storage capacity of 60,000 m^3, and a vaporization capacity of 300 MMcfd. These facilities do not add to the total supply of natural gas, rather, they serve to even out the discrepancies in supply and demand created by varying seasonal demands.

We considered the possibility of converting one of the existing peakshaving LNG storage plants into an LNG import terminal as a system alternative to the proposed project. However, such an alternative would likely not be economically viable due to the small size and limited capacity of the existing storage facilities. The Portland facility is located on the Willamette River and would potentially be accessible to LNG ships; however, the waterway for LNG marine transit would be over 100 miles long. While Plymouth is located on the Columbia River, it is upriver of several dams, and so it would not be accessible for LNG ships. Newport is on the Oregon coast; however, the port of Newport is relatively small, with channel depths ranging from 20 to 30 feet. The port at Newport could not accommodate LNG ships without extensive dredging. We estimate at least 16 million cubic yards of material would need to be dredged to accommodate LNG ships at this location. Therefore, we conclude that converting existing peakshaving LNG storage plants in the region into LNG import terminals is not a reasonable or feasible system alternative to the proposed project.

There are four existing onshore LNG import terminals in operation in the United States (in Massachusetts, Maryland, Georgia, and Louisiana) and one offshore facility (in the Gulf of Mexico). In addition, there are three newly authorized onshore LNG import terminals currently under construction along the Gulf Coast (in Louisiana and Texas). None of the existing or under-construction LNG import terminals would be a reasonable or feasible system alternative to the proposed project because of their distance from the proposed market area.

Numerous new LNG import terminals are proposed throughout the United States. The FERC has recently authorized eight onshore LNG import facilities along the Gulf Coast (three projects in Corpus Christi, Texas; one in Port Arthur, Texas; one in Sabine Pass, Texas; one in Cameron, Louisiana; and two in Pascagoula, Mississippi), and two in the Northeast (Massachusetts and New Jersey); although final design construction has not yet begun at any of these approved facilities. We did not study any of the authorized but not yet built LNG import terminals located along the East or Gulf Coasts as potential system alternatives to the Bradwood Landing Project, since we do not consider them to be reasonable or feasible alternatives because of their distance from the proposed market area.

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Figure 3.1.2-2 Existing Peakshaving Facility Locations

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3.1.3 Proposed West Coast Alternative LNG Import Terminals

We assessed proposals for offshore and onshore LNG import terminals to be located on the Pacific Coast of North America, including facilities proposed on the West Coast of Mexico, Canada, and the United States (see figure 3.1.3-1).

3.1.3.1 Proposed LNG Import Terminals on the West Coast of Mexico

The proposed LNG import terminals on the West Coast of Mexico include two offshore facilities (Terminal GNL Mar Adentro de Baja California and Moss-Maritime LNG Project) and two onshore facilities (Terminal GNL de Sonora and Energia Costa Azul LNG Facility). The Terminal GNL Mar Adentro de Baja California, proposed by Chevron Corporation (Chevron), would have been a gravity-based structure (GBS) (see section 3.1.4.1) located near the Coronado Islands off the coast of Tijuana with a projected average sendout capacity of 700 MMcfd. In March 2007, Chevron announced it was dropping its plans to develop its proposed Baja, Mexico LNG import terminal (East Bay Business Times, 2007). The Moss-Maritime LNG Project, proposed by a partnership between Moss-Maritime and Terminales y Almacenes Maritimos de Mexico, would be a floating storage and regasification unit (FSRU) (see section 3.1.4.1). The terminal would be located about 5 miles from Rosarito Beach off the coast of Baja, Mexico and have an average sendout capacity of 297 MMcfd. This facility was granted a permit from the Mexican government, but its current status is unknown (Lindquist, 2007).

The Terminal GNL de Sonora would be an LNG import terminal located near Puerto Libertad, Sonora, on the eastern shore of the Gulf of California (Sea of Cortez), with a sendout capacity of 1.3 Bcfd, proposed by El Paso Corporation (El Paso) and DKRW Energy LLC. The partners have received some environmental permits from the Mexican Federal Ministry of the Environment and Natural Resources. Gas supply for this facility still needs to be secured, and in May 2006 El Paso announced it was halting plans for a 59-mile-long sendout pipeline that would link the proposed terminal to markets in Tucson (California Energy Commission, 2007).

The Energia Costa Azul LNG Facility, proposed by Sempra Energy LNG Corporation, is located near Ensenada, on the Pacific Coast of Baja, Mexico. The terminal is sited within a 400-acre parcel, with two full containment LNG storage tanks with a total capacity of 320,000 m^3, open rack vaporizers (ORV), and a 42-mile-long, 36-inch-diameter pipeline with an average sendout capacity of 1.0 Bcfd. All permits have been secured for this facility and it is currently under construction.

The target markets for the LNG import terminals on the West Coast of Mexico would be northern Mexico, southern California, and other states in the southwestern United States (Arizona and Texas). These proposed facilities would be far from the market area proposed for the Bradwood Landing Project and could not meet the objective of providing natural gas to the Pacific Northwest. Therefore, we do not consider the Mexican LNG terminals to be reasonable or feasible alternatives to the proposed project and did not evaluate them further.

3.1.3.2 Proposed LNG Import Terminals on the West Coast of Canada

One proposed onshore LNG import facility WestPac Terminals, Inc. (WestPac) in British Columbia, Canada is in the process of obtaining regulatory approval and a second Kitimat LNG Inc. (Kitimat) has obtained approval (see figure 3.1.3-1).

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Figure 3.1.3-1 Proposed LNG Import Terminals on West Coast

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WestPac LNG Facility, British Columbia

The WestPac LNG Facility, proposed by WestPac Terminals, Inc. (Westpac), would be located on 250 acres of industrial land on Ridley Island in Prince Rupert, British Columbia. The facility would use existing dock facilities capable of handling LNG tankers. It would have a sendout capacity of 300 MMcfd, one 180,000 m^3 LNG storage tank, and a regasification plant (LNG Express, 2005). The project would serve as a regional LNG liquid-fuel distribution center by dispatching LNG in smaller vessels to supply gas distribution systems in other coastal cities. No new pipelines would be needed. In June 2006, Westpac initiated formal project review with the Prince Rupert Port Authority (California Energy Commission, 2007).

The WestPac LNG Facility would not be a reasonable alternative to the proposed Bradwood Landing Project because it would not have an interconnection to a regional pipeline system and it is currently designed to serve markets only in British Columbia. No LNG ship docking/unloading facilities currently exist in coastal cities in either Oregon or Washington that could receive LNG from the proposed WestPac LNG Facility.

Kitimat LNG Terminal, British Columbia

The Kitimat LNG terminal, proposed by a subsidiary of Galveston LNG, Inc. would be located at Bish Cove, about 8 miles south-southwest of the Port of Kitimat, British Columbia. The facility would receive four or five LNG shipments per month. The LNG terminal design includes marine offloading, two 160,000 m^3 LNG storage tanks, natural gas liquids recovery, and regasification facilities, with a nominal sendout capacity of 610 MMcfd of natural gas. A 30-inch-diameter, 9-mile-long pipeline would run from the terminal to the Pacific Northern Gas Pipeline in Kitimat, where the gas would then be transported to an interconnection with the existing Duke Energy's Westcoast Energy Main system (Kitimat LNG, 2006). An environmental assessment was completed for the Kitimat LNG terminal, and the project was approved by the Canadian Environmental Ministry in August 2006. Possible markets for the natural gas imported by this facility include British Columbia, Alberta, the Pacific Northwest, and California (California Energy Commission, 2007).

The Kitimat LNG terminal appears to be a reasonable alternative for importing new additional volumes of natural gas to the Pacific Northwest. However, it will have only about half of the sendout capacity of the Bradwood Landing Project, and only a portion of the natural gas from Kitimat would end up in the United States, as most would probably go to Canadian markets. As such, the Kitimat LNG terminal could not satisfy all of the objectives of the Bradwood Landing Project. Nevertheless, both of these facilities could help satisfy the increasing demand for natural gas in the region (see section 1.1).

3.1.3.3 Proposed LNG Import Terminals on the California Coast

There are five offshore (Cabrillo, Clearwater, Ocean Way, Pacific Gateway, and Esperanza) and one onshore (Long Beach) LNG import terminals proposed for the Pacific Coast in California.

Long Beach LNG Import Terminal Project

The Long Beach LNG Import Terminal Project was proposed by Sound Energy Solutions, a joint venture between Mitsubishi Corporation and ConocoPhillips, in FERC Docket Nos. CP04-58-000 et al., to be located within the Port of Long Beach, California. Features of the terminal include an LNG ship berth capable of handling an LNG ship up to about 200,000 m^3 capacity in size, two LNG storage tanks with a combined capacity of 320,000 m^3, four shell and tube vaporizers (STV), and a typical sendout capacity of 700 MMcfd of natural gas. A 2.3-mile-long 36-inch-diameter pipeline would be constructed to transport natural gas from the LNG terminal to existing Southern California Gas (SoCal) facilities. In addition, a 4.6-mile-long 10-inch-diameter pipeline would be constructed to transport vaporized ethane from the LNG terminal to an existing ConocoPhillips plant. In October 2005, the FERC and Port of Long Beach produced a joint draft EIS for this project. In January 2007, the Long Beach Board of Harbor Commissioners, who would be responsible for leasing the property for the LNG terminal, decided to end its environmental review (Polakovic, 2007). Sound Energy Solutions is in the process of appealing this decision through the local judicial system.

California Offshore LNG Import Terminal Proposals

All of the proposed LNG terminals off the California shore would be reviewed by the Coast Guard and U.S. Department of Transportation, Maritime Administration (MARAD) under the authority of the Deepwater Port Act.

Cabrillo Deepwater Port LNG Facility

The Cabrillo Deepwater Port LNG Facility, proposed by BHP Billiton, would be located in the Santa Barbara Channel about 14 miles from Point Mugu. The import facility would consist of an FSRU permanently moored to the ocean floor, with three independent Moss spherical storage tanks mounted within the hull together with eight vaporizers. An underwater 30-inch-diameter pipeline would extend about 21 miles, coming ashore in the vicinity of Ormond Beach in Ventura County, California, and interconnecting with the existing SoCal system. The facility would have the ability to send out an average of about 800 MMcfd of natural gas.

The Coast Guard and California State Lands Commission (CLC) issued a final EIS for this project in March 2007. In April 2007, the CLC and the California Coastal Commission voted against authorizing the Cabrillo Deepwater Port LNG Facility. California Governor Arnold Schwarzenegger rejected BHP Billiton’s proposal in May 2007.

Clearwater Port LNG Project

The Clearwater Port LNG Project was proposed by NorthernStar Natural Gas, Inc., the same developers promoting the Bradwood Landing Project. The Clearwater Port project would use existing offshore Platform Grace, located in the Santa Barbara Channel about 13 miles from Oxnard. A new floating dock would need to be installed adjacent to the existing platform to moor LNG ships during transfer. No storage facilities are proposed. The platform would be reconfigured to accommodate vaporizers. The natural gas would be delivered from the platform to the shore via a new 32-inch-diameter, 13-mile-long subsea pipeline. An additional 12-mile-long underground pipeline would convey the gas onshore from Oxnard to an interconnection with the existing SoCal system near Camarillo. The average sendout capacity of the facility would be about 1.2 Bcfd. A revised Deepwater Port application, submitted in June 2006, is currently being reviewed by the Coast Guard and CLC.

Ocean Way LNG Terminal

The Ocean Way LNG Terminal, to be located in the Pacific Ocean about 22 miles south of Los Angeles, California, is proposed by Woodside Energy, Inc. (Woodside) The project would include a mooring facility and an underwater pipeline that would come onshore near Los Angeles International Airport and interconnect with the existing SoCal intrastate local distribution system. The LNG would be regasified while still on board the ship, and the facility would have a first phase nominal sendout capacity of about 400 MMcfd. Woodside submitted its Deepwater Port application to the Coast Guard and City of Los Angeles in August 2006 (California Energy Commission, 2007).

Pacific Gateway LNG Facility

The Pacific Gateway LNG Facility is proposed by Excelerate Energy LLC (Excelerate) to be located off the shore of northern California. Excelerate, which currently operates an offshore LNG import terminal in the Gulf of Mexico, would use specially designed LNG tankers for the transportation of LNG and vaporization into natural gas. The northern California proposal would deliver up to 1.0 Bcfd of natural gas. This project is currently in the conceptual design phase, with Excelerate conducting "fatal flaw" analyses of offshore terminal locations and pipeline routes (Excelerate, 2007). An application under the Deepwater Port Act has not yet been submitted for this project.

Esperanza LNG Terminal

In March 2007, Esperanza Energy LLC (Esperanza), a subsidiary of Tidelands Oil and Gas Corporation, announced plans for an offshore LNG import terminal to be located in the Pacific Ocean about 15 miles from Long Beach, California. This facility would use the proprietary HiLoad system developed by TORP Technology to vaporize LNG as it is offloaded from ships. The natural gas would be transported to shore by an undersea pipeline, with a sendout capacity of about 1.2 Bcfd. One unique feature of this proposal would be the use of warm water discharged from an onshore host to regasify the LNG. Esperanza indicated it intends to submit a Deepwater Port application to the Coast Guard, MARAD, and the CLC by the end of 2007 (Esperanza, 2007; Nemec, 2007).

California LNG Import Terminal Conclusions

None of the proposed LNG import terminals in California are viewed as reasonable or feasible alternatives to the Bradwood Landing Project. None of these proposals have been authorized at this time. In fact, some (Pacific Gateway and Esperanza) are in the speculation stage, with no applications yet submitted. In addition, the target markets for these projects are in southern California. The California LNG import terminal proposals, therefore, could not meet the objectives of the Bradwood Landing Project to supply the states of Oregon and Washington with new sources of natural gas.

3.1.3.4 Proposed LNG Import Terminals in Oregon

There are three other potential LNG import terminal alternative locations along the Columbia River, in addition to the Bradwood Landing Project, and one in Coos Bay.

Jordan Cove Energy Project, Coos Bay, Oregon

On May 1, 2006, the FERC accepted a request to begin the Pre-filing Review Process for an LNG import terminal proposed by Jordan Cove Energy Project, L.P. (Jordan Cove) in Docket No. PF06-25-000, and an associated sendout pipeline proposed by Pacific Connector Gas Pipeline, L.P. (PCGP) in Docket No. PF06-26-000. The Jordan Cove LNG import terminal would be located between Mile 7 and 8 along the Coos Bay navigation channel, on the eastern shore of the North Spit in Coos County, Oregon. Proposed facilities would include a single berth capable of handling about 80 LNG ships per year, and two full containment LNG storage tanks with a net volume of 160,000 m^3, and a sendout capacity of 1 Bcfd. PCGP's sendout pipeline would consist of a 223-mile-long 36-inch-diameter pipeline, extending from the Jordan Cove LNG import terminal across Coos, Douglas, Jackson, and Klamath Counties, terminating at an interconnection with Pacific Gas and Electric facilities near Malin, Oregon. Aboveground facilities associated with the pipeline include a 20,620 hp compressor station near Butte Falls and four meter stations (see figure 3.1.3-2).

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Figure 3.1.3-2 Proposed Jordan Cove Energy Project and Oregon LNG Project

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Jordan Cove and PCGP have not yet filed formal applications with the FERC. Because these projects are still undergoing Pre-filing review, the environmental impacts of the Jordan Cove LNG and PCGP projects are not fully known at this time. The PCGP sendout pipeline would be more than six times longer than NorthernStar's pipeline. PCGP's pipeline route would have to go over difficult terrain of the Coastal Range and the Cascade Range, and cross lands administered by four BLM districts (Coos Bay, Rosburg, Medford, and Lakeview) and portions of the Fremont-Winema, Rogue River-Siskiyou, and Umpqua National Forests administered by the FS. On federal lands, the pipeline would cross about 25 miles of habitat categorized as Late Successional Reserves, 45 miles of Matrix, and almost 2 miles of Riparian Reserves. The proposed pipeline would also cross 363 waterbodies, and potentially impact about 421 acres total of wetlands. Preliminary cultural resources surveys identified 112 archaeological sites along segments of the pipeline route. While biological surveys are not yet completed, the PCGP pipeline could affect habitat for northern spotted owl and marbled murrelet. The FERC intends to produce an EIS for the Jordan Cove LNG and PCGP projects combined.

Jordan Cove and PCGP indicate that their project would supply natural gas to the Pacific Northwest and northern California. In some respects, that is similar to the objectives of NorthernStar's project. There are no clear environmental advantages of the Jordan Cove LNG Project over the Bradwood Landing Project, so it is not believed to be a preferable alternative.

Oregon LNG Project, Skipanon Peninsula, Warrenton, Oregon

A proposed LNG import terminal on the East Skipanon Peninsula would occupy about 96 acres within the City of Warrenton, near the confluence of the Skipanon and Columbia Rivers, at about CRM 11.5, in Clatsop County, Oregon (see figures 3.1.3-2 and 3.1.3-3). This site was originally proposed for an LNG terminal by a subsidiary of Calpine Corporation (Calpine). However, after Calpine declared bankruptcy, development rights were acquired by a consortium known as the Oregon LNG Project (Oregon LNG), funded by the Leucadia National Corporation. Oregon LNG requested the initiation of the FERC's Pre-filing Review Process in a letter dated May 31, 2007, and the FERC accepted that request on June 19, 2007, in Docket No. PF07-10-000. The FERC intends to produce a separate, stand alone, independent EIS for the Oregon LNG Project.

The portion of the East Skipanon Peninsula containing the site for Oregon LNG terminal is owned by the State of Oregon, and leased by the ODSL to the Port of Astoria. Oregon LNG holds a 65-year sublease with the Port of Astoria for the parcel. The Skipanon Peninsula was created by placement of sandy sediments dredged from adjacent waterways beginning in the 1920s. The surrounding land use is industrial and recreational. An 18-hole golf course was planned for this area, but if the LNG terminal is developed the golf course design would be modified to accommodate the facility (Port of Astoria, 2006a). The City of Warrenton recently rezoned the area for water dependent industrial use in order to allow for an LNG terminal at this location (Ramsayer, 2005). The onshore portions of the parcel are zoned Water Dependent Industrial Shorelands 1-2, while the marine facilities are zoned Aquatic Development A-1.

The site is located downstream of the Astoria-Megler Bridge. Oregon LNG would have a single berth designed to handle about 150 LNG ships per year, sized from 70,000 m^3 to 200,000 m^3 in capacity. Construction of the ship berth and turning basin for Oregon LNG would require dredging of an estimated 800,000 cubic yards of material. The berth would be located offshore in Young's Bay, adjacent to the Columbia River navigation channel, on submerged lands owned in fee by the ODSL. Oregon LNG believes that its dock would qualify for the "wharf exception" under OSR 780.040(1), which would not require a lease from ODSL.

Figure 3.1.3-3
Bradwood Landing Project
Photograph of Tansy Point Looking West

Onshore facilities would include three 160,000 m^3 full containment LNG storage tanks, vaporizers, and a sendout system with a peak capacity of 1.5 Bcfd of natural gas. Oregon LNG would install a new 117-mile-long, 30- to 36-inch-diameter natural gas sendout pipeline, routed through Clatsop, Tillamook, Washington, Yamhill, Marion, and Clackamas Counties, Oregon to interconnect with the Northwest Natural intrastate pipeline system and the Williams Northwest interstate natural gas pipeline system at Molalla.

The closest residences are about 0.5 mile from the southern boundary of the Oregon LNG terminal site. The population density of the surrounding areas where the Oregon LNG terminal would be visible is greater than at Bradwood Landing. In addition to the City of Warrenton, the facility would be visible from the hillside of the western portion of the City of Astoria.

NWI data indicate approximately 70 acres of wetlands are present within the 96-acre site proposed for the LNG terminal. Oregon LNG estimates that construction of its import terminal would affect about 21 acres of wetlands in total, including about 2.2 acres of mudflats, 18 acres of high marsh, and 1 acre of low marsh.

Calpine conducted a preliminary habitat category determination according to ODFW standards for the Skipanon site (Ellis Ecological Services and CH2M Hill, 2005). Most of the parcel was proposed as Category 4 or 5 habitat, because it is degraded and does not provide important habitat for fish and wildlife. The shallow subtidal and mudflat habitats, where the trestle and unloading pipeline from the berth would be located, was proposed as Category 2 because these areas are important for salmonids. No Category 1 habitat was identified within the property.

The lower portion of the Skipanon Waterway, like the lower Columbia River, is designated critical habitat for salmon. The area that would require dredging for the Oregon LNG turning basin and berth was identified as deep subtidal habitat, proposed as Category 4. Listed adult and juvenile salmonids use deep subtidal habitat for migration. Juvenile salmonids may also seasonally feed on zooplankton in such habitat. The deep subtidal habitat likely supports Dungeness crab (*Cancer magister*). It may also provide foraging opportunities for bald eagles (*Haliaeetus leucocephalus*). Steller sea lions (*Eumetopias jubatus*) are known to congregate along the South Jetty at the mouth of the Columbia River in the fall and winter months, and may forage in the estuary during this period (Lower Columbia Fish Recovery Board (LCFRB), 2004).

In summary, the main environmental advantage of the Oregon LNG site would be the shorter distance up the Columbia River for LNG marine traffic. The main disadvantage, in comparison to the location for the Bradwood Landing LNG terminal, would be environmental impacts associated with the additional length of the sendout pipeline. In conclusion, the Oregon LNG terminal alternative does not appear to be environmentally superior to the Bradwood Landing Project.

Other Potential LNG Terminal Locations along the Columbia River

<u>Tansy Point</u>

Tansy Point is a low-lying headland located between the mouth of the Skipanon Waterway and Trestle Bay, 10 miles upriver from the mouth of the Columbia River, in Clatsop County, Oregon (see figures 3.1.3-4 and 3.1.3-5). The potential LNG terminal site is owned by the City of Warrenton and is leased to Warrenton Fiber Company. The company currently operates the 50-acre site as a log yard and wood processing facility. It is within the City of Warrenton's Water Dependent Industrial zoning district. Warrenton Fiber has been given a 5-year period to negotiate with the City for lease amendments, which would be required in order to construct an LNG facility on the site. While Warrenton Fiber is exploring the possibility of developing this site as an LNG terminal, no LNG development company or other financial backer has come forward, and no LNG import terminal proposal has been submitted to the FERC.

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Figure 3.1.3-4 Tansy Point

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Figure 3.1.3-5
Bradwood Landing Project
Photograph of Oregon LNG Looking Southeast

LNG ships would have a relatively short transit up the navigation channel in the Columbia River to Tansy Point, and would not have to go under the Astoria-Megler Bridge. The site is currently equipped with a ship dock, and the river adjacent to the site is 43 feet deep. Therefore, no or minimal dredging would be required; however, the ship dock area would need to be rebuilt to meet the specific requirements for berthing and unloading LNG ships.

The lower Columbia River is designated critical habitat for salmon. However, the designated salmon critical habitat near the mouth of the river is spread out over a larger area and fish in this part of the river generally spend less time in the habitat (NMFS, 2006a). This area is also EFH for groundfish and pelagic species, as well as salmon.

Based on National Wetlands Inventory (NWI) data, there are approximately 14 acres of wetlands present on the 50-acre Tansy Point site. These wetlands are confined to the southern half of the parcel. Assuming the LNG terminal would have a footprint of 45 acres and the terminal could be situated to minimize wetland impacts (i.e., the entire unused 5 acres would be wetland acres) development of the site for an LNG terminal would permanently impact about 9 acres of wetlands.

Some years ago, Tansy Point was the site of a terminal for a steamship that traveled between Warrenton and San Francisco. The topographic map for this area indicates ruins are present in the river adjacent to Tansy Point, and the Columbia River Maritime Museum in Astoria displays a record of the steam tug Firefly having sunk off Tansy Point in 1854. Therefore, cultural resources, including submerged remains of ship wrecks in the river, may be present at this location.

The berth for the Tansy Point site would be closer to the navigation channel compared to the other alternative sites along the Columbia River. This proximity could pose a higher risk of allisions between LNG ships unloading their cargo and other ship traffic in the channel.

Of the potential alternative LNG terminal locations considered along the Columbia River, Tansy Point has the largest number of nearby residences and the area immediately southwest of the site is zoned for intermediate density residential use. Based on examination of aerial photographs, we estimate over 85 residential structures are present within 0.5 mile of the site. The proposed LNG terminal would also have visual impacts on residents of Warrenton.

Because there is no application before us, the FERC staff had to speculate about the length and location of a sendout pipeline for the Tansy Point LNG import terminal alternative. We assumed that the sendout pipeline would have to interconnect with the Williams Northwest pipeline, which is the closest existing interstate transportation system. In selecting the pipeline route, we made an effort to avoid populated areas without increasing the length of the pipeline by an unreasonable amount. The conceptual pipeline route would follow an existing power line corridor where possible. While it is standard practice to collocate pipelines with existing rights-of-way, we have not field verified that this route would be constructible for a natural gas pipeline. The sendout pipeline route we propose would be about 58 miles long. Its location is illustrated on figure 3.1.3-6.

In summary, the main environmental advantages of Tansy Point would be the short LNG marine transit distance, little or no dredging necessary for a turning basin in the Columbia River, and limited impacts on wetlands. Because the site is already being used for industrial purposes, development as an LNG terminal would have fewer impacts on wildlife habitats than if the land were previously undeveloped. Disadvantages include little separation of the berth from the navigation channel, population density around the site, and greater length for a sendout pipeline. In conclusion, the Tansy Point alternative LNG import terminal site is not clearly environmentally superior to the proposed Bradwood Landing Project.

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Figure 3.1.3-6 Tansy Point Alternative Sendout Pipeline Route

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Port Westward

The Port Westward alternative LNG terminal site is located on the south side of the Columbia River, opposite Oak Point, about 12 miles down river from Longview, Washington, in Columbia County, Oregon (see figures 3.1.3-7 and 3.1.3-8). The site is part of an economic zone managed by the Port of St. Helens. Port Westward LNG has an agreement with the Port of St. Helens to develop an LNG import facility within this zone. However, Port Westward LNG's request to the FERC to initiate our Pre-filing Review Process was not accepted because it could not demonstrate that it fully owned or controlled the entire parcel proposed for the LNG import terminal.

The proposed Port Westward LNG import terminal alternative site consists of two parcels totaling about 270 acres. The Thompson family owns a 145-acre wooded parcel fronting the Columbia River. The Port of St. Helens negotiated a 99-year lease agreement with the Thompson family to sublease this land (The Daily News, 2006). Based on discussions between the FERC staff and representatives of Port Westward LNG, it appears that the terms of the lease agreement between the Thompson family and the Port of St. Helens are not ideal for the construction and operation of an LNG marine berth on that property.

The second parcel at the Port Westward site consists of agricultural land used for grazing cattle and a tree farm for pulp production, controlled by the Port of St. Helens. A farmstead is located on the property; however, the Port of St. Helens has an agreement with the residents for abandonment of the farm in the event the parcel is developed for industrial purposes. Surrounding land use is agricultural and industrial. We identified several residential structures east of the southeast corner of the site. However, depending on the exact placement and configuration of the 45-acre LNG terminal footprint within the site, these structures would likely be more than 0.5 mile away.

The existing Beaver Power Plant, a natural gas and fuel oil fired facility operated by PGE, is located east of the proposed Port Westward LNG terminal site. PGE is currently constructing another power plant (fired by natural gas and coal) within the Port of St. Helens economic zone. Additional industrial facilities are planned for this area, including another new power plant and an ethanol production plant. An LNG terminal at the Port Westward site would have minor visual impacts, based on the relatively low population density of the surrounding area and the fact that the view has already been compromised by existing industrial infrastructure.

Power plants frequently use river water for cooling and discharge the warmed water back into the river, often with adverse impacts on aquatic resources. For example, there is a warm water discharge associated with operation of the Beaver Power Plant and the existing NPDES permit for this facility includes a schedule requiring PGE to conduct an evaluation and to implement controls to reduce effluent temperature. Further, water quality at this segment of the Columbia River is limited because of warm temperatures (ODEQ, 2004). "Waste heat" from one of the existing or planned power plants within the Port of St. Helens industrial zone could be a potential source of heat in a closed loop system to vaporize LNG for the proposed project. The use of waste heat could eliminate or reduce the need to burn natural gas in the LNG vaporization process. This would reduce air emissions and provide both environmental and economic benefits to the operation of the LNG terminal. It follows that the LNG terminal could also provide a source of "waste cold" that could be used to condense the steam used to produce electricity at one of the power plants. It is conceivable that an LNG terminal at this location could provide a source of cold water (or other liquid mixture) as part of a closed loop system between a power plant and the LNG vaporizers. The sharing of these processes could potentially provide environmental and economic benefits to both the LNG terminal and to the industrial facilities because it could eliminate or reduce air emissions associated with LNG vaporization at the LNG terminal and it could eliminate or reduce warm water discharges associated with the operation of the industrial facilities. A system similar to this is

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Figure 3.1.3-7 Port Westward

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Figure 3.1.3-8 Photograph of Port Westward Looking Southeast

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planned for Ingleside Energy Center LNG Project in Corpus Christi, Texas (see FERC Docket No. CP05-13-000). While environmental and economic advantages of such a system can be envisioned, conducting the technical design and commercial negotiations necessary to fully analyze the specific benefits and feasibility of a waste heat/cold system is outside the scope of this EIS.

NWI data indicates wetlands are present over the entire riverfront parcel, but no wetlands are present on the rest of the site. We assume the LNG terminal would be located back from the river with an extended pipe and trestle system to minimize impacts on wetlands and the slough. Assuming a 150-foot corridor for the pipe and trestle, 2.6 acres of wetlands would be permanently impacted, including 0.9 acre of forested/scrub-shrub wetlands, if the site was developed as an LNG import terminal. Without field wetland delineations, the extent of wetland impacts at this location is speculative, and the NWI data may underestimate potential wetland impacts at the Port Westward LNG terminal alternative site.

Using navigation charts with bathymetric data for the area, we estimate approximately 538,000 cubic yards of sediment would need to be dredged from the Columbia River bottom to create room for the ship berth and turning basin at Port Westward. Although this estimate is less than the volume that would be dredged at Bradwood Landing, a more detailed project-specific berth design and dredging plan would be required for Port Westward to allow for an accurate comparison of dredging between the two sites.

The Columbia River navigation channel up which the LNG marine traffic would have to transit some 54 miles is designated critical habitat and EFH for salmon. In addition to safety and security issues related to LNG marine traffic, the transit distance may increase the potential for impacts on aquatic and other resources. The wakes of LNG ships may result in the stranding of juvenile fish at specific locations and contribute to river bank erosion (see sections 4.6.2.1 and 4.1.3.3, respectively). Port Westward is the only Columbia River LNG terminal alternative site located outside of the Oregon Coastal Zone.

The Port Westward site is located along the proposed Bradwood Landing pipeline route at about MP 18.0. The sendout pipeline would therefore follow the proposed route from the Port Westward site to the terminus north of Kelso, Washington for a total length of 18.3 miles. However, to achieve the project objective of interconnects at the Wauna Mill and Northwest Natural pipeline delivery points, a lateral pipeline to those locations would be necessary. This lateral would follow the same route as the proposed pipeline route for a total length of 14.3 miles. As such, the effective pipeline length for the Port Westward alternative would be 32.6. The lateral would be 24 inches in diameter to the Northwest Natural pipeline interconnect and then 4 inches in diameter to the Wauna Mill interconnect. For comparing impacts on wetlands we assume the construction right-of-way through wetland areas would by 75 feet for the 24-inch pipeline and 50 feet for the 4-inch pipeline. This compares to a construction right-of-way of 100 feet through wetlands for the proposed sendout pipeline and the sendout pipeline for the Tansy Point site alternative.

Because no NWI mapped wetlands are present along the proposed Bradwood Landing pipeline route between MPs 0.0 and 3.7, the same lineal feet of wetlands would be crossed by the Port Westward alternative pipeline as for the proposed sendout pipeline. However, because of the narrower construction right-of-way necessary for the smaller diameter pipeline, about 40 percent less wetlands would be impacted during construction. These impacts would be primarily temporary impacts as opposed to the impacts on the wetlands at the terminal site, which would be permanent. Six fewer waterbodies would be crossed by the Port Westward site alternative pipeline.

In summary, the Port Westward LNG terminal alternative would have some environmental advantages over the Bradwood Landing proposal. Port Westward would be located outside of the Oregon Coastal Zone, and upriver from the lower Columbia River estuary, which is considered critical habitat for some life stages of listed salmonids. It appears that somewhat less dredging would be necessary and fewer acres of wetlands would be impacted by construction of an LNG import terminal at Port Westward.

The sendout pipeline from Port Westward would be slightly shorter than any of the other Columbia River LNG import terminal alternative sites. In addition, an LNG terminal at Port Westward could potentially take advantage of waste heat/waste cold exchanges with power plants within the Port of St. Helens economic zone.

However, there are also some disadvantages associated with the Port Westward location. First, the LNG marine traffic transit would be longer than any of the other alternative sites along the lower Columbia River. Second, it is unclear if the terms of the agreement between the Port of St. Helens and the Thompson family would allow for the economical construction and operation of an LNG marine berth on that property. Because of the longer LNG vessel transit, and uncertainties over the lease agreement for the marine berth parcel, we do not believe that the Port Westward LNG terminal alternative is significantly environmentally superior to the Bradwood Landing site.

3.1.4 LNG Terminal Alternatives Offshore of Oregon

Commentors have requested the study of offshore LNG terminal alternatives, in order to avoid many of the environmental issues and safety concerns associated with siting an LNG facility onshore. Offshore LNG import terminals located in federal waters fall under the jurisdiction of the MARAD and the Coast Guard (pursuant to the Deepwater Port Act of 1974, as amended by the Maritime Transportation Security Act of 2002).

3.1.4.1 Offshore LNG Terminal Technologies and Strategies

Companies that have proposed to construct and operate offshore LNG import terminals have advanced various technologies and strategies for platform construction, LNG ship mooring, LNG transfer and storage, vaporization, and sendout (LNG Express, 2003). These technologies/strategies include:

- offshore docking/onshore storage;
- fixed offshore terminals (GBS or platforms);
- transport/regasification vessels; or
- FSRUs.

Below we discuss these various technologies/strategies for offshore LNG import terminals as alternatives to the Bradwood Landing Project, compare their potential environmental impacts, and analyze their feasibility.

Offshore Docking/Onshore Storage

Where deepwater access to a coastal port or harbor is unavailable, LNG can be transported to onshore storage tanks from ships using specially designed cryogenic pipelines. Such facilities enable LNG ships to berth and transfer their LNG cargo to the cryogenic pipeline at docking facilities in offshore areas where natural water depths exceed 40 feet. Although feasible, a number of technical factors related to transporting LNG in a pipeline place limits on the practical maximum length of such a pipeline. This approach has been used at the existing Cove Point LNG terminal where the ship docking/unloading platform is located in the Chesapeake Bay about 1 mile from the shoreline. Similar facilities have been proposed for the Irving Oil LNG site in New Brunswick, Canada, and the Keltic Petrochemicals LNG and Bear Head LNG facilities in Nova Scotia, Canada. No such facility has been proposed for the West Coast.

While it would be possible to transfer LNG to shore through a cryogenic pipeline from an offshore docking structure, such a design would still require locating LNG storage tanks and process facilities at an onshore location, therefore resulting in similar environmental impacts as an onshore LNG import terminal, in addition to the disadvantages associated with an offshore docking structure and pipeline. Because of severe winter weather conditions and significant wave heights along the Oregon and Washington coasts (ABSG Consulting Inc. (ABSG), 2006), we did not identify a site where the use of this approach appeared practical for this project.

Fixed Offshore Terminals

There are basically two different types of fixed structures that can be used as an offshore LNG import terminal, either a GBS located directly on the seafloor or a pile-based platform. A GBS would contain LNG storage tanks and vaporizers on a platform with foundations directly on the seafloor. LNG could be offloaded from conventional LNG ships, placed in the storage tanks within the GBS, and then vaporized for delivery as natural gas to the onshore market via an undersea pipeline. A GBS is only feasible in areas of relatively shallow water, where depths range between 45 and 100 feet. Given the costs associated with constructing and operating a GBS, it appears that these facilities are economical for projects with relatively large LNG storage (e.g., 250,000 to 330,000 m^3) and large natural gas sendout volumes (e.g., 800 to 2,000 MMcfd). Another limitation would be the articulation of the unloading arms between the GBS and a docked LNG ship, whose movement would be affected by high winds and large waves.

Chevron received approval from the Coast Guard to build an LNG import terminal in the Gulf of Mexico (the Port Pelican Project) using a GBS, but has formally put the project on hold indefinitely and license rescission is expected. The recently abandoned Terminal GNL Mar Adentro de Baja proposed by Chevron as an LNG terminal off the western coast of Baja, Mexico also would have used a GBS at a depth of about 65 feet.

Another strategy using a fixed offshore terminal involves constructing offshore platforms on piles or converting existing offshore platforms to LNG use. Such fixed-tower structures, could be located in deeper water than a GBS. The platforms could be fitted with docking, unloading, storage, and vaporization equipment. As with a GBS, LNG could be unloaded from a conventional LNG ship, vaporized at the platform, and sent as natural gas to the onshore market via an undersea pipeline. A fixed platform would have limited space for LNG storage, and would need calm seas or protection from the elements (such as being located on the lee side of an island) to allow for safe LNG ship docking.

Depending on the specific design, offshore platforms may or may not include LNG storage facilities. The Clearwater Port proposed by NorthernStar Natural Gas, Inc. would retrofit an existing offshore platform off the coast of Ventura County, California as an LNG import terminal, but would not have any LNG storage on the platform, and instead would use underground gas storage onshore to compensate for irregular deliveries of gas (LNG Express, 2005).

Transport/Regasification Vessels

Several companies have proposed the installation of vaporization equipment on conventional LNG carrier ships, which would be called transport and regasification vessels. These ships would be able to dock at a floating unloading buoy and riser system where LNG could be vaporized onboard the LNG ship and injected directly into offshore pipelines that interconnect with onshore natural gas transmission systems. The vaporization equipment located on the ships would use technology that is similar to land-based LNG terminals.

Because LNG is vaporized on board the LNG ship, this approach eliminates the need for fixed LNG storage. Some of the tradeoffs of this approach are that it requires a dedicated LNG fleet with vaporization equipment on all of the vessels. Additionally, it takes 6 to 10 days to unload a ship at a maximum design rate of about 0.5 Bcfd.

In March 2005, the first project using this strategy began operation, and is the only existing offshore LNG import terminal of any type in North America. Excelerate's Gulf Gateway Deepwater Port includes a submerged turret loading system and about 8 miles of 20-inch-diameter pipeline that connects to two existing subsea pipelines located about 116 miles south of Cameron, Louisiana (LNG Express, 2002 and 2003). Excelerate ordered three LNG ships to be constructed to include onboard vaporization equipment. One of these ships is now in service and is delivering natural gas to the United States. Excelerate has indicated that it is exploring the installation of another offshore buoy and regasification vessel system to serve offshore northern California, known as the Pacific Gateway Project (see section 3.1.3.3).

As described above in section 3.1.3.3, Woodside has proposed a project using a similar technology at an offshore location 22 miles southwest of Los Angeles, California. The Ocean Way LNG Terminal Project would consist of a ship mooring facility with a flexible connection to an underwater natural gas pipeline that would come onshore at the Los Angeles International Airport and connect to the Southern California Gas Company delivery network (California Energy Commission, 2007).

Floating, Storage, and Regasification Units

FSRUs are another approach being considered for importing LNG into the United States from offshore terminals. In essence, an FSRU would be an oversized LNG carrier vessel that is outfitted with LNG vaporizers and docking/unloading equipment. The FSRU would be up to 1,200 feet long, 180 to 215 feet wide, and would be able to store between 250,000 and 350,000 m^3 of LNG; over twice the capacity of typical LNG ships that are currently available. These units would be anchored offshore of the proposed market area where conventional LNG ships could dock next to and unload LNG to the FSRU. After the LNG is unloaded, it could be vaporized and the natural gas could be transported to onshore markets through an undersea pipeline. Depending on the vaporizers and the size of the pipeline, these units could have a natural gas sendout capacity ranging from 700 to 1,500 MMcfd. BHP Billiton's Cabrillo Port Project, to be located about 14 miles off the southern California Coast, proposes to use an FSRU. The Moss-Marine LNG terminal proposed off the coast of Baja, California would also use an FSRU, as would the Broadwater LNG Project proposed for the Long Island Sound between Connecticut and New York (see FERC Docket No. CO06-54-000, et al.).

3.1.4.2 Application of Offshore Technologies to the Proposed Project

NorthernStar evaluated four offshore technologies (GBS, fixed platform, transport/regasification vessels, and FSRU) to determine if they were viable alternatives to the Bradwood Landing Project and could meet the project objectives as stated in section 1.1. These technologies were compared to the proposed project and evaluated relative to existing offshore conditions near Astoria, Oregon. This analysis was based to a large degree on a study performed by ABSG (ABSG, 2006). The four offshore technologies are summarized and compared to the proposed onshore project in table 3.1.4-1 and are discussed in greater detail below.

The Pacific Ocean off the coast of Oregon is subject to rough weather and high sea states. ABSG compared three wave characteristics (i.e., maximum significant wave heights, average significant wave heights, and average wave periods) for Oregon, the Gulf of Mexico, and Massachusetts. Relative to all three of these wave characteristics, conditions are less favorable for an LNG import terminal off the Oregon coast compared to the other regions. The coastline in this area provides no islands, reefs, or prominent headlands for protection from rough seas or adverse weather (ABSG, 2006).

TABLE 3.1.4-1

Assessment and Comparison of Offshore Technology to the Proposed Project

	GBS	Fixed Platform	Transport/Regasification Vessels	FSRU	Proposed Project
Performance in rough seas/weather	Poor	Poor	Good	Poor	NA
Terminal Cost ($billion) [a]	1.8	1.3	2.5 [b]	1.3	0.7
Pipeline Cost ($billion) [a]	0.3	0.3	0.3	0.3	0.1
Environmental Impacts Terminal	Low	Low	Low	Low	Low
Environmental Impacts Pipeline	Medium	Medium	Medium	Medium	Low

[a] Assumes a natural gas sendout capacity of 1.5 Bcfd.
[b] Cost includes purchase of specialized LNG transport and regasification vessels as well as a mooring/unloading system.
NA Not Applicable

Of the four offshore technologies evaluated, the transport/regasification vessel alternative (Excelerate's Energy Bridge technology) is the only one that would not be affected by rough sea conditions. For the other three technologies, LNG ships would be able to unload only during calm sea conditions, thus leading to substantial operational limitations. While transport/regasification vessels would perform well in rough seas and weather, they generally have lower regasification rates (e.g., 0.5 Bcfd), require specially modified ships, and have no storage capabilities. This alternative would be the most expensive offshore option (assuming four buoys and eight ships to provide a comparable capacity and uninterrupted supply), and it would be nearly four times the cost of the proposed onshore terminal. The other offshore terminal alternatives would cost at least twice as much as the proposed onshore terminal.

Locating an LNG terminal on an offshore fixed platform may have impacts on the ocean bottom and affect aquatic habitat. A GBS would need to be constructed onshore and then towed out to sea. The onshore graving dock[1] facility for constructing the GBS would have associated environmental impacts that the other offshore technologies would not have. These might include impacts on terrestrial wetlands, wildlife and vegetation, and cultural resources.

The kind of vaporizers used at an offshore LNG terminal would influence the kind of impacts the facility may have on the aquatic environment. For example, ORVs that use seawater may entrap or entrain small aquatic species and ichthyoplankton during intake. Further, once the water is run through the ORVs, it would be cooled, with the discharge changing sea temperature and perhaps impacting marine life and water quality. ORVs were proposed for the Port Pelican and Gulf Landing offshore LNG terminal projects in the Gulf of Mexico. However, neither of these projects is moving forward; as indicated above, the Port Pelican Project has been put on hold indefinitely, and Shell recently announced it was discontinuing plans for the Gulf Landing terminal off the shore of Louisiana (Reuters, 2007).

The location chosen for the offshore LNG terminal alternative is a point southwest of the mouth of the Columbia River, 10 miles offshore of Clatsop Plains, Oregon (see figure 3.1.4-1). NorthernStar selected this offshore alternative location after considering the most feasible route of an undersea pipeline to connect to onshore facilities. Water depths at the offshore terminal alternative location would be about 250 feet. This site could accommodate most offshore LNG terminal technologies, but not a GBS, which would need to be located in more shallow water. In order for a GBS to be used for an offshore LNG import terminal alternative, it would have to be within 2 miles of the Oregon shore.

[1] A graving dock consists of an excavated area adjacent to a deepwater channel that is used to fabricate the GBS. When the GBS is complete, the graving dock is flooded, allowing the GBS to float and be moved into the adjacent channel, from which it can then be towed to the offshore LNG terminal location.

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Figure 3.1.4-1 Location of Offshore LNG Terminal for Alternatives Analysis

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Assuming the use of NorthernStar's hypothetical offshore LNG import terminal alternative location, the corresponding sendout pipeline would cross beneath the sea for 10 miles to shore. It would then have to continue as an underground pipeline onshore heading eastward for at least 40 additional miles, compared to the proposed project, to reach the existing interstate pipeline system of Williams Northwest. Such a pipeline would require a compressor station along the route and would cost more than twice as much as the proposed sendout pipeline for the Bradwood Landing Project. Environmental impacts associated with the offshore portion of the pipeline route would be most likely to occur during construction and could include:

- direct disturbance of the seafloor and associated habitats;
- increased turbidity and sedimentation affecting water quality and marine biota;
- disturbance of sensitive marine mammals, birds, and fish;
- disruptions to shipping, fishing, and recreational activities;
- air emissions from construction equipment; and
- disturbance of archaeological resources.

The types of environmental impacts associated with the onshore portion of the sendout pipeline for an offshore LNG terminal alternative would be similar to those associated with the pipeline for the proposed project. However, the impacts would be roughly twice as great due to the greater length.

An offshore LNG import terminal alternative would avoid some of the environmental impacts of the proposed Bradwood Landing Project, such as effects associated LNG marine traffic up the Columbia River, critical salmon habitat in the river, nearby population and visual effects, and impacts on terrestrial resources, including wetlands. However, based on our review of the analysis conducted by ABSG and NorthernStar, we do not consider an LNG terminal off the coast of Oregon to be a viable alternative to the proposed project because of the rough sea and weather conditions and the additional environmental impacts associated with the longer sendout pipeline.

3.1.5 Regional LNG Import Terminal Site Alternatives

The examination of alternative sites for an LNG import terminal involved a comprehensive process that considered environmental, engineering, economic, safety, and regulatory factors within a regional context. The first step included determining the most suitable area for an LNG terminal based on the stated purpose of the project of providing natural gas to customers in the Pacific Northwest. That limited the search for alternative sites to areas of Washington and Oregon that would be accessible for LNG marine traffic. The second step included the identification of ports within this region that would be capable of accommodating LNG ships. The third step evaluated specific locations at qualified ports that had proper zoning and land necessary to support LNG ship docking, storage, and regasification facilities of an onshore import terminal. As discussed above in section 3.1.4, offshore alternatives do not currently appear economically, technically, or environmentally feasible or reasonable in the Pacific Northwest. As such, only onshore terminal site alternatives were considered in more detail, below.

3.1.5.1 Regional Review

As discussed in section 1.1, there is a growing demand for natural gas in the Pacific Northwest. We considered alternative LNG terminal sites along the coast of Washington and Oregon that would be accessible to LNG ships and within a reasonable distance of an interstate pipeline system.

3.1.5.2 Port Area/Waterway Review

Ships that are presently used to transport LNG typically have capacities of up to 154,000 m^3. The larger ships are from 950 to 1,000 feet long with typical drafts up to 39 feet. To ensure that the LNG ships do not easily or frequently run aground, up to an additional 2 feet of water is desirable under the keel. This means that LNG ships will typically only access areas with depths of at least 40 feet. Although dredging in shallow water areas could provide access for LNG ships, the dredging required in undeveloped ports or areas without deepwater channel access would be cost prohibitive and would most likely result in significant environmental impacts. Consequently, our analysis of alternative LNG terminal sites was limited to existing deepwater coastal ports that could readily accommodate LNG ships without dredging or without significantly more dredging than would be required for use of the proposed site. We identified Puget Sound (Washington), Grays Harbor (Washington), Coos Bay (Oregon), and the Columbia River (Washington/Oregon) as appropriate areas for an LNG import terminal. Coos Bay was previously discussed in section 3.1.3.4 under the proposed Jordan Cove Energy Project alternative.

3.1.5.3 Site Review

In addition to providing reasonable access to the Pacific Northwest market from sites with depths that would allow LNG ship access, coastal port areas or waterways were evaluated for the availability of sites suitable for developing an LNG terminal. To narrow the range and fully evaluate project alternatives, we developed criteria to assist in identifying and comparing specific sites for consideration as LNG terminal alternatives. The review process included the examination of required and favorable review criteria.

Required criteria included regulatory specifications regarding LNG facility layout and safety siting factors that are required to be met for the project to be feasible. If not met, the required criteria served to exclude a site from further consideration. Required criteria included:

- **Thermal Exclusion/Vapor Dispersion Zone** (49 CFR 193.2057 and 193.2059) – Thermal exclusion and vapor dispersion zones must be established in accordance with NFPA 59A. Based on the proposed project design, we have assumed a representative exclusion zone with a radius of 1,000 feet from the center of the LNG storage tank.

- **Airports** (49 CFR 193.2155(b)) – LNG storage tanks must not be located within a horizontal distance of 1 mile from the ends of a runway, or 0.25 mile from the nearest point of a runway, whichever is longer. The height of LNG structures in the vicinity of an airport must also comply with Federal Aviation Administration requirements.

- **LNG Waterfront Handling Requirements** (33 CFR 127.105) – Waterfront facilities where LNG is handled must comply with Coast Guard regulations pertaining to layout and spacing of the marine transfer area. These regulations require that each LNG loading flange be located at least 985 feet from general public or railway bridges crossing navigable waterways or entrances to any tunnel under navigable waterways.

We evaluated alternative LNG terminal sites to determine if environmentally preferable alternatives to the proposed site exist. Favorable review criteria, although not absolute alternative requirements, were applied to identify those sites that would be reasonable and most likely to provide some environmental advantage over the proposed project. For example, criteria were identified that would specifically improve upon some aspects of the Bradwood Landing Project such as those associated with impacts on aquatic resources. Favorable criteria were not intended to strictly eliminate the evaluation of certain sites. Some sites were selected for further analysis because they satisfied a majority, but not all, of the favorable criteria. Given the limited availability of suitable sized parcels in areas with deepwater access, it was not possible to locate an alternative that met all of the favorable review criteria. Favorable criteria included:

- **Population Centers/Residences** – We made an effort to identify alternative LNG terminal sites in areas that are not in close proximity to population centers and/or residences. Similarly, alternative LNG terminal sites were considered preferable if the location did not require LNG ships to transit near residentially and commercially developed shorelines. In addition to avoiding potential conflicts with existing land uses, application of this favorable criterion would ideally avoid conflicts regarding perceived safety issues related to transport and storage of LNG.

- **LNG Terminal Footprint** – Based on the proposed design and the need to contain the thermal exclusion zone, a waterfront site of about 45 acres (the size of the proposed terminal site) would be preferred to accommodate the proposed configuration of the LNG unloading, storage, and sendout facilities. An ideal waterfront site available for development would include an area in excess of the exclusion zone that would provide an additional buffer from development.

- **Dredging Required** – Given the environmental impacts associated with significant dredging projects, we considered the amount of dredging necessary to provide access to LNG ship access one of the alternative site review criteria. Areas requiring minimal dredging to develop and maintain a ship berth and a shipping channel of sufficient depth for the LNG ships were considered more favorable than those areas requiring more substantial dredging. In addition to avoiding impacts on water quality and aquatic resources, minimal dredging requirements provide the added benefit of reducing costs associated with disposal of dredged material.

- **Parcel Availability** – One of the greatest challenges of siting an LNG facility is finding suitable property that is available for industrial development. Availability is critical since section 3 of the NGA does not provide the project proponent the authority of eminent domain in acquiring property for the LNG terminal project facilities. In some cases, a site may possess the size required for an LNG terminal but the owner is unwilling to sell or has placed unacceptable conditions on the acquisition of the site.

- **Existing Land Use** – Areas previously disturbed or cleared for industrial or commercial activities were preferred over undisturbed areas (greenfield sites) when identifying alternative LNG terminal sites. Additionally, we preferred sites where existing land use zoning, coastal zone management guidelines, or development plans were consistent with an LNG import terminal. For example, although we considered all areas with deepwater access, areas outside of designated ports were generally determined to be less preferable than areas within designated ports. Those sites in areas consistent with existing land uses were considered the most practical alternatives to the proposed site.

- **Sendout Pipeline Factors** – We considered sites proximal to existing interstate pipeline systems that could accommodate the proposed volume throughput more favorably than sites farther from existing pipelines. In addition, we favored pipeline routes that would cross fewer waterbodies and impact less wetlands. On top of the additional costs and environmental impacts, longer pipelines would likely directly and indirectly affect more landowners/residences.

- **Navigational Suitability** – Sites that offer minimal disturbances to existing shipping and allow for good access by LNG ships were considered a favorable selection criterion. We also considered bridge transit along the navigation channel in our site analysis, since LNG ships require a vertical clearance of at least 135 feet and horizontal clearance of not less than 165 feet.

- **Various Environmental Factors** – Environmental factors that were considered in our site selection included: minimizing wetland disturbance and preferring sites in uplands; avoiding areas that would conflict with recreational activities; and selecting sites where the LNG storage tank would have a minimal impact on the viewshed from roadways and surrounding communities.

- **Special Interest Areas** – We considered favorably those sites that avoided conflicts with special interest areas such as state or national parks and marine sanctuaries. When applying this criterion, we considered potential conflicts with special interest areas from either an LNG terminal or its associated sendout pipeline.

The sites discussed below include reasonable alternatives to the terminal location proposed by NorthernStar. We have also included a discussion of alternative LNG terminal sites that were brought up during project scoping. Figure 3.1.5-1 depicts the locations of these sites.

Puget Sound Area

During the public scoping process, we received comments that the Puget Sound area would be more suitable for an LNG import terminal than the Columbia River. We considered two locations along Puget Sound - Cherry Point and Port Angeles. As described below, both locations were eliminated before specific sites were identified.

<u>Cherry Point</u>

The Cherry Point Urban Growth Area (UGA) extends along the coast of Georgia Strait from just south of Birch Bay State Park to the northern boundary of the Lummi Reservation in Whatcom County, Washington. The County has designated the Cherry Point UGA for industrial development and it is currently the site of two oil refineries and an aluminum smelter. A proposed 1,100-acre bulk commodities shipping port is also planned for the Cherry Point UGA. Approximately 1,800 acres (the equivalent of two sites with piers) remain for additional major industrial development with deepwater shipping access (Whatcom County, 2005). The Williams Northwest pipeline could be accessed approximately 18 miles east of the Cherry Point industrial area.

According to a recent newspaper article in the Bellingham Herald (Stark, 2007), the Lummi Nation, in partnership with Mercator Energy LLC, has been exploring the possibility of locating an LNG import terminal at Cherry Point since 2003. The Lummi Reservation is located adjacent and south of the Cherry Point UGA; however, the newspaper article indicated that new land would be acquired by the tribe for the terminal and would then be converted to tribal trust land. At this time the project is considered dormant by the tribe, because property for the proposed terminal has not yet been acquired.

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Figure 3.1.5-1 LNG Import Terminal Alternatives in Washington and Oregon

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At first glance, the Cherry Point location appears to be suitable for an LNG import terminal; however, the Washington Commissioner of Public Lands signed a Withdrawal Order creating the Cherry Point State Aquatic Reserve (CPSAR) on August 1, 2000. The land was set aside to protect various aquatic resources, including the declining stocks of Pacific herring in the area as well as the local crab fishery and migratory habitats for waterbirds and marine mammals. The CPSAR extends from the southern boundary of Birch Bay State Park along the coast to the northern boundary of the Lummi Reservation (roughly protecting the area from 0 mean lower low water (MLLW) to -70 MLLW).

The development of a specific management plan by the Washington State Department of Natural Resources (WDNR) for the CPSAR will not likely be finalized until late 2007 or early 2008. Interim guidelines for managing the CPSAR prohibit the development of any new in-water structures within the CPSAR (e.g., dock or pier construction). According to the WDNR, interim development restrictions for this aquatic reserve are consistent with Whatcom County's Shoreline Management Plan, which also prohibits development of new docks or piers in this area. Because of the restrictions on development associated with the CPSAR, the Cherry Point location was eliminated from further consideration for an LNG terminal site alternative.

Port Angeles

Port Angeles is a small city of around 20,000 people located on the south shore of the Strait of Juan de Fuca in Clallam County, Washington. It is the West Coast's northernmost deepwater port. The harbor is home to a top-side ship repair facility, a luxury yacht builder, and the terminal for the ferry to Victoria, British Columbia. The waterfront area is fully developed. The Clallam County Economic Development Council lists a number of large industrial parcels available for development, including 112 acres owned by the Port of Port Angeles; however, none of these parcels has waterfront access (Clallam County Economic Development Council, 2006).

We determined there was no available industrial use land with deepwater port access in the Port Angeles area that could be considered for an LNG terminal site alternative and therefore did not further consider this alternative.

Grays Harbor

Located on Washington's coast about 40 miles north of the mouth of the Columbia River, Grays Harbor includes a deepwater shipping port used by a variety of industrial tenants. Within the Port of Grays Harbor, we identified one site (located at Terminal 3) that could potentially accommodate an LNG terminal and that is available for sale or long-term lease. The Port of Grays Harbor Terminal 3 is a marine industrial site located in the City of Hoquiam less than 1.5 hours by ship from open sea and 1 hour by vehicle from Olympia, Washington. The site consists of 150 level acres with good drainage. A 600-foot by 120-foot deepwater marine terminal, with 38 to 40 foot depths, already exists adjacent to the site. The site is owned by the Port of Grays Harbor and is zoned for heavy industrial use. Electrical service, industrial water, and wastewater treatment facilities are available on site (Grays Harbor Economic Development Council, 2005).

The site is just east of Bowerman Field, a small general aviation airport with a 5,000-foot paved runway. According to 49 CFR 193.2155(b), LNG storage tanks must not be located within a horizontal distance of 1 mile from the ends of an airport runway, or 0.25 mile from the nearest point of a runway, whichever is longer. Because the entire site would be located within 1 mile of the east end of Bowerman Field runway, this site was eliminated from further consideration. We are not aware of other properties within Grays Harbor that would potentially be suitable for an LNG terminal.

Columbia River

Three alternative LNG terminal sites were identified along the Columbia River (Tansy Point, Oregon LNG, and Port Westward) in addition to the proposed Bradwood Landing Project. These alternative LNG import terminal locations are discussed above in section 3.1.3.4. In conclusion, none of the other alternative locations for an LNG import terminal along the Columbia River appear to be clearly environmentally superior to the Bradwood Landing Project. Other LNG import terminals in Oregon would not be considered mutually exclusive. If they do not cause significant environmental impacts, and the market could support them, multiple LNG import terminals could be authorized to serve a growing demand for natural gas in the Pacific Northwest.

3.1.6 Bradwood Landing LNG Terminal Design Alternatives

3.1.6.1 Alternative LNG Storage Tank Designs

The most visible component of an LNG import terminal facility is typically the LNG storage tanks. We evaluated three alternative LNG tank designs relative to their potential visual impacts and other environmental impacts, engineering/design feasibility, and costs. These three alternatives are summarized below.

Conventional at-grade LNG storage tanks would have the highest profile and thus the greatest visual impacts, particularly on sensitive viewers located on Puget Island. However, these impacts would be mitigated by use of appropriate color paint (i.e., natural colors such as green or brown) and appropriate surface material finishing (see section 4.7.2.7). This alternative would have the lowest cost, the highest engineering/design feasibility and, aside from visual impacts, the smallest environment impact of the three alternatives. Therefore, at-grade LNG storage tanks were selected for use on the proposed project.

Below-grade LNG storage tanks would use the same design as the at-grade tanks but would be placed in excavated pits to reduce the height of the tank located above the ground surface. The pits would be designed to mitigate potential earthquakes and flooding, impacts resulting from the excavation, and dewatering during excavation. Depending on the final depth of the tanks, 0.5 to 1.0 million cubic yards of soil would be excavated and taken off site. The 40,000 to 80,000 truck trips necessary to transport this soil would have associated traffic, noise, and air quality impacts. The dewatering that would be required during excavation, and permanent groundwater control requirements, could have impacts on groundwater and surface water resources. Use of below-grade LNG storage tanks would extend the project schedule by up to 1 year compared to at-grade storage tanks, and it is the most expensive LNG storage tank alternative. Below-grade LNG tanks have not been used or proposed for any LNG import project in North America.

A type of low-profile LNG storage tank, referred to as LNG Smart Horizontal Tank Storage, has been developed by Mustang Engineering but has not been used on a scale as large as the proposed project. These tanks would consist of multiple horizontal vessels located inside a concrete box. Many smaller horizontal vessels would be required to provide the storage capacity required by the project, resulting in a 65 percent increase in the size of the LNG storage tank area. This increased area would have a corresponding increase on environmental impacts at the terminal site and could make future expansion of the terminal difficult or impossible. Although not as costly as the below-grade tank alternative, this alternative would be significantly more expensive than the conventional above-grade LNG storage tanks.

3.1.6.2 Alternative LNG Terminal Layout

As proposed, the Bradwood Landing LNG terminal would require the permanent development of 40 acres. This is a relatively small footprint compared to many existing LNG import terminals in the United States, which may occupy as much as 318 acres (i.e., Cove Point). In originally developing the LNG terminal layout at Bradwood, NorthernStar considered engineering/design, worker safety, economic, and environmental factors.

Through consultation with various resource agencies, NorthernStar has continued to refine the facility layout to minimize environmental effects. Specifically, NorthernStar considered alternative LNG terminal site configurations to reduce impacts on wetlands. The original site boundary was modified by truncating the northwest and southwest corners. This modification reduced the area of wetlands that would be filled with dredged material by 3.1 acres (16 acres covered by the original layout as compared to 12.9 acres by the modified layout). NorthernStar indicated that no additional reductions in wetland impacts, including retaining the log pond, are possible because remaining areas of the terminal site are needed for LNG terminal facilities, operations, utilities, a maintenance area, safety buffers, circulation, stormwater management, an emergency helicopter landing area, and laydown areas for construction. For example, the area used for stormwater management must have adequate capacity to temporarily retain water after a large storm event prior to infiltration. During annual critical maintenance events known as "turn overs," the maintenance area would be fully occupied by a full range of construction equipment (including cranes, trucks, welding machines and other large pieces), contractor trailers, and facility parts. Furthermore, the helicopter landing area must be located a safe distance from equipment filled with flammable liquids. Additional reductions in the site size and/or other alternative site layouts would reduce efficient use of space and could risk worker safety during construction or operation of the facility.

As described in section 2.9, NorthernStar has not committed to expanding the proposed LNG terminal. However, if there is a future demand for additional natural gas in the market area, provisions have been made in the layout of the site to allow for a possible future expansion by adding a third LNG storage tank and other equipment/facilities. Failing to plan for a growth in market demand and subsequent expansion of the LNG terminal to serve this demand may severely compromise the ability of NorthernStar to expand in the future. If the facility is not designed to accommodate reasonable changes, future expansion activities could be unnecessarily expensive, require schedule delays for subsequent permitting, and/or involve additional environmental impacts. According to NorthernStar, designing a project to allow for future expansion is a typical model for energy projects of this size and is necessary to make the project viable.

3.1.6.3 Alternative Vaporization Technologies

There are various designs of equipment that are used to warm LNG to the point it returns to a gaseous state. NorthernStar considered engineering feasibility, operational requirements, reliability, safety, past commercial application, environmental impacts, and permitting feasibility as the main criteria in selecting the vaporization equipment for the Bradwood Landing Project. The basic technologies assessed by Northern were ORVs, SCVs, STVs, and water baths.

Various sources of heat were considered, including ambient air, river water, natural gas, electric power, wood chips, and waste heat from cogeneration. Ambient air-heated vaporizers were initially considered for the Bradwood Landing Project but were determined to be infeasible because of the long periods of cool, wet weather typical for this area. Technologies relying on electric power for heating were also eliminated because the amount of power necessary could not be generated on site and could not be purchased for an acceptable price. Burning of wood chips for a heating source was eliminated because of the large variability in wood chip costs over time, air emissions, lack of storage areas on site for the wood chips, and because of potential impacts associated with transporting large volumes of wood chips to the site.

Waste heat from cogeneration was eliminated as a source for vaporization because of substantial uncertainties regarding the transmission of power out of the facility. Specifically, in order to implement this alternative, there was a possibility NorthernStar might have to construct a 50-mile-long power line out of the facility to a connection with the existing BPA grid. To remove the uncertainty associated with the power line, NorthernStar would need to pay now for capacity in the grid that it would not need for some time in the future in order to use the grid. Constructing this transmission line and purchasing this capacity would be prohibitively expensive.

Based on its analysis of the various technologies and heat sources, NorthernStar chose SCV with natural gas for vaporization at the Bradwood Landing LNG terminal. Because NorthernStar selected a vaporizer design that utilizes the combustion of natural gas for heating, and air emissions would be generated, other designs were evaluated to determine if an alternative design could result in reduced impacts. For purposes of an environmental comparison, vaporizers can be broadly categorized into two groups depending on whether or not they require on-site combustion of a fuel to warm the LNG.

Natural Gas Combustion

Three vaporizers that use natural gas combustion were considered for the Bradwood Landing Project, the SCV, water bath, and STV.

SCVs are generally based around a concrete structure containing a water bath with submerged stainless steel pipe coils. LNG enters the coils and, as it is warmed by the water bath, the vaporized LNG (natural gas) exits the coils. The water bath is warmed by burning natural gas. Blowers provide combustion air at a pressure sufficient to force the combustion emissions up through the water bath where they heat the water. SCVs typically consume about 1.5 percent of the sendout natural gas from the terminal. This type of vaporization system is very efficient and is able to accommodate wide fluctuations in the amount of LNG vaporized. SCVs tend to have higher air emissions, particularly NO_x, than other combustion units because the use of selective catalytic methods to control emissions has not proven reliable. Excess condensate water, on the order of several million gallons per day (mgd), is produced. Disposal of the excess water requires treatment with alkaline chemicals to neutralize the acidity caused by absorbed CO_2.

Water baths use an open bath containing combustion tubes and LNG tubes. The fired gases transfer heat through the combustion tubes to the water bath and the water bath transfers heat to the LNG piping. The combustion gases and the water bath are not in direct contact with each other (unlike in SCVs). The combustion gases are discharged to the atmosphere. Approximately 2 percent of the natural gas produced by the terminal would be used in this process resulting in more air emissions than SCVs. This system is less efficient than SCVs.

STV systems involve a heat exchanger in which tubes containing LNG pass through a shell containing a counter-current of heat exchange media such as a water/glycol mixture. On the opposite end of the heat exchanger loop, the water/glycol mixture is typically heated by using direct-fired combustors burning natural gas. However, the source of heat may vary depending on the particular design. For this project, a vertical shell and tube design with a closed-loop hot water system that provides heat to the vaporizers was considered. The water is heated using direct-fired heaters that run on natural gas. About 100,000 gallons of fresh water would be necessary to operate this closed-loop system. An advantage of the STV is that selective catalytic reduction systems and oxidation catalysts can be used on the heaters to reduce NO_x and CO emissions.

Estimated air emissions associated with SCVs, water baths, and STVs are presented in table 3.1.6-1.

TABLE 3.1.6-1

Estimated Air Emissions Associated with Vaporizer Combustion

	Air Emissions (tpy) [a]		
Vaporizer Design	NO_x	CO [b]	PM_{10}
SCV [c]	94	64	6
Water Bath [d]	310	261	24
STV [d]	310	261	24

[a] Based on a sendout rate of 1.0 Bcfd and 12-month operation of vaporizers.
[b] Carbon monoxide.
[c] The SCV firing rate is 14 MMcfd.
[d] Based on large wall-fired boiler with flue gas recirculation and low NO_x burners, assuming 17 MMcfd firing rate.

None of these vaporizer technologies would use water from the Columbia River. The water bath and STV would not discharge water to the river, but SCV would generate water condensate that would be discharged to the Columbia River at a rate of 160 gpm and a temperature of about 68 °F. This discharge water would contain approximately 0.4 percent of sodium carbonate and trace amounts of sodium nitrate and other sodium salts, but would not require treatment other than pH neutralization.

Non-Combustion Alternatives

At some locations with warm climates, it is possible to use ambient warm air or ambient warm water as a source of the heat needed to vaporize the LNG. The advantage of vaporizers that utilize ambient air or water vaporization systems is that air emissions tend to be lower than for a system that involves combustion of a hydrocarbon fuel (Coast Guard and MARAD, 2003). Although air or water vaporizers can result in very small quantities of air emissions associated with electrical generation required to power fans or pumps, the power is generally produced off-site and the amount needed for the vaporizers is relatively minor (Coast Guard and MARAD, 2003).

Ambient air-heated vaporizers use air warming structures to warm and vaporize the LNG. Because the surface area of the heat exchangers needs to be large for efficient heat transfer, the structures would be large and require significant space for construction and operation. Ambient air-heated vaporizers utilize air warming structures as heat exchangers to recirculate the cooled water from the water bath and warm it through exposure to the air. Because the surface area of the water–air interface needs to be large for efficient heat transfer, the structures are generally large and require significant space for construction and operation. Because water would condense on the warming structures, ambient air vaporizers at the Bradwood Landing LNG terminal would produce about 1.3 mgd of water during operation compared to approximately 0.4 mgd for operation of SCV units. Ambient air-heated vaporizers were not considered practical for the Bradwood Landing Project because of limitations associated with periods of cool weather along the Columbia River.

River water, used exclusively as a heat source for vaporization, was also eliminated as a practical vaporization technology for the Bradwood Landing Project. However, river water was considered further in combination with the use of either natural gas fired SCVs or STVs during the coolest 5 months of the year. If the river water temperature is above approximately 63 °F, the water can typically serve as the sole heat source for LNG vaporization. When water temperatures drop to between 50 °F and 63 °F, supplemental heat is typically required. As an indication of river water temperatures in the vicinity of the proposed site, in 1996, the mean temperatures measured 3 miles upstream from the proposed LNG terminal site ranged from a low of 41 °F in March to a high of 71.4 °F in July (U.S. Geological Survey (USGS), 1996).

For the Bradwood Landing Project, a water-based vaporization system would require withdrawing (and discharging) large volumes of water from the Columbia River. The water would be treated for sodium hypochlorite with sodium bisulphite before discharging at a rate of 100,000 gpm. On other LNG terminal projects (e.g., Long Beach LNG Import Project), agencies such as the NMFS have expressed concerns that significant numbers of fish and/or fish larvae could be entrained during the withdrawal of water. With the large number of federally protected species found in the Columbia River (see section 4.6.1.1), concerns related to entrainment are particularly relevant. Additional concerns have been raised about the thermal plume associated with discharging cold water back into the affected waterbody. NorthernStar estimates there would be a maximum decrease of 14 °F in the discharge water compared to the ambient river water temperature. Although the use of river water during 7 months of the year would result in decreased air emissions compared to technologies that use combustion year round, given the environmental concerns associated with withdrawal and discharge of the river water, this vaporization technology would not offer an overall environmental advantage compared to SCVs.

3.1.6.4 Alternative Fill Sources

Geotechnically suitable fill is required to raise the grade at the LNG terminal site to 20 feet NAVD. NorthernStar proposes to use up to about 400,000 cubic yards of material dredged from the maneuvering area in the Columbia River for this purpose. During preliminary meetings held to discuss the content of the BA, the agencies requested an analysis be performed for an alternative source or sources of fill that would be from an upland area so that material dredged for the ship berth and maneuvering area could be used for in-river placement. NorthernStar determined that the most likely upland fill source would be Teavin’s Pit, a permitted aggregate mine. The cost of the fill would be between $3.5 million and $5.2 million. Transporting the fill to the proposed LNG terminal site would require about 10,500 truck loads at an estimated round-trip travel time of 30 minutes, totaling 5,250 hours of truck time. In addition, four pieces of heavy equipment would be required, totaling about 21,000 hours. The pollution generated from operation of the truck and heavy equipment would result in the following emissions:

- 53.5 tons of carbon monoxide (CO);
- 43.5 tons of NO_x;
- 6.3 tons of SO_x;
- 2.5 tons of particulates (does not include dust generated from the fill handling itself); and
- 1.3 tons of volatile organic compounds (VOC).

In addition, increased emissions would result from the increased time that the dredge would operate in order to transport the dredged material a greater distance to an alternative placement site. Given the increased air emissions and economic costs of trucking in fill material to raise the LNG terminal site, this alternative does not appear to offer a significant environmental advantage over the proposed source of fill.

3.1.7 Power Line Route Alternatives

As described in section 2.2.1, a 1.5-mile-long non-jurisdictional electric power line would be constructed on a 105-foot-wide right-of-way to bring electricity to the terminal. Five new 69-foot-high H-frame structures would be constructed for the power line and an existing BPA tower would be rebuilt. NorthernStar evaluated four alternative power line routes from the BPA system to the terminal:

Alternative Route 1, located closest to the Columbia River; Alternative Route 2, located west of Alternative Route 1; Alternative Route 3, located west of Alternative Route 2, and the proposed route, located between Alternative Route 1 and Alternative Route 2. These routes are depicted on figure 3.1.7-1.

The alternative routes are generally similar with respect to overall length, habitats crossed, and most other important characteristics. Alternative Route 3 is slightly shorter than the other two routes. Use of Alternative Routes 2 and 3 would result in clearing of more closed canopy forest than Alternative Route 1. NorthernStar initially selected Alternative Route 1 for the power line on the basis that this route would result in less visual impacts on sensitive viewers on Puget Island because it is located at a lower elevation, and the hillside on which much of the route is located would be present as background when viewed from Puget Island. However, Alternative Route 1 crosses late-successional (old growth) conifer forest. The proposed power line route completely avoids the old growth forest. In some places the power line would be visible against the sky when viewed from Puget Island, but the overall visual impact would be minor.

The proposed power line route is 0.1 mile shorter than Alternative Route 1 and crosses better topography for construction. Existing access roads could be used for both Alternative Route 1 and the proposed route but the proposed route would require approximately 465 feet of additional access roads for construction and maintenance of the H-pole towers. No wetlands would be affected by construction of the additional access roads.

NorthernStar also evaluated the feasibility of a power line route following Clifton Road. The absence of a right-of-way along Clifton Road and steep topography would make construction of the H-towers difficult and the route would be about 2 miles longer than the proposed route. The Clifton Road route would cross Hunt Creek twice. Such a route would have no advantages over the proposed route and the waterbody crossings would result in impacts on riparian and estuarine habitats.

3.1.8 Pipeline Route Alternatives

We assessed whether it might be possible to reduce the environmental impacts associated with construction and operation of the proposed sendout pipeline by following a major route alternative. Additionally, we evaluated minor variations to the proposed pipeline route to avoid or minimize impacts on specific, localized resources such as residences, waterbodies, forest habitat, and wetlands.

3.1.8.1 Major Pipeline Route Alternatives

Alternatives to the proposed pipeline route would have to meet the project objective of transporting natural gas from the Bradwood Landing LNG terminal to existing and future markets in the Pacific Northwest. Specifically, the project is designed to provide up to 1.3 Bcfd of natural gas to the region by: 1) delivering natural gas to the Georgia-Pacific paper mill at Wauna, Oregon and the PGE Beaver Power Plant at Port Westward, Oregon; 2) interconnecting with Northwest Natural's existing bidirectional intrastate pipeline facilities capable of transporting gas to their Mist underground storage facility; and 3) interconnecting with the Williams Northwest interstate pipeline system.

NorthernStar considered three major alternatives to the proposed sendout pipeline route: 1) the Railroad Route Alternative, 2) the Northern Route Alternative, and 3) the Southern Route Alternative (see figure 3.1.8-1). In addition, a route alternative requiring crossing of the Columbia River at Bradwood Landing was initially considered. However, due to the limitations of HDD technology and the length of the crossing at this location, the route was determined to be unconstructable and was eliminated from further consideration.

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Figure 3.1.7-1 Power Line Route Alternatives

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Figure 3.1.8-1 Major Pipeline Route Alternatives

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Railroad Route Alternative

The Railroad Route Alternative would parallel the existing PWRR from Bradwood Landing to Rainier, Oregon. The pipeline would then cross the Columbia River by HDD methods and terminate at Williams Northwest pipeline, southeast of Longview, Washington. The total approximate length of this alternative is 35.8 miles, which would be slightly shorter than the proposed route. NorthernStar evaluated this alternative in an effort to minimize project impacts on environmental resources by collocating the project within an existing industrial corridor.

Although this route alternative achieves delivery to interstate markets, it fails to meet the project objective of delivery to the PGE Beaver Power Plant at Port Westward without the construction of a lateral that would significantly increase the overall length of the pipeline system and subsequently increase the number of landowners and environmental resources impacted by the project. Additionally, the portion of the railroad bed between Bradwood Landing and the Georgia Pacific paper mill at Wauna, Oregon is adjacent to a basalt ledge that would require blasting for installation of the pipeline. Blasting could result in stability issues for the railroad bed.

Northern Route Alternative

The Northern Route Alternative would exit the LNG terminal site to the south and continue along Nikolai Ridge for approximately 6 miles. The pipeline would then turn to the east and parallel, where possible, existing logging roads and other rights-of-way, proceeding south of Clatskanie, and turning roughly southeast at Rainier, to the vicinity of Prescott, Oregon. The pipeline would cross the Columbia River using the HDD construction method near the decommissioned Trojan nuclear power plant, and continue east to tie-in with the Williams Northwest pipeline system north of Kalama, Washington. The approximate length of this alternative route is 42.6 miles. This was the route originally proposed by NorthernStar when it entered into the FERC’s Pre-filing Process in March 2005.

Although this route alternative would achieve delivery to interstate markets, it fails to meet the project objective of delivery to the PGE Beaver Power Plant at Port Westward without the construction of a lateral, which would significantly increase the overall length of the pipeline system and subsequently increase the numbers of landowners and environmental resources impacted by the project. Additionally, crossing under the Columbia River near the decommissioned Trojan nuclear power plant using the HDD method would be problematic due to the width of the river at this location. The Port of Kalama raised objections about this route because of potential impacts the crossing of the Columbia River may have on future port development activities.

A variation of the Northern Route, referred to as the Longview Alternative, was also considered. The Longview Alternative would follow the Northern Route to near Rainier, cross the Columbia River into Longview, Washington, then proceed east to tie-in with the Williams Northwest pipeline system. The Longview Alternative would decrease the length of the Northern Route by 1.3 miles and avoid impacting the Port of Kalama property. However, this variation would still be 5.0 miles longer than the proposed route and the crossing of the Columbia River would be difficult at the Longview Alternative location.

Southern Route Alternative

The Southern Route Alternative would exit the LNG terminal site to the south and continue along Nikolai Ridge for approximately 9 miles. The pipeline would then follow a mostly southeast alignment to a point south of Deer Island, Oregon, cross the Columbia River by HDD methods, and terminate at a tie-in with the Williams Northwest pipeline system north of Woodland, Washington. The length of this alternative is about 55.0 miles, which would be 18.7 miles longer than the proposed route.

Although this route alternative achieves delivery to interstate markets, it fails to meet the project objective of delivery to the PGE Beaver Power Plant at Port Westward without the construction of a lateral which would significantly increase the overall length of the pipeline system and subsequently increase the numbers of landowners and environmental resources impacted by the project. Because of the large increase in length compared to the proposed route, the overall footprint of the project (including extra workspaces and access roads) would significantly increase the potential for environmental impacts compared to the proposed pipeline route.

Major Pipeline Route Alternatives Conclusion

Table 3.1.8-1 compares the proposed Bradwood Landing pipeline route to the three alternative routes. As indicated by table 3.1.8-1, the Railroad Route Alternative would be the shortest route and the Southern Route Alternative would be the longest. The proposed route, which would be only slightly longer than the Railroad Route Alternative, would have the fewest residences within 50 feet of the construction right-of-way; the Railroad Route Alternative would have the most nearby residences. The Railroad Route Alternative would also have the most commercial and industrial structures within 50 feet of the construction right-of-way. The proposed route would cross the most waterbodies; however, a relatively large number of manmade ditches (approximately 36) within agricultural land between Westport and Port Westward account for a majority of the additional waterbodies along the proposed route. The Railroad and the Southern Routes would cross the fewest waterbodies, but the Railroad Route Alternative would cross the most wetlands. Although the proposed route would cross significantly more agricultural land than three of the other alternative routes, the impacts on agricultural lands would generally be temporary (i.e., these lands would return to agricultural production within one growing season). With the exception of the Railroad Route Alternative, the proposed route would impact the least amount of forested land.

The proposed route presents advantages over the three alternative routes in terms of environmental impacts, constructability, proximity to populations, and proximity to target markets. Because this route is the shortest in length; the overall area that would be impacted is less as compared to the other route alternatives. In addition, this route achieves the market objectives of the pipeline while eliminating constructability issues, reducing environmental impacts, and reducing the overall length of the pipeline. Therefore, we agree that the proposed route is preferred over the alternative routes.

3.1.8.2 Minor Pipeline Route Variations

During refinement of the proposed Bradwood Landing pipeline route, a number of minor route variations were considered by NorthernStar in an effort to eliminate or minimize potential impacts on specific localized resources, including residences, wetlands, or waterbodies. Route variations were also identified as specific landowner concerns were raised. In some cases, NorthernStar determined that the new route variation would be preferable to the initially proposed route segment and in other cases, the initial route segment was determined to be the best option. We reviewed the route variations identified by NorthernStar and agree that the selected route segments (whether initial route segment or an alternative route variation) would reduce the overall environmental impacts of the project. These route variations are summarized in table 3.1.8-2, and depicted on the proposed route maps in Appendix B.

TABLE 3.1.8-1

Comparison of the Proposed Bradwood Landing Pipeline to the Alternative Routes

Environmental Factor	Proposed	Railroad	Northern	Northern with Longview Alternative	Southern
Total length (miles)	36.3	35.8	42.6	41.3	55.0
Permanent Right-of-Way (acres) [a]	220.0	216.0	258.2	250.3	333.3
Extra Work Spaces (number)	61	109	86	89	124
Residences within 50 feet of Construction Right-of-Way (number)	13	32	28	20	15
Commercial or Industrial Structures within 50 feet of Construction Right-of-Way (number)	13	19	1	5	0
Perennial Waterbodies Crossed (number) [b]	61	26	43	44	28
Wetlands Crossed (miles) [c]					
Palustrine Forested	0.2	1.4	0.2	0.8	0.6
Palustrine Nonforested	5.8	3.7	0.9	1.7	0.5
Palustrine Combination Forested/Nonforested	0	0.9	<0.1	0.0	0.0
Riverine	0.9	1.8	0.6	0.4	0.6
Total	6.9	7.8	1.7	2.9	1.7
Federal and/or State Threatened and Endangered Species					
Fish species inhabiting waterbodies crossed (number)	10	9	9	10	9
Waterbody crossings through habitats of one or more fish species (number)	13	14	11	11	12
Bird species within 0.5 mile of route (number)	2	4	3	4	5
Bird nest locations within 0.5 mile of route (number)	7	4	4	4	3
Priority bird habitats, species, and nest buffers within 0.5 mile of route (number)	9	7	9	7	7
Bird habitat to be disturbed (acres) [d]	4.9	18.2	61.4	68.9	66.7
Amphibian species/habitats within 0.25 mile of route (number)	1	0	0	0	0
Reptile species/habitats within 0.25 mile of route (number)	0	0	0	0	0
Plant species/habitats within 0.25 mile of route (number)	2	1	4	3	3
Plant species habitat to be disturbed (acres) [d]	68.9	63.7	2.5	68.6	57.8
Mammals species/habitats within 0.25 mile of route (number)	4	3	2	2	1
Mammal species habitat to be disturbed (acres) [d, e]	99.8	82.1	29.8	29.8	25.1
Public Lands Crossed (miles)	0.2	0.0	6.7	4.9	12.1
Agricultural Land Affected (acres) [d]	166.1	163.2	22.5	48.1	52.1
Forest Required to be Cleared (acres) [d]	228.9	163.1	462.9	378.8	587.0
Roads Crossed (number)	49	103	82	81	121
Major Utilities Crossed (number)	5	4	9	7	5

[a] Assumes a 50-foot-wide permanent right-of-way throughout.
[b] Includes manmade ditches.
[c] Based on NWI data for all routes, including the proposed route.
[d] Assumes a 100-foot-wide construction right-of-way throughout.
[e] Based on GIS calculation of the sum of habitats from the WDFW, Priority Habitats and Species and Oregon Natural Heritage Information Center databases.

TABLE 3.1.8-2

Minor Route Variations Evaluated for the Proposed Pipeline Route by NorthernStar

Variation	Beginning MP	Reason Route Variations Were Evaluated and Selected	Initial Route Segment Length (miles)	Alternative Route Variation Length (miles)
NS-1	0.0	Impacts on environmental resources, including forest habitat, waterbodies, and wetlands, would be avoided along Nikolai Ridge by using the HDD method along the initial route segment as opposed to trenching along the alternative route variation. Also, the initial route segment would be 0.19 mile shorter.	1.6 **selected**	1.7
NS-2	2.6	The initial route segment is slightly longer; however, alignment along a secondary road within Georgia-Pacific property and within scrub-shrub habitat (an area that appears to have been clear-cut and is dominated by non-native Himalayan blackberry) avoids impacts on forest habitat.	0.2 **selected**	0.2
NS-3	10.7	The selected alternative route variation follows property boundaries and would minimize impacts on agricultural fields in response to landowner concerns. Additionally, the selected route would be further from residences than the initial route segment. Slightly more emergent wetlands would be temporarily impacted along the selected alternative route variation compared to the initial route segment.	1.7	2.2 **selected**
NS-4	13.5	The alternative route variation was selected in response to landowner concerns. Although longer than the initial route segment, the alternative follows property boundaries and road alignments and would minimize impacts on active agricultural areas without significant additional construction impacts on natural resources.	3.1	4.7 **selected**
NS-5	19.0	The initial route segment was considered so existing roads could be used to avoid impacts on forested areas. The alternative route was selected because it would minimize impacts on landowners associated with the use of private roads. Impacts on natural resources are generally consistent between the two segments.	1.3	1.2 **selected**
NS-6	20.3	The initial route segment was selected over the alternative route variation because it would minimize impacts on property owners. Other impacts are generally consistent between the two route segments.	1.4 **selected**	1.6
NS-7	31.1	The alternative route variation was selected to accommodate landowner concerns related to a pond/spring on their property. The alternative route follows a ridgeline on the property to increase the distance between the pipeline and the pond/spring - the nearest potion of the proposed construction work area is 450 feet west and 1,150 feet south of the pond/spring.	0.3	0.3 **selected**
NS-8	33.9	This alternative route variation considered a different location for the entry pit of the HDD borehole that would cross the Cowlitz River, taking into consideration the proximity of residences, oak trees, and the scales of a rock pit. The HDD entry pit work space for the alternative route variation would be 300 feet from several residences compared to more than 600 feet for that of the initially proposed route; however, the initially proposed work space would be 50 feet from a residence and would damage oak trees and the rock pit scales. Also, the selected alternative route variation would use a soon to be abandoned power line right-of-way.	1.1	1.1 **selected**
NS-9	35.1	Although 1.25 acres more forest habitat would be impacted, the initial route segment would avoid several residences east of Interstate Highway 5 compared to the alternative route variation.	1.2 **selected**	1.1

Note: Comparisons of wetland impacts were made using NWI data for consistency rather than actual field delineations.

3.1.9 Dredging and Dredged Material Placement Alternatives

As discussed in section 2.4.1.2, NorthernStar would dredge up to about 700,000 cubic yards of sediment from the ship berth and maneuvering area to enable LNG ships to dock and turn in the Columbia River. This volume was determined based on the minimum amount needed to safely accommodate LNG ships. Alternatives requiring more dredging could be identified; however, alternatives requiring less dredging would not be able to safely accommodate LNG ships. As such, we did not consider it feasible to reduce the volume or extent of dredging and still satisfy the objectives of the project at the proposed site.

Dredging and dredging related activities would be conducted in accordance with applicable federal, state, and local permit stipulations. To avoid or minimize impacts on water quality or biological resources associated with these activities, alternative dredging methods and dredge disposal alternatives were considered.

Dredging and placement of structures within waters of the United States requires authorization from the COE under section 404 of the CWA and section 10 of the RHA (see section 1.3). As an element of its review, the COE is required to consider whether a proposed project represents the least environmentally damaging practicable alternative pursuant to the CWA section 404(b)(1) guidelines (40 CFR 230). The term practicable means available and capable of being done after taking into consideration cost, existing technology, and logistics in light of overall project purposes. As a cooperating agency, the COE has recommended that the alternatives analysis in this EIS consider project design, configuration, and construction alternatives that avoid or minimize effects on the aquatic environment. In this way, this EIS could be used to identify the COE's least environmentally damaging practicable alternative.

Ultimately, activities associated with dredging, as well as construction of the LNG ship berth and unloading facility, would be conducted in accordance with COE permit stipulations as well as the requirements of state and local permits (see section 1.3). To avoid or minimize impacts on water quality or biological resources associated with these activities (see sections 4.3.2.2 and 4.5.2.1), alternative dredging methods and dredged material placement areas were considered.

3.1.9.1 Alternative Dredging Methods

Dredging technologies can be separated into two basic categories, hydraulic and mechanical. Two types of hydraulic dredge units (self-propelled hopper dredges and cutterhead pipeline dredges) have historically been used in the Columbia River area. The hopper dredge is a seagoing vessel that can move from one area to another under its own power. It excavates dredged material by lowering drag arms onto the bottom to dislodge material, and then suctions the material into the hopper, or holding area. In order to effectively operate, a hopper dredge must be moving forward while dredging, and it typically operates most efficiently over long distances, such as in navigation channels. A hopper dredge would not be well suited for this project because of the relatively confined work space at the proposed LNG terminal.

A hydraulic cutterhead pipeline dredge uses its cutterhead to break up the materials to be dredged, then suctions the material into a pipeline. Prior to dredging, the pipeline is laid between the site to be dredged and the dredged material placement area. The pumping distance is a limiting factor for selection of this method. The typical maximum pumping distance is roughly 2 miles but use of booster pumps can increase the distance to 5 to 8 miles, depending on the grain size of the sediment. Dredging production rates are dependent on the characteristics of the materials to be dredged, the equipment employed in the operation, and the length of the pipeline. Hydraulic dredging has the potential to capture small fish and aquatic invertebrates in the flow of water and entrain them along with dredge materials being suctioned.

NorthernStar proposes to use a cutterhead pipeline dredge to remove the sediments in the ship berth and maneuvering area.

The two types of mechanical dredges used in the Columbia River area are clamshell dredges and dipper dredges. A dipper dredge is basically a barge-mounted power shovel. Dipper dredges are best suited for excavating hard, compacted materials such as glacial till, stone, or blasted rock. Although they can be used to remove softer bottom sediments, the action of this type of equipment may cause considerable sediment disturbance and resuspension of fine-grained material. With mechanical dredging, mobile aquatic species such as fish would be less likely to be entrained with the dredged materials compared to hydraulic dredging.

A clamshell dredge consists of a crane with a cable attached to a clamshell bucket. Clamshell dredges can be used in tight quarters or shallow areas. Studies by the COE indicate that clamshell dredging generally results in greater sediment resuspension than other forms of dredging (e.g., hydraulic cutterhead dredges) (COE, 1988). Clamshell and dipper dredges both use barges or scows to haul the dredged material to placement areas. The bottoms of these barges or scows are generally designed to be opened, whereby the dredged material is dropped to the river bed or seafloor at the placement area. Typical production dredging with these two methods includes multiple barges or scows and tugs so that production can be maintained while full barges are towed to the placement site(s). The production rate is dependent upon several factors including dredged material characteristics, bucket size, and the efficiency of exchanging the barges or scows. Mechanical dredging would typically not be cost effective compared to hydraulic cutterhead pipeline dredging when the dredged material placement site is less than 5 to 8 miles from the dredging area.

3.1.9.2 Dredged Material Placement Alternatives

NorthernStar proposes to place about half of the material dredged from the ship berth and maneuvering area in upland areas at the Bradwood Landing site and the other half at the Wahkiakum County Sand Pit beach area on Puget Island. Other alternatives considered for dredged material placement include additional upland placement sites, Columbia River placement, and ocean placement. Table 3.1.9-1 lists the various dredged material placement alternatives, the associated dredging method, and a summary of potential advantages and disadvantage for each alternative. A detailed discussion of the alternatives follows.

Upland Placement

Available designated upland dredged material placement sites are limited along the lower Columbia River. The two closest are Bradwood Landing itself and Tenasillahe Island.

The Bradwood Landing site is designated as a dredged material management site on the Clatsop County Comprehensive Plan. Between 1966 and 2002, the COE placed almost 900,000 cubic yards of material from maintenance dredging of the Columbia River navigation channel at the Bradwood Landing site. NorthernStar proposes to place at least 350,000 cubic yards of material dredged from the Columbia River during creation of the ship berth and maneuvering area at Bradwood Landing. The material would be used to raise the grade of the site in preparation for construction of the onshore components of the LNG terminal. Another alternative to consider, if no other locations can be permitted for additional dredge disposal, would be to place the entire 700,000 cubic yards of material dredged from the maneuvering basin at Bradwood Landing.

TABLE 3.1.9-1

Dredged Material Placement Alternatives

Placement Alternative	Primary Dredging Methodology	Advantages	Disadvantages
Upland Placement			
Bradwood Landing	hydraulic cutterhead pipeline	Proximity of site; already designated a dredged material placement area; could accommodate entire volume; most cost effective alternative.	Not an environmentally beneficial use. Sediment is removed from the river system.
Tenasillahe Island	hydraulic cutterhead pipeline	Proximity of site, already designated a dredged material placement area.	Not an environmentally beneficial use. Sediment is removed from the river system. Site is reserved for Columbia River channel and maintenance projects and not available for the Bradwood Landing Project.
Columbia River Placement			
Flow-Lane: Price Island and Brookfield Reach	hydraulic hopper or cutterhead pipeline	Beneficial use; sediments remain in river system.	Dredging area configuration is not suited for hopper dredge, which would be required for more distant placement sites. Minor impact on benthic communities. Permitting for in-water placement is more rigorous than for upland placement.
Scour Holes: Welcome Slough and Pancake Point	mechanical clamshell	Proximity of site; beneficial use; cost effective.	Could only accommodate up to 30 percent of material. The COE may fill sites first. Placement area is within designated salmonid critical habitat and EFH for coho and Chinook salmon.
Ocean Placement			
Shallow Water	mechanical clamshell	No significant environmental concerns provided the sediments to be dredged pass required testing. Could accommodate entire volume.	Sediment is removed from the river system. Distance of site results in relatively high cost. Requires permit under section 103 of the Marine Protection, Research, and Sanctuaries Act (MPRSA).
Deepwater	mechanical clamshell	No significant environmental concerns provided the sediments to be dredged pass required testing. Could accommodate entire volume.	Not an environmentally beneficial use. Sediment is removed from the river system. Distance of site results in relatively high cost. Requires permit under section 103 of the MPRSA.
Beach Nourishment			
Wahkiakum County Sand Pit on Puget Island	hydraulic cutterhead pipeline	Proximity of site; beneficial use; could accommodate a significant volume.	Placement area is within designated salmonid critical habitat and EFH for coho and Chinook salmon. Additional post-placement handling costs. Wahkiakum County has not yet obtained permits.

Tenasillahe Island is located directly across Clifton Channel from the Bradwood Landing site and would be close enough that cutterhead pipeline dredging could be used. The island has been designated as a dredged material placement site for Columbia River improvement and maintenance projects. Based on consultation with the COE, ODSL, and the Port of Portland, this placement site would not be available for material from the Bradwood Landing Project. Available space for additional dredge disposal on the eastern end of the island has already been committed to other future projects; the rest of the island is protected as part of the Julia Butler Hansen National Wildlife Refuge (JBHNWR). Tenasillahe Island has therefore been eliminated from further consideration as an alternative dredge disposal location for the Bradwood Landing Project. No other upland placement sites were identified that would be close enough to the Bradwood Landing site to be reasonable, practicable alternatives.

Columbia River Placement

The lower Columbia River is sediment deficient because upstream dams limit downstream movement of sediment. Consequently, placing the dredged material at another location in the river can have environmental benefits, such as counteracting shoreline and beach erosion. On the other hand, such actions can affect water quality, sediment transport, and water circulation, which in turn can have potential impacts on fisheries and biological communities. It follows that the permitting process for in-water placement of dredged materials is more rigorous and requires detailed testing and analysis of the potential environmental impacts of the proposed placement alternative. NorthernStar evaluated two types of in-water placement sites in the Columbia River, flow lanes and scour holes.

Flow Lanes

Flow-lane placement sites are located in or adjacent to the Columbia River navigation channel at depths generally from -50 to -65 feet CRD. Flow-lane placement sites are used by the COE for the Columbia River channel improve project. The locations of these sites vary from year to year depending on the condition of the channel. Placement of dredged material at a flow-lane site would raise the bottom elevation from 2 to 6 feet, depending on the location. This rise in the river bottom would not be expected to cause significant changes in water circulation, current pattern, water fluctuation, or water temperature. The dredged material would be similar in characteristics to the existing sediments. Flow-lane placement is used in areas where no other alternatives are available or where the quantity of material to be dredged is too small to warrant use of a cutterhead pipeline dredge that would be necessary for upland disposal. Flow-lane placement would not have a significant impact on aquatic resources because benthic invertebrate productivity is generally low in the deeper channel areas.

NorthernStar assessed two potential flow-lane sites that are located downstream of the Bradwood Landing site and would require use of a hopper dredge or bottom-dump barge, based on the distance from the dredging area. The Price Island site is located immediately north of the navigation channel at CRM 34.8 (see figure 3.1.9-1). NorthernStar determined that existing pile dikes at this location would present an operational safety hazard for dredge vessels and the Price Island site was not considered further. The Brookfield Reach site is located north of the navigation channel at CRM 30.5. Because of the distance between the dredging area and the Brookfield Reach site, which would require the use of a hopper dredge or bottom-dump barge, this alternative was also eliminated from further consideration.

Scour Holes

In addition to flow lanes, NorthernStar identified two scour holes locations as possible dredged material placement sites in the Columbia River. Currently, Wahkiakum County is in the process of obtaining a permit to place clean sands in two scour holes, Pancake Point and Welcome Slough, located along the southwestern side of Puget Island (see figure 3.1.9-1). While Wahkiakum County expects to receive sands from the COE as part of Columbia River navigation channel improvement or maintenance projects, it may consider receiving material from other sources. The Welcome Slough scour hole, located at CRM 40.5, covers 2.3 acres. The Pancake Point scour hole, at CRM 43.6, covers 6.1 acres. Currently, the bases of the scour holes reach depths of -90 feet CRD. A total of 192,000 cubic yards of material will be required to bring the riverbed elevation up to the desired elevation of -20 feet CRD. Supplemental material will be required over time to maintain this level.

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Figure 3.1.9-1 Dredged Material Placement Site Alternatives

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The scour-hole sites could be used for up to 30 percent of the dredged material from the ship berth and maneuvering area if the space is still available when the dredging for the Bradwood Landing Project begins. The material would need to be clean sand. The scour holes would also be options for placement of material generated during maintenance dredging at the LNG terminal; however, NorthernStar currently proposes to place this material at the Wahkiakum County Sand Pit site.

Ocean Placement

Ocean placement of dredged materials beyond the 3-mile state waters boundary requires a permit under section 103 of the Marine Protection, Research, and Sanctuaries Act (MPRSA). Such placement is only allowed if no other reasonable alternatives are available, and the material must pass specific testing requirements.

The EPA has designated two open water dredged material placement sites offshore of the mouth of the Columbia River as part of the Columbia River Deepening Project. The first is a shallow water placement area located approximately 40 miles from the Bradwood Landing site. The site is a near-shore dispersive environment where material is expected to disperse into the littoral (beach) zone after placement. This placement area may be capable of accommodating all of the proposed dredged material from the Bradwood Landing Project. The second ocean placement site is a deepwater placement area located south of the Columbia River and 47 miles from the Bradwood Landing site. This placement area was selected to avoid biologically diverse areas and has enough capacity to be useable for at least 50 years.

Because of the distance of the ocean placement alternatives from the dredging area, a mechanical clamshell dredge would be used and the dredged material would be transported by bottom-dumping barges or scows to the placement site. The long distances, particularly for the deepwater placement area, needed to transport the dredged material make these placement alternatives the most costly, and they were eliminated from further consideration.

Beach Nourishment

Beach nourishment provides a beneficial use for dredged material that consists of clean sands. Based on consultation with Wahkiakum County, NorthernStar initially identified several beaches along Puget Island that would benefit from a beach nourishment project. Generally, beach nourishment projects entail placing dredged materials on a beach and in the adjacent aquatic areas. After the material has been placed, the beach must be graded at a uniform and gentle slope to minimize fish stranding problems and provide a safe beach. The dredged material must closely match the sediment composition of the eroding beach and be relatively free of contaminants. Costs for the beach nourishment alternative would be comparable to the Columbia River placement options plus some additional costs for grading and contouring.

Based on a feasibility study, the Wahkiakum County Sand Pit site was selected as a second proposed dredged material placement site along with the LNG terminal site for sediments dredged during construction of the ship berth and maneuvering area. The Sand Pit site is located on the northwest point of Puget Island across the Columbia River navigation channel from the Bradwood Landing LNG terminal site (see figure 3.1.9-1). The shoreline located between the Wahkiakum County Sand Pit and the federal navigation channel is subject to a combination of ship wakes, wind, and tidal effects that are currently eroding sand from the river beach at a rapid rate. Dredged material was most recently applied to the beach area in 2001 to mitigate the erosion. Wahkiakum County is currently in the process of obtaining the necessary permits and authorizations that would allow placement of dredged materials from the Bradwood Landing Project at the Sand Pit site.

NorthernStar proposes to pump up to about 350,000 cubic yards of dredged material to an existing upland settling basin at the Sand Pit site through a pipeline using a cutterhead pipeline dredge. Once drained, the sand would be moved from the settling basin and distributed by earthmoving equipment along the eroding shoreline and pushed into scour holes adjacent to the shoreline. The material would be dispersed as evenly as possible to avoid creating mounds. Furthermore, the beach would be graded to a minimum steepness of 10 to 15 percent to prevent the possibility of creating areas where fish could be stranded by wave action. No riparian vegetation is present that would be disturbed by the placement activities and no emergent vegetation was observed in the beach area. Up to 20,000 cubic yards of the dredged sand would be left within the settling basin to be used by Wahkiakum County for public projects.

NorthernStar also proposes to place approximately 80,000 cubic yards of material generated during maintenance dredging once every approximately 2 to 4 years at the Wahkiakum County Sand Pit site. Each round of maintenance dredging would take about 2 weeks and would be accomplished using a cutterhead suction dredge. Based on an assessment performed in 2006, the Sand Pit site currently has capacity to accept 700,000 cubic yards of dredged material (Coast and Harbor Engineering, 2006). Additional capacity would be generated by ongoing erosion estimated at a rate of 7,000 to 14,000 cubic yards per year. Assuming that NorthernStar initially deposits up to 350,000 cubic yards of dredged material at this location during construction of its LNG terminal, and the beach fill at the Sand Pit erodes at an average rate of 10,000 cubic yards per year, the site has a minimum of 10 years, and likely 20 to 30 years, of maintenance dredge capacity, depending on the actual frequency that dredging occurs.

3.2 COAST GUARD ALTERNATIVES

On February 28, 2007, the Coast Guard issued its WSR to the FERC (Appendix H). This report indicated that the Columbia River waterway may be suitable for LNG marine traffic if certain safety and security measures are adopted. After the final EIS is produced, the Coast Guard will complete its review and issue an LOR to address the suitability of the waterways for LNG ship transport.

The Coast Guard's proposed action is to issue an LOR finding the waterway suitable for LNG marine traffic with conditions. These conditions would include the safety and security measures described in the WSR, as discussed in detail in section 4.11.5.5. Among these measures are: 1) establishment of a 500-yard moving safety/security zone during LNG vessels' transit of the waterway, including the requirements for one-way LNG marine traffic along certain portions of the waterway such as at turns and for a 200-yard security zone around the LNG vessel when it is moored at the LNG terminal; 2) a 50-yard security zone around the LNG terminal when there is not a vessel at the dock; 3) the submission by the applicant of an annual review of its WSA to evaluate if any conditions in the waterway have changed that would require issuance of a new LOR and submit the annual review to the COTP for his/her review and issuance of a new LOR if necessary; 4) the requirement that LNG vessels must board a pilot(s) at least 5 miles before the CR Buoy and for at least the first 6 months, at least two pilots must be on board throughout the transit and that at least two tugs escort the vessel along the waterway with a third to assist with turning and mooring; 5) implementation of a Coast Guard-approved *LNG Vessel Transit Management Plan*; 6) improvements to the Columbia River's Vessel Traffic Information System; and 7) availability of Coast Guard as well as other safety and security resources to implement the above security measures. If these conditions to the LOR are imposed, the potential for accidental releases or releases from terrorist attacks would be minimized.

Reasonable alternatives to the Coast Guard's proposed action with conditions include: 1) issuance of an LOR finding the waterways suitable for LNG marine traffic without conditions; and 2) issuance of an LOR finding the waterways not suitable for LNG marine traffic (no action alternative).

The Coast Guard's preferred alternative is to issue an LOR finding the waterway suitable for LNG traffic with certain conditions.

If the Coast Guard finds the waterway not suitable, project-related environmental impacts resulting from LNG marine traffic would not occur. However, the no action alternative would mean that the project objectives would not be met. If LNG ships are not able to transit up the Columbia River to the import terminal, then the Bradwood Landing Project could not supply new sources of natural gas to meet projected future demands in the Pacific Northwest. As discussed in section 3.1.1, there are a number of environmental consequences that may result as potential users seek other sources of energy to replace the natural gas not imported in the case of a no action alternative where the Bradwood Landing Project is not constructed and operated.

A reasonable alternative to the Coast Guard action of issuing an LOR, which finds the waterway suitable for LNG marine traffic with certain conditions, is to issue an LOR without any conditions. With this alternative, some of the economic effects of the conditions would be lessened. For example, the cost to the Coast Guard for escort patrols would not be required if the condition of establishment of a moving safety/security zone was not imposed; the cost to the facility for additional WSAs would not be required if the condition of requiring an annual review of the WSA was not imposed; the cost for vessel traffic information system improvements would not be required if the condition for additional equipment and personnel was not imposed; the cost to the facility for tug assistance would not be required if this condition was not imposed; and the cost for shoreline security patrols would not be required if the condition for a security zone around the facility was not imposed.

However, the potential for adverse environmental effects would be greater if conditions were not imposed. There would be an increase in the potential for adverse environmental effects from collisions, allisions, and terrorist threats if: 1) moving and stationary safety zones were not required; 2) the WSAs were not updated with the most current information on changes in the waterway; 3) vessel traffic information system improvements were not required; 4) an *LNG Vessel Transit Management Plan* was not implemented; and 5) the Coast Guard lacks resources to ensure implementation of the safety zones and other security measures.

The preferred alternative of issuing a conditional LOR would allow LNG marine traffic to reach Bradwood Landing and provide a new source of imported natural gas for customers in the Pacific Northwest to meet future demands. The conditions in the LOR would reduce adverse impacts associated with LNG marine traffic in the waterway by providing mitigation measures for safety and security of vessels in transit.