DRAFT ENVIRONMENTAL IMPACT STATEMENT
SR 520 BRIDGE REPLACEMENT AND HOV PROGRAM

MAY 2010

SR 520 Pontoon Construction Project

Energy Technical Memorandum

Washington State Department of Transportation

U.S. Department of Transportation Federal Highway Administration

THE INFORMATION IN THIS REPORT IS ACCURATE; HOWEVER, THE PONTOON CONSTRUCTION PROJECT DRAFT ENVIRONMENTAL IMPACT STATEMENT IS THE SOURCE OF THE MOST CURRENT PROJECT INFORMATION AND ANALYSIS.

SR 520 Pontoon Construction Project
Draft Environmental Impact Statement

Energy
Technical Memorandum

Prepared for

Washington State Department of Transportation
Federal Highway Administration

Lead Author

CH2M HILL

Consultant Team

HDR Engineering, Inc.
Parametrix, Inc.
CH2M HILL
Parsons Brinckerhoff
ICF Jones & Stokes
Michael Minor and Associates
Cherry Creek Consulting
J. Irwin Writing and Editing

May 2010

Washington State Department of Transportation

U.S. Department of Transportation Federal Highway Administration

Contents

Exhibits

Abbreviations and Acronyms

Btu	British thermal unit
CALTRANS	California Transportation Department
CTC	Concrete Technology Corporation, Inc.
EIS	environmental impact statement
HOV	high-occupancy vehicle
LED	light-emitting diode
MBtu	million British thermal unit
PUD	public utility district
VMT	vehicles miles traveled
WSDOT	Washington State Department of Transportation

1. Introduction

Why is energy considered in an EIS?

When energy is used to build something, it cannot be recovered. Building the pontoon construction facility (casting basin) at Grays Harbor, fabricating the pontoons at the Concrete Technology Corporation, Inc. (CTC) casting basin facility in Tacoma and the Grays Harbor facility, and transporting the pontoons to their moorage locations would consume large amounts of energy that would be expensive and no longer available for other purposes. The Pontoon Construction Project Environmental Impact Statement (EIS) must discuss this energy consumption and how it could be kept to a minimum. These activities would also emit greenhouse gases.

For each build alternative, this technical memorandum estimates how much energy would be consumed during construction of the casting basin at Grays Harbor. This analysis also considers the amount of energy that would be used to build pontoons at the existing CTC facility and the new Grays Harbor facility and transport the pontoons by tugboat to their respective moorage locations. Finally, the technical memorandum discusses ways to conserve energy throughout the project. In addition to addressing energy, this technical memorandum estimates the amount of greenhouse gases emitted from activities associated with the project.

What are the key points of this technical memorandum?

The Washington State Department of Transportation (WSDOT) proposes building a casting basin facility at one of two sites in the Grays Harbor area to manufacture large concrete floating bridge pontoons needed to replace the floating portion of the Evergreen Point Bridge in the event of a catastrophic failure or to support the planned replacement of the bridge. To expedite pontoon construction, however, each build alternative could include using the existing CTC casting basin facility in Tacoma to build pontoons while the new casting basin facility at Grays Harbor is being constructed. If used, the CTC facility, which has a limited operations area, could build up to three longitudinal pontoons and up to ten supplemental stability pontoons.

WSDOT would float most of the completed pontoons built at the new casting basin facility out of the casting basin and tow them to an open-water moorage location in Grays Harbor; the last pontoons built would be stored in the casting basin until needed. Any pontoons constructed at the CTC facility would be moored at existing marine berths in Puget Sound.

Following are the key points of this energy technical memorandum:

- From the perspective of energy consumption, the two proposed build alternative sites should be considered equivalent. The Anderson & Middleton Alternative would consume approximately 3 percent more energy than the Aberdeen Log Yard Alternative. This finding is based on the additional cost required to construct the facility at the Anderson & Middleton site. This difference, however, falls well within the margin of error for current methodologies and contingencies included in the cost estimates.

- The energy consumed during building, transporting, and mooring the pontoons is expected to be similar for both build alternatives.
- Constructing the casting basin facility at the Anderson & Middleton site would emit approximately 5 percent more greenhouse gases than would building the facility at the Aberdeen Log Yard site; this finding is based on the additional energy that would be needed to construct the casting basin facility at the Anderson & Middleton site. This difference also falls within the margin of error for current methodologies. From the perspective of greenhouse gas emissions, therefore, the two sites should be considered equivalent.
- Total greenhouse gas emissions from constructing and operating f the casting basin facility at the Anderson & Middleton site would be about 2 percent higher than from using the Aberdeen Log Yard site; this difference falls within the margin of error for current methodologies. As a result, from the perspective of greenhouse gas emissions, the two sites should be considered equivalent.

What are the project alternatives?

The Pontoon Construction Project Draft EIS evaluates two build alternatives that would involve constructing a new casting basin in Grays Harbor and one No Build Alternative. Two waterfront sites in the Grays Harbor area are being evaluated for the new casting basin facility:

- Anderson & Middleton property in Hoquiam
- Aberdeen Log Yard property in Aberdeen

The new Grays Harbor casting basin facility could produce all 33 pontoons needed for this project: 21 longitudinal pontoons (360 feet long by 75 feet wide), 10 supplemental stability pontoons (98 feet long by 60 feet wide), and 2 cross pontoons (240 feet long by 75 feet wide). To expedite pontoon construction, however, each build alternative could include using the existing CTC casting basin facility in Tacoma to build pontoons while the new casting basin facility at Grays Harbor is being constructed. If used, the CTC facility, which has a limited operations area, could build up to three longitudinal pontoons and up to ten supplemental stability pontoons.

What is a casting basin facility?

Pontoons for this project would be built at a casting basin facility. The facility would consist of a casting basin (a large chamber in which pontoons are constructed, see the next text box for a more thorough description) and several supporting facilities, such as a batch plant to produce concrete, access roads, storage and laydown areas, office space for workers, and water treatment facilities.

WSDOT would float most of the completed pontoons built at the new casting basin facility out of the casting basin and tow them to a moorage location in the Grays Harbor area. The last pontoons built would be stored in the casting basin until needed. Any pontoons constructed at the CTC facility would be moored at existing marine berths in Puget Sound.

After the project is completed, the new casting basin would be available to produce additional pontoons needed for the planned Evergreen Point Bridge replacement, a component of the I-5 to Medina: Bridge Replacement and High-Occupancy Vehicle (HOV) Project. Pontoons for other WSDOT bridge replacement projects in the future could also be produced at this facility.

Each alternative is described below. For more details, see the Description of Alternatives and Construction Techniques Discipline Report (WSDOT 2009), included as Appendix B to the Draft EIS.

Site Descriptions

Anderson & Middleton Alternative

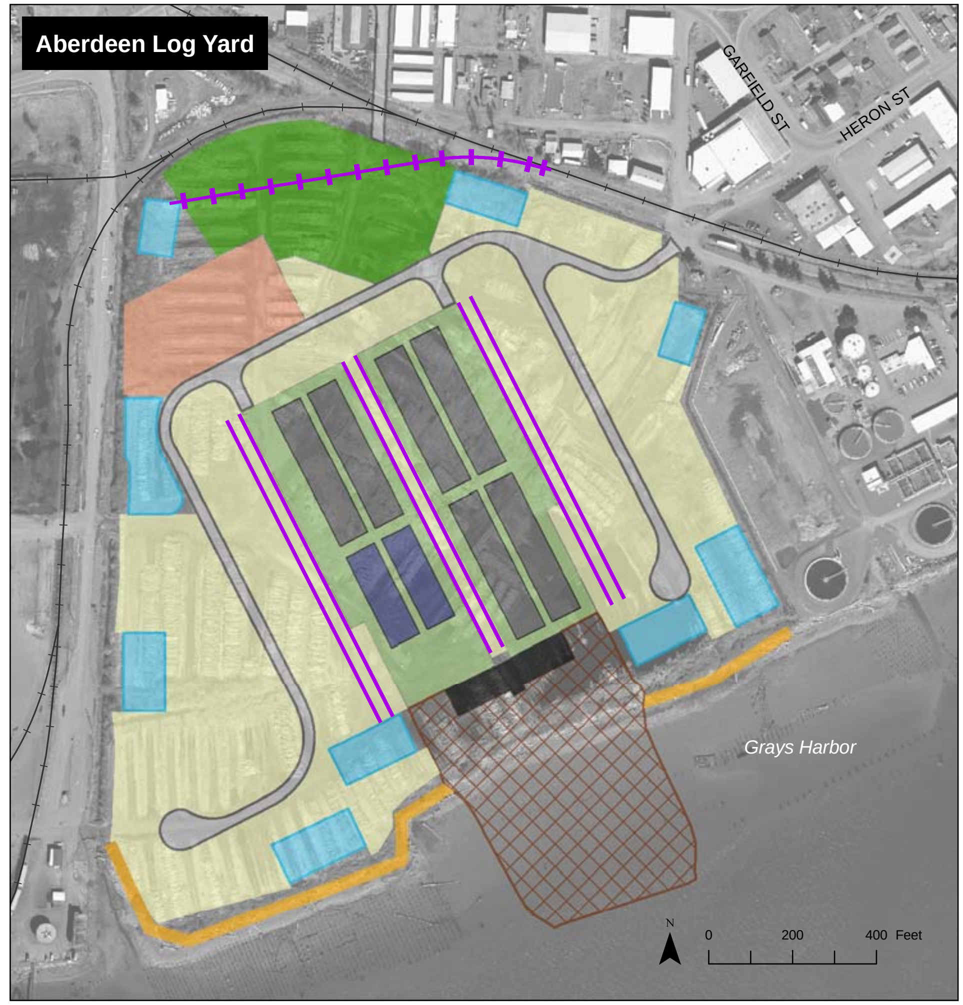
The 105-acre Anderson & Middleton Alternative site is on the north shore of Grays Harbor in Hoquiam, Washington (Exhibit 1). This generally flat property is privately owned and is zoned for industrial use. The site is surrounded by industrial maintenance shop buildings to the west, railroad tracks to the north, and vacant industrial property to the east; a rock berm borders the shoreline. The Anderson & Middleton site has no structures on it except for an existing small office building on the northern edge of the property. The site also has some gravel roads and an asphalt pad remaining from its former use as a log sorting yard. WSDOT would purchase 95 acres of this site for the project, and the casting basin and support facilities would occupy the eastern half of the site, amounting to approximately 55 acres.

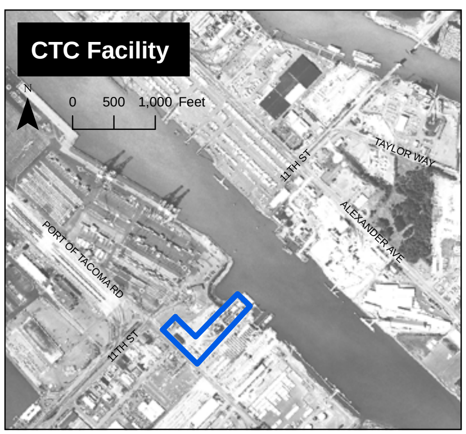
Historically this site has been used for lumber industry activities. In the early twentieth century there was a sawmill and other related facilities, such as machine shops and burners, west of what was then an extension of 8th Street. Over the next several decades, fill from harbor dredging and refuse accumulation increased the land area of the site. By the late 1960s, the former mill structures were all gone. Since then, the site has been used for timber storage.

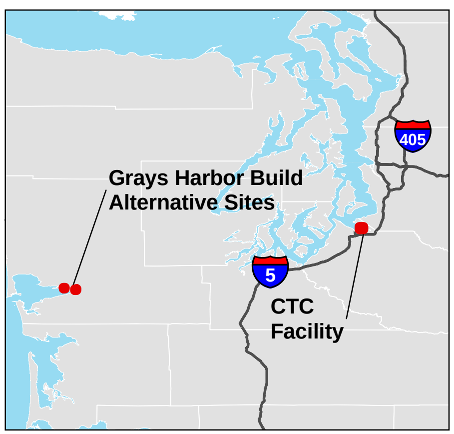
Aberdeen Log Yard Alternative

The 51-acre Aberdeen Log Yard Alternative site lies on the north shore of Grays Harbor in Aberdeen, Washington, near the mouth of the Chehalis River (Exhibit 1). This generally flat site is zoned industrial and is currently owned and used for log storage by Weyerhaeuser Corporation. There are no structures on the site now but there is a system of unpaved access roads connecting to East Terminal Road to the west and State Street to the northeast. Immediately west of the site is paved Port of Grays Harbor industrially zoned property, the City of Aberdeen wastewater treatment plant borders the eastern boundary, and the Puget Sound & Pacific Railroad mainline and siding run along the northern boundary of the site. WSDOT would purchase all 51 acres, and the casting basin and support facilities would occupy the entire site.

Two sawmills operated on the site in the last century, but since 1971, the site has been used mostly for log storage. All former sawmill-related structures have been demolished. Between 1971 and 1981, the shoreline was extended to the south through backfilling with sediments dredged from the Chehalis River, accumulated wood waste, and other fill material.







- Crane rail
- Proposed rail spur
- Existing railroad
- CTC facility limits
- Cross pontoon
- Longitudinal pontoon
- Water treatment area
- Access road
- Batch plant
- Berm
- Casting basin
- Dry storage and laydown area
- Gate
- Launch channel
- Office and parking

Source: WSDOT (2005, 2006) Aerial Photo, USDA-FSA (2006) Aerial Photo, Grays Harbor County (2006) GIS Data (Roads), Horizontal datum for all layers is State Plane Washington South NAD 83; vertical datum for layers is NAVD88.

Exhibit 1. **Locations and Conceptual Layouts for Build Alternative Sites**

Pontoon Construction Project

Washington State Department of Transportation

\\SIMBA\PROJ\PARAMETRIX\180171\GIS\MAPFILES\PONTOON\COMMON\PON_DR_COMMON_PROJECTFOOTPRINT.MXD 10/06/2009

No Build Alternative

For the Pontoon Construction Project, the No Build Alternative is continued existing conditions and uses at all proposed alternative sites. Specifically, this means that WSDOT would not construct or store any pontoons—either at a new Grays Harbor facility or at the existing Tacoma CTC facility—needed to respond to a catastrophic failure of the Evergreen Point Bridge. As a result, any environmental effects resulting from the proposed project activities would not occur.

For this Draft EIS, WSDOT assumes that, if unused by this project, the alternative site properties would continue to be used as they are today: the Aberdeen Log Yard would remain an active log yard, the Anderson & Middleton site would remain largely inactive, and the CTC site would be used as a casting basin for other projects and clients. While either Grays Harbor site could be developed for new uses should this project not occur, the use of these properties has remained unchanged since the 1990s. Potential future uses for these two properties, other than our proposed project, are speculative and therefore not considered under the No Build Alternative.

Key Components of Both Build Alternatives

Both build alternatives would carry out the proposed action by constructing a casting basin in the Grays Harbor area. Use of the existing CTC facility in Tacoma to produce pontoons while the new casting basin is constructed could also occur.

Potential Use of the Existing CTC Casting Basin Facility

The existing CTC facility is adjacent to the Blair Waterway on the eastern edge of Commencement Bay in Tacoma (Exhibit 1). This casting basin is too small to accommodate the timely construction of the pontoons required for the Pontoon Construction Project, but WSDOT could use this facility to supplement pontoon construction at the larger casting basin proposed in the Grays Harbor area. The pontoons manufactured at the CTC facility would most likely be the smaller supplemental stability pontoons.

WSDOT would moor the pontoons built at the CTC facility at existing marine berths in Puget Sound, subject to availability.

What is a casting basin?

A casting basin is a construction facility built next to a navigable waterway that consists of a concrete slab built deep below ground level and surrounded by high concrete walls. The interior area of the casting basin provides a flat dry space where several pontoons can be constructed side by side at the same time. After the pontoons are completed, the basin is flooded. The basin walls contain the flood water, allowing the pontoons to float. When the pontoons are floating, a gate is opened and the pontoons are towed from the casting basin into navigable waters.

Proposed Grays Harbor Casting Basin

The design of the proposed Grays Harbor casting basin would be basically the same at both build alternative sites, with variations depending on site-specific features. (See the Description of Alternatives and Construction Techniques Discipline Report [WSDOT 2009] for information on the casting basin conceptual design.) The casting basin would be positioned a few hundred feet from the shoreline and partitioned into two separate work areas—called chambers—connected to the water by a single launch channel. The launch channel would consist of an onshore portion excavated between the casting basin and shoreline, a breach in the shoreline berm, and a dredged channel extending offshore to the federal navigation channel in Grays Harbor.

Up to four concrete pontoons could be cast and cured in each of the two chambers of the partitioned casting basin, allowing pontoon construction to be phased for efficiency. That is, while the second chamber is under construction, pontoon construction could be initiated in the first partitioned chamber as soon it was completed. Two reinforced floating concrete gates leading to each chamber would allow each to be independently flooded and drained, as well as control access to the launch channel.

Constructing a casting basin facility at either Grays Harbor build alternative site would require heavy construction activities to transform the vacant land into an industrial facility. Such activities include, but would not be limited to, the following:

- Grading (leveling) the site and excavating the casting basin
- Pile-driving to install support piles for the casting basin floor
- Paving onsite access roads
- Making multiple truck trips for hauling materials to and from the site
- Dewatering the soils during casting basin construction

All stormwater, process water, and groundwater collected onsite would be handled and treated in accordance with state water quality requirements and discharged to Grays Harbor. Project engineers are designing a water supply, distribution, and treatment system for each site to meet state standards.

Dewatering

WSDOT would install two different dewatering systems to remove groundwater from the casting basin work area at either build alternative site. Before and during casting basin construction, a temporary construction dewatering system would operate at the site. During pontoon-building operations and after the Pontoon Construction Project is completed (but while the site is still maintained by WSDOT), a permanent operation dewatering system would operate.

Operational Support Facilities

To support the use of the casting basin, each build alternative would include onsite operational support facilities such as an access road, a concrete batch plant, large laydown areas, water handling and treatment areas, office space, a rail spur, and a designated parking area for workers**.**

Pontoon Towing and Moorage

If WSDOT uses the existing CTC facility in Tacoma, it would moor the pontoons built there at existing marine berths in Puget Sound. Using these berths would be subject to availability, but there are several locations in the Puget Sound region that could accommodate this project's needs. The first two cycles of eight pontoons manufactured at the new Grays Harbor casting basin facility would be towed from the casting basin and moored in the Grays Harbor area outside of navigation channels. The last construction cycle of pontoons could be stored in the dry casting basin behind the closed gate.

For the pontoons to be moored in the Grays Harbor area, there are several existing berths that WSDOT could lease for pontoon moorage, if available when needed. In addition, WSDOT has identified another potential moorage location—open-water moorage in Grays Harbor. Please see the Description of Alternatives and Construction Techniques Discipline Report (WSDOT 2009) for more information on these potential moorage locations.

The constructed pontoons would be stored together until they are needed to replace the Evergreen Point Bridge in the event of a catastrophic failure, and they would be identified with navigation lighting in compliance with U.S. Coast Guard requirements.

Construction Schedule

If WSDOT uses the existing CTC facility, pontoon construction would take 2 years there to complete. WSDOT would start site development for the new Grays Harbor casting basin facility about the same time pontoon construction begins at the CTC facility. For the Grays Harbor facility, casting basin construction would take 2 years, as would pontoon construction. In total, overall pontoon project construction would span 4 years.

WSDOT anticipates that it would take approximately 6 to 9 months to complete a pontoon construction cycle at either the existing Tacoma facility or at the new Grays Harbor facility. The new Grays Harbor facility could produce eight pontoons during one cycle; as a result, two and a half pontoon construction cycles would be required to produce 20 pontoons. At the existing CTC facility, five supplemental stability pontoons could be constructed during each pontoon construction cycle, and one longitudinal pontoon could be constructed during a cycle. As a result, three construction cycles would be needed to produce ten supplemental stability pontoons and one longitudinal pontoon.

2. Affected Environment

How did WSDOT collect information on energy?

The study area encompasses the CTC casting basin facility in Tacoma and the Tacoma Power service area. Tacoma Power is owned by the City of Tacoma and provides electricity to the CTC facility, the City of Tacoma, and surrounding portions of Pierce County. Generation capacity and existing energy consumption data were obtained from Tacoma Power.

The energy study area at Grays Harbor, shown in Exhibit 1, consists of the two build alternative sites in Grays Harbor and all of Grays Harbor County. The larger regional area is included because the project would affect energy use beyond the immediate project site. Information was also obtained local energy consumption and generation data from Grays Harbor Public Utility District (PUD), the local electric utility in the Grays Harbor study area.

What are the existing energy characteristics of the study area?

CTC Facility

The CTC facility, where some of the pontoons could be built, is located within an approximately 3-square-mile area of land zoned as an industrial center on the Blair Waterway in Tacoma. The CTC facility is a fully constructed facility and is routinely used for industrial activities, including building pontoons. As a result, WSDOT's proposed use of this site to build pontoons would not alter the character of the human and natural environment in the study area.

The CTC facility is served by Tacoma Power, a municipal electric utility serving the City of Tacoma and surrounding portions of Pierce County (Tacoma Power 2007a). Exhibit 2 lists Tacoma Power's average number of customers, total energy sales, and total revenues for 2007, the most recent year for which data are available.

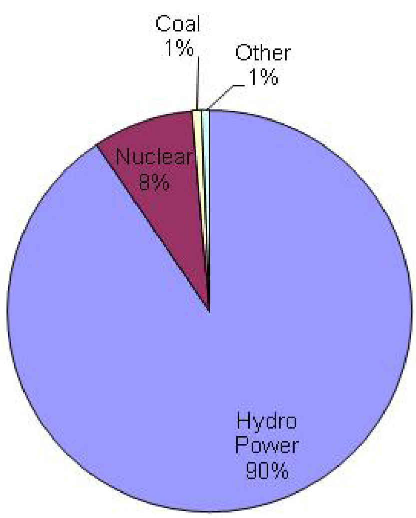
EXHIBIT 2
Tacoma Power Utility Data

Utility Data	2007
Average number of customers	165,122
Energy sales (megawatt-hours)	6.8 million
Revenues from energy sales	$366 million

Source: Tacoma Power (2008)

Tacoma Power produces or purchases power from a variety of sources, but hydroelectric power dominates the mix. Exhibit 3 shows Tacoma Power's estimated power generation mix, including the utility's reliance on hydroelectric power.

EXHIBIT 3
Tacoma Power Generation Mix



Source: Tacoma Power (2007b).

Grays Harbor

Because detailed information about energy use on the Grays Harbor build alternative sites is not available, the analysts used Grays Harbor County data to help determine energy trends at the local level.

The study area's energy needs are currently served by Grays Harbor PUD, a county-owned electric utility serving nearly all of Grays Harbor County. Exhibit 4 lists the PUD's average customers, total energy sales, and total revenues for 2006, the most recent year for which data were available.

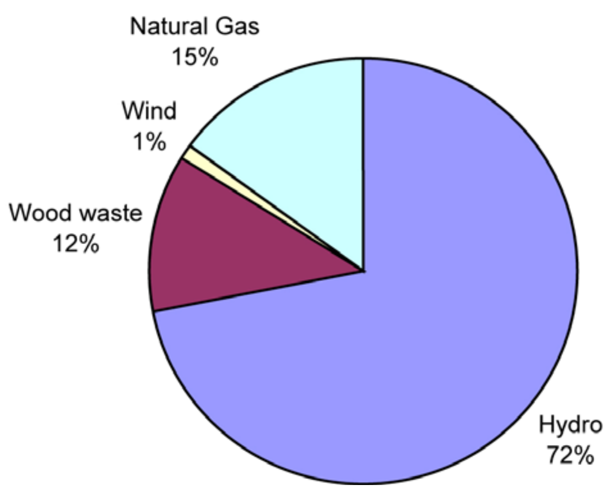
EXHIBIT 4
Grays Harbor PUD Utility Data

Utility Data	2006
Average number of customers	41,414
Energy sales (megawatt-hours)	1.8 million
Revenues from energy sales (wholesale and retail)	$113 million

Source: Grays Harbor County PUD (2006a, b).

Grays Harbor PUD obtains about 72 percent of its power supply through long-term contracts with the Bonneville Power Administration. Additional power requirements are supplied by short- and long-term contract purchases through other power suppliers and PUD-owned generation facilities. Exhibit 5 shows the estimated power generation mix of the PUD's power sources. This chart demonstrates the PUD's reliance on hydroelectric power purchased from Bonneville Power Administration.

EXHIBIT 5
Grays Harbor PUD Power Generation Mix



Source: Grays Harbor PUD (2006b).

Washington State Trends

According to the Washington State Department of Commerce, Washington's per capita energy consumption was approximately 200 million British thermal units (MBtu) in 2005 after averaging close to 250 MBtu from 1970 through 1999. The drop in per capita energy consumption was due to decreased energy use in some energy intensive industries (for example, aluminum) and also to higher energy prices (Washington State Department of Commerce 2009). Washington's economy is also becoming less energy intensive because of improved technology, efficiency increases, and a shift from natural resource manufacturing to less energy-intensive industries such as software and biotechnology. Washington's average energy consumption per capita in 2005 was below the national average of 232 MBtus.

Fuel Consumption

Most of the energy consumed during project construction will be in the form of diesel fuel resulting from the transportation of site materials, construction products, and other items to and from the site. Detailed fuel consumption data are not available for the county level; therefore, WSDOT included a discussion on statewide fuel consumption. In 2007, the transportation sector in the state of Washington consumed approximately 338.0 trillion British thermal units (Btus) of gasoline and approximately 143.2 trillion Btus of distillate fuel (EIA 2009a, b). Distillate fuel includes diesel fuel and fuel oils, including on-highway diesel engines for trucks and cars as well as off-highway diesel engines such as railroad locomotives.

3. Potential Effects of the Project

How did WSDOT evaluate project effects on energy?

The energy analyst used the guidance in Chapter 440 of the WSDOT *Environmental Procedures Manual* (WSDOT 2008) to estimate the likely energy-related effects of the alternatives. The analyst also used information provided in *Energy and Transportation Systems*, a report by the California Department of Transportation (CALTRANS 1983). The energy consumption factors developed by CALTRANS are still widely used in the energy industry today. The energy consumption factors are designed to provide a way to compare one alternative to another. The amount of energy used during the construction of a project is roughly proportional to the cost of the project.

The consumption factors were reported in Btus per dollars of construction spending. Because the CALTRANS report was developed using 1977 construction dollars, the energy consumption factors were adjusted to account for the change in construction costs the California Construction Cost Index was used to adjust the factors to 2012 dollars.

The energy required to build a pontoon casting basin at Grays Harbor was estimated by starting with the total estimated construction cost for each build alternative site and then applying the energy consumption factors developed by CALTRANS (1983) for structures.

The energy consumption factor for concrete box girders was used to estimate energy consumption during pontoon manufacturing.

While the energy consumption factors developed by CALTRANS were not specifically developed for casting basin or pontoon construction, they serve as a proxy for estimating the energy consumed during casting construction and pontoon manufacturing. For example, the materials needed to construct the pontoons (cement and rebar) would likely be similar to the materials needed to build a concrete bridge. Thus, the energy consumption factor for concrete box girders was used to estimate energy consumption during pontoon manufacturing.

Energy consumption factors developed by CALTRANS include energy consumed during site preparation, mining and production of construction materials such as portland cement used in concrete and iron used in rebar, and transporting materials and equipment to and from the construction site. Materials, quantities, and haulage requirements would vary from one site to another, and these variances will be reflected in the cost estimates to construct the casting basin at each alternative project site.

Exhibit 6 shows the energy consumption factors used to estimate energy consumption during construction of the casting basin facility and pontoons.

EXHIBIT 6
Energy Consumption Factors

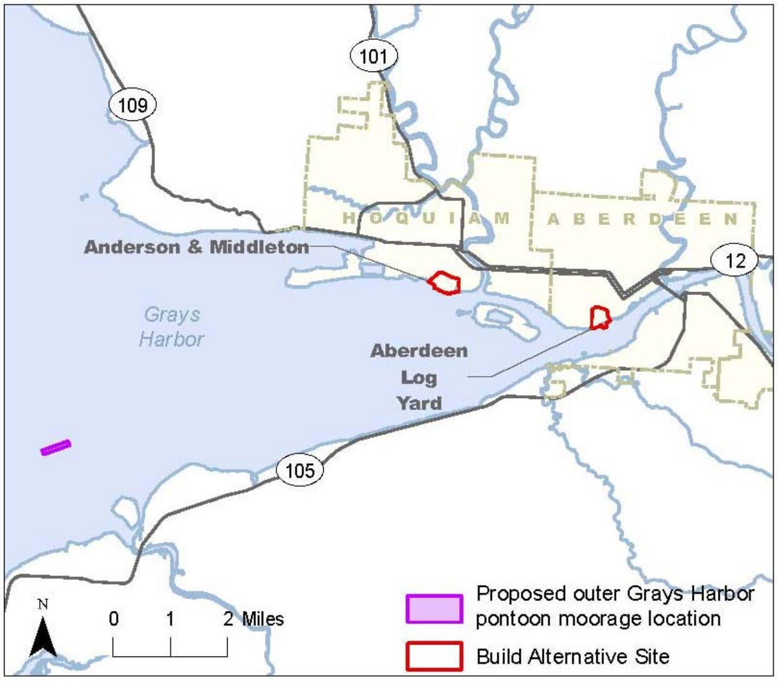
Project Element	Energy Consumption Factor Name	Energy Consumption Factor (Btu/$)
Casting basin facility construction	Structures	7,916
Pontoon construction	Concrete girders	4,440

Source: CALTRANS (1983).

Transporting the finished pontoons from the casting basins to temporary moorage locations would also consume energy. To estimate the diesel fuel that would be consumed during pontoon transport, the following assumptions were applied:

- The diesel fuel consumption rate would be 150 gallons per hour of operation.
- The average towing speed would be 3 miles per hour.
- One tug would tow each pontoon from its casting basin to the moorage location.
- Following are the estimated distances from the casting basins to the moorage locations:
  - **CTC site.** 25 miles (to an existing marine berth in Puget Sound)
  - **Anderson & Middleton.** 5 miles (to a Grays Harbor open-water location [Exhibit 7])
  - **Aberdeen Log Yard.** 8 miles (to a Grays Harbor open-water location [Exhibit 7])

EXHIBIT 7
Potential Grays Harbor Pontoon Moorage Location



How would construction of the casting basin affect energy consumption?

In this technical memorandum, "project construction" refers to building a pontoon casting basin facility at one of the proposed Grays Harbor build alternative sites.

CTC Facility

Project construction would not occur at the CTC facility because it is an established industrial facility that already includes a pontoon casting basin.

Anderson & Middleton Alternative

Construction costs for the Anderson & Middleton Alternative would be approximately $217 million (based on preliminary estimates), excluding sales tax and construction engineering costs. The construction cost estimate is higher for this alternative because of required design variation to the foundation and dewatering activities, both of which would be more expensive at the Anderson & Middleton site. The energy consumed during construction of the casting basin facility at this site would be approximately 1.7 million MBtus (1.7 trillion Btus), which is equivalent to the energy used by 18,100 household during 1 year (based on conversion factor of 94.9 MBtu per year per household) (EIA 2009c). Assuming that site construction energy was consumed evenly over the 2-year construction period, the average level of energy consumption would represent a fraction (approximately 0.2 percent) of total annual gasoline and distillate fuel consumption in Washington (EIA 2009a, b).

Aberdeen Log Yard Alternative

Construction costs for the Aberdeen Log Yard Alternative would be approximately $206 million (based on preliminary estimates), excluding sales tax and construction engineering costs. The energy consumed during casting basin construction at this site would be approximately 1.6 million MBtus. This is equivalent to the energy used by 17,200 household during 1 year (based on conversion factor of 94.9 MBtu per year per household) (EIA 2009c). Assuming the site construction energy was consumed evenly over the 2-year construction period, the average level of energy consumption would represent a fraction (approximately 0.2 percent) of total annual gasoline and distillate fuel consumption in Washington (EIA 2009a, b). Exhibit 8 summarizes the construction cost and energy consumption for each of the casting basin facility site alternatives.

EXHIBIT 8
Estimated Energy Consumption for Each Alternative during Casting Basin Construction

Alternative	Cost (2012 dollars)[a]	Energy Consumption Factor (Btu/$)	Energy Use (MBtu)
Anderson & Middleton	$217,500,000	7,916	1,722,000
Aberdeen Log Yard	$205,900,000	7,916	1,630,000

[a]Excludes sales tax and construction engineering costs.

No Build Alternative

Under the No Build Alternative, there would be no construction-related energy consumption.

How would pontoon-building operations affect energy consumption?

In this technical memorandum, “project operation” refers to manufacturing concrete pontoons, towing them to temporary moorage locations in Puget Sound and Grays Harbor, and mooring the anchored pontoons at those locations.

CTC Facility

Manufacturing one large pontoon and multiple smaller supplementary stability pontoons at the existing CTC facility during a 2-year period would consume a large amount of energy; temporarily mooring the pontoons built at the CTC facility would also consume energy. The energy consumed by building the pontoons and moorage anchors at CTC would be approximately 316,000 MBtus.

Exhibit 9 presents the energy consumption estimates for the pontoons. After being anchored at their moorage locations, the pontoons would be illuminated with navigation lighting at night and during poor visibility conditions. The amount of energy consumed during illumination would likely be minor when compared to the energy consumed during pontoon manufacturing.

EXHIBIT 9
Estimated Energy Consumption during Pontoon Manufacturing for CTC Facility

Item	Cost (2012 dollars) [a]	Energy Consumption Factor (Btu/$)	Energy Use (MBtu)
Pontoons	$55,100,000	4,440	245,000

Note: Total may not add because of rounding.
[a]Excludes sales tax or construction engineering costs.

Grays Harbor Build Alternatives

Because the number of pontoons constructed at the Grays Harbor facility would be the same for each alternative, the energy used for pontoon construction is also the same for each alternative.


Tugboat towing a pontoon in Puget Sound.

Exhibit 10 presents the energy consumption estimates for the pontoons. After being anchored at their moorage locations, the pontoons would be illuminated with navigation lighting at night and during poor visibility conditions. The amount of energy consumed by the illumination would likely be minor when compared to the energy consumed during pontoon manufacturing. Assuming that energy consumed during pontoon fabrication was evenly consumed over the 2-year construction period, the average estimated energy consumption to manufacture the pontoons represents less than 0.1 percent of total annual energy consumption in Washington in 2007 (EIA 2009d). WSDOT would not expect pontoon construction to substantially affect energy resources.

EXHIBIT 10
Estimated Energy Consumption during Pontoon Manufacturing for Either Grays Harbor Build Alternative Site

Item	Cost (2012 dollars) [a]	Energy Consumption Factor (Btu/$)	Energy Use (MBtus)
Pontoons	$238,700,000	4,440	1,060,000

Note: Total may not add because of rounding.
[a]Excludes sales tax or construction engineering costs.
N/A = not available

How would towing the pontoons to the moorage locations affect energy consumption?

Exhibit 11 presents the estimated diesel fuel calculation and energy use to transport the pontoons from Grays Harbor and Tacoma to their respective temporary moorage locations. At the time of this anlaysis, the final offsite pontoon moorage location had not yet been determined.

The fuel consumption estimates for each build alternative are based on the assumptions previously described in this report under *What methods were used to evaluate the project's potential effects?*. The energy and fuel consumption involved in transporting pontoons built at the CTC facility is added to the equivalent estimates for each Grays Harbor build alternative site to estimate the totals for each build alternative site.

Anderson & Middleton Alternative

Transporting pontoons from the Anderson & Middleton Alternative site to the potential open-water Grays Harbor moorage location would likely to consume slightly less fuel than from the Aberdeen Log Yard sites because it is closer to the probable mooring location. From the Anderson & Middleton Alternative site, the estimated diesel fuel consumption and energy use to tow the pontoons to their offsite moorage would be approximately 4,050 gallons and approximately 600 MBtus.

Aberdeen Log Yard Alternative

Transporting pontoons from the Aberdeen Log Yard Alternative site to the potential open-water Grays Harbor potential moorage location is expected to consume more fuel than from the Anderson & Middleton Alternative site because the Aberdeen Log Yard property is farther from the probable mooring location. From the Aberdeen Log Yard site, the fuel consumption and energy use would be approximately 6,450 gallons and approximately 900 MBtus.

No Build Alternative

Under the No Build Alternative, no pontoons would be manufactured for this project and the need for temporary moorage would not exist. Therefore, no towing related energy would be consumed.

How would the project affect energy consumption in the long term?

In this technical memorandum, long-term refers to effects that would continue after project construction and operation were completed.

CTC Facility

Using the CTC facility for building pontoons would have no long-term effect on energy consumption. CTC is a commercial manufacturing facility producing a variety of industrial concrete products. If WSDOT were to use the CTC facility to build pontoons, then using the facility would likely last only 2 years. After that, the CTC facility would continue to produce concrete products not related to this project.

Grays Harbor Build Alternatives

The selected Grays Harbor build alternative site would likely be used for approximately 2 years after the facility is built. Building and operating the facility, therefore, are addressed as construction effects and operational effects, respectively. Because the facility's effects on energy would not persist after operation, they would not be long-term.

EXHIBIT 11
Energy Consumption during Pontoon Transport

Alternative/ Route	Number of Tugs	Number of Trips	Estimated Miles Traveled per Trip	Estimated Total Miles Travelled	Estimated Average Miles per Hour	Estimated Operating Hours	Diesel Fuel Consumption Rate (gallons/hour)[a]	Diesel Fuel Consumption (gallons)[b]	MBtu
Anderson & Middleton Alternative									
CTC to temporary moorage	1	8	25.0	200	3	67	150	10,050	1,400
Anderson & Middleton to temporary moorage	1	16	5.0	80	3	27	150	4,050	600
Total		24		280		94		14,100	2,000
Aberdeen Log Yard Alternative									
CTC to temporary moorage	1	8	25.0	200	3	67	150	10,050	1,400
Aberdeen Log Yard to temporary moorage	1	16	8.0	128	3	43	150	6,450	900
Total		24		328		110		16,500	2,300

[a] Fuel consumption per hour based on delivery tow estimate (WSDOT 2005).
[b] Conversion rate: 1 gallon of diesel = 139,000 Btu

No Build Alternative

There would be no project-related energy consumption under the No Build Alternative.

How would the alternatives compare in their effects on energy?

Exhibit 12 summarizes the estimated construction and operational costs and the estimated total energy use for each build alternative. The CTC facility is included with the facility built at either of the Grays Harbor alternative sites. Exhibit 13 graphically presents the estimated energy use for each alternative.

EXHIBIT 12
Energy Consumption and Costs during Project Construction and Operation

Project	Cost (2012 dollars) [a]	Energy Consumption Factor (Btu/$)	Energy Use (MBtu)
Anderson & Middleton			
Civil and structures	$217,500,000	7,916	1,722,000
Pontoons	$293,800,000	4,440	1,305,000
Towing to moorage			2,000
Total	**$511,300,000**		3,029,000
Aberdeen Log Yard			
Civil and structures	$205,900,000	7,916	1,630,000
Pontoons	$293,800,000	4,440	1,305,000
Towing to moorage			2,300
Total	**$499,700,000**		2,937,300

[a]Excludes sales tax or construction engineering costs. Each alternative includes energy consumed during pontoon manufacturing and floating to the CTC site.

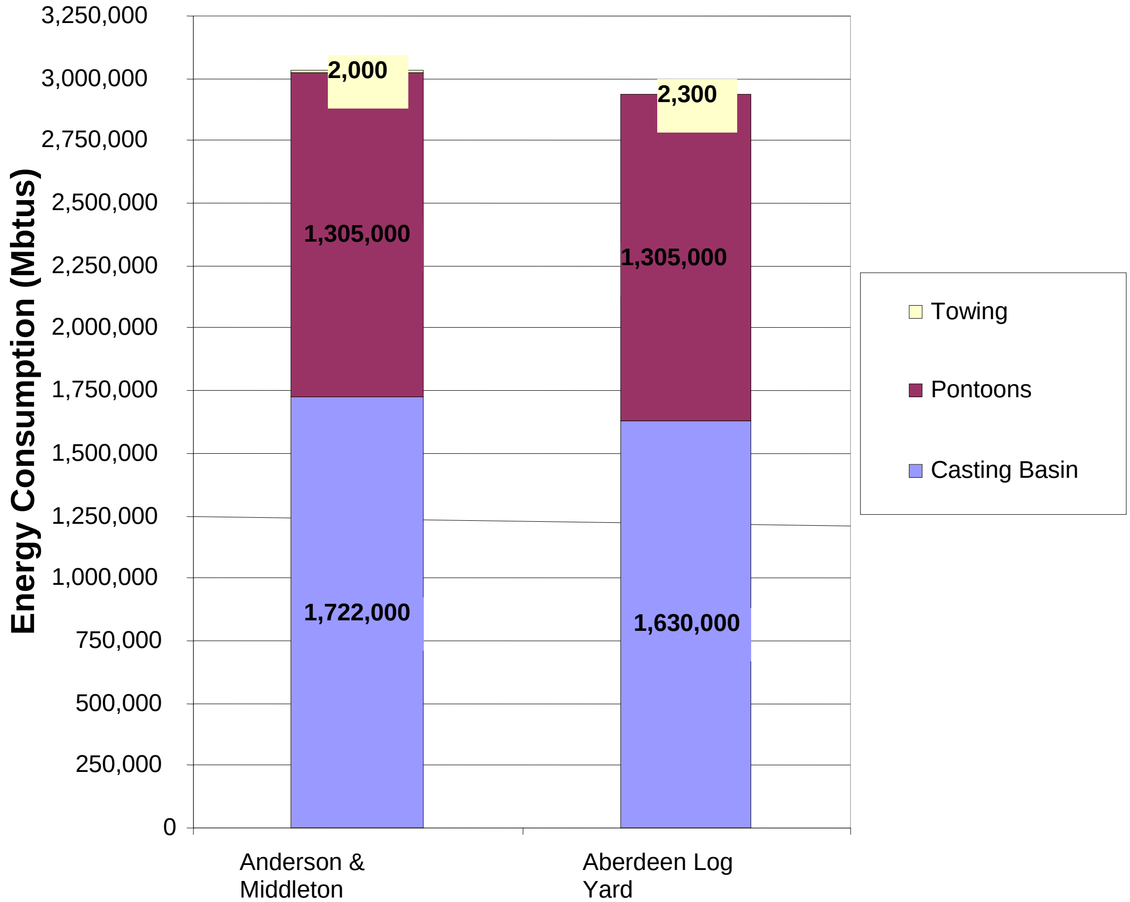
Exhibit 14 summarizes and compares the effects of the build alternatives. Effects from CTC are not included because they would be the same for both build alternatives. The energy effects differences between the two alternatives are likely within the margin of error of the methodology used for analysis in this report. This means that, while there are energy consumption differences between the alternatives, they would be so similar they could be considered to be the same.

4. Mitigation

What measures would WSDOT propose to reduce energy use?

Building the casting basin facility at Grays Harbor, constructing the pontoons, and transporting the pontoons to their moorage locations would consume large amounts of energy that would no longer be available for other purposes. However, WSDOT could implement the following potential measures to minimize the unintended negative effects of energy consumption:

EXHIBIT 13
Energy Consumption during Project Construction and Operation Expressed in Equivalent Gallons of Gasoline



Note: Each alternative includes energy consumed during pontoon manufacturing and floating to the CTC site.

EXHIBIT 14
Summary of Potential Effects

Alternative	Relative Comparison of Construction Effects	Relative Comparison of Operational Effects	Relative Comparison of Long-Term Effects
Anderson & Middleton	Slightly higher than Aberdeen Log Yard because of higher construction costs	Similar to Aberdeen Log Yard	No long-term effects
Aberdeen Log Yard	Slightly lower than Anderson & Middleton	Similar to Anderson & Middleton	No long-term effects
No Build	No construction effects	No operational effects	No long-term effects

- Adhere to construction practices that encourage efficient energy use, such as avoiding the double-handling of excavated soil, limiting idling equipment, and locating staging areas near work sites.
- Encourage workers to carpool to the site.
- Purchase construction materials from local suppliers to limit transportation fuel consumption.
- Encourage the use of efficient lighting systems in the casting basin facility.
- Coordinate with the local utilities to minimize the impact on energy demand and supply.
- Use solar-powered light-emitting diode (LED) lights to illuminate the moored pontoons.

How could the project compensate for unavoidable negative effects?

WSDOT would not compensate for the energy expended to manufacture pontoons at CTC, build the Grays Harbor pontoon construction facility, and manufacture pontoons at the Grays Harbor facility. The energy used during this project would be irretrievable. There is no practicable way to compensate for that energy loss without eliminating other scheduled transportation projects and activities that are also necessary.

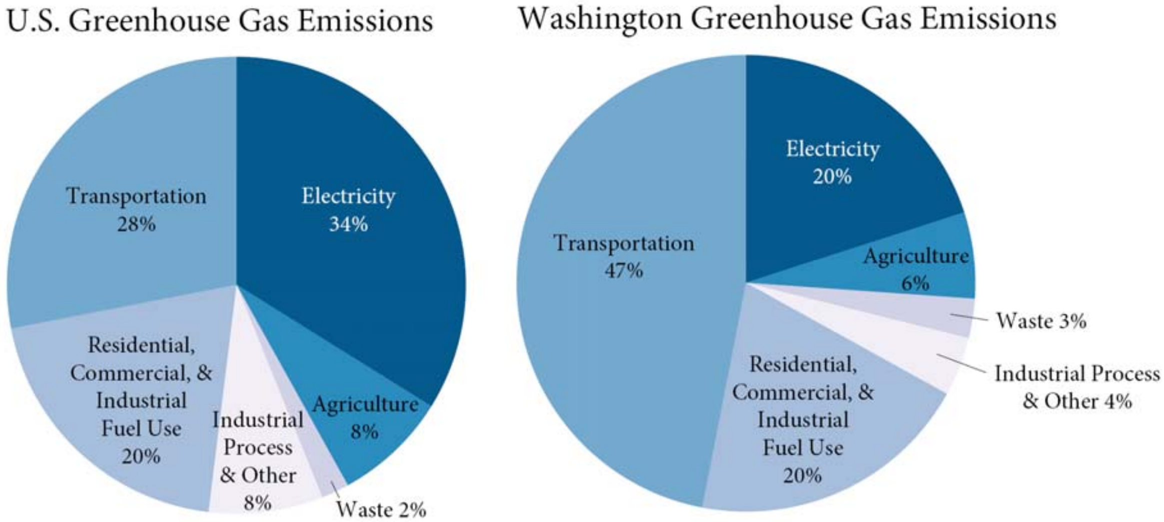
5. Green House Gas Emissions

How would the project affect greenhouse gas emissions?

Vehicles emit a variety of gases during their operation, and some of these are greenhouse gases. The greenhouse gases associated with transportation are water vapor, carbon dioxide, methane (also known as marsh gas), and nitrous oxide (used in dentists' offices and sometimes called laughing gas). Any process that burns fossil fuel releases carbon dioxide into the air. Carbon dioxide makes up the bulk of the emissions from transportation.

Vehicles are a substantial source of greenhouse gas emissions and contribute to global warming primarily through the burning of gasoline and diesel fuels. National estimates show that the transportation sector (including on-road vehicles, construction activities, airplanes, and boats) accounts for almost 30 percent of total domestic carbon dioxide emissions. However, in Washington, transportation accounts for nearly half of greenhouse gas emissions because the state relies heavily on hydropower for electricity generation. Other states rely on fossil fuels such as coal, petroleum, and natural gas to generate electricity. The next largest contributors to total greenhouse gas emissions in Washington are fossil fuel combustion in the residential, commercial, and industrial sectors at 20 percent; and in electricity consumption, also 20 percent. Exhibit 15 shows the gross greenhouse gas emissions by sector, nationally and in Washington.

EXHIBIT 15
Greenhouse Gas Emissions by Sector, 2005, U.S. and Washington (Ecology 2007)



What efforts are underway to reduce greenhouse gas emissions in Washington State?

In 2007, Governor Gregoire and the legislature set greenhouse gas reduction goals for Washington state:

- Reduce greenhouse gases to 1990 levels by 2020.
- Reduce greenhouse gases to 25 percent of 1990 levels by 2035.
- Reduce greenhouse gases to 50 percent of 1990 levels by 2050.

Also in 2007, the Climate Advisory Team was formed by Governor's Executive Order 07-02 to find ways to reduce greenhouse gas emissions. The final report included 13 broad recommendations.

The Washington legislature passed and the Governor signed House Bill 2815 in the spring of 2008. This bill includes, among other elements, statewide per capita vehicle miles traveled (VMT)[1] reduction goals as part of the state's greenhouse gas emission reduction strategy.

This bill also established the Climate Action Team, a group similar to 2007's Climate Advisory Team. This group refined 2007's broad recommendations into specific actions the state can take to reduce emissions. WSDOT worked as a member of this group on strategies to reduce VMT and on how to include climate change in State Environmental Policy Act

[1]VMT stands for vehicle miles traveled and is the number of miles vehicles travel each year. For transportation projects with set boundaries, VMT can refer to the aggregate number of miles that all the vehicles travel using the specified roadways. Per person (or per capita) VMT in Washington has been stable at 9,000 miles per person since the 1980s, meaning the statewide VMT has grown at roughly the same pace as population. Methods of reducing VMT typically target transferring trips from single occupant vehicles to multiple person vehicles like carpools, vanpools, and transit. VMT can also be lowered by reducing the distance of travel through changes in land use.

evaluations. The final report and other information on the process are available from the Washington State Department of Ecology (2008a).

In addition to work with others in Washington state, WSDOT is leading the development of effective, measurable, and balanced emission reduction strategies. Current WSDOT activities that reduce greenhouse gas emissions include the following:

- **Transportation options.** For 30 years, WSDOT has supported carpooling, vanpooling, and public transportation through the funding, building, and maintenance of the freeway HOV system, ferries, rail, and other programs. The Commute Trip Reduction program has been partnering with employers to offer alternatives to drive alone commuting for 17 years, and WSDOT has the nation's largest public vanpool program. These programs continue to expand and with recent high gas prices, demand for these programs has surged. These investments help to reduce the number of vehicles on the roadway during peak congestion and help reduce VMT.
- **Incident Response Team.** WSDOT has 55 vehicles that patrol 500 miles of highway to clear blocking incidents quickly and safely. The Incidence Response Team clears 98.6 percent of all incidents in less than 90 minutes, reducing the amount of time motorists spend sitting and idling in traffic.
- **Using biodiesel in ferries.** Each year, the state ferry system burns approximately 17 million gallons of diesel fuel in its ferries, making the agency a substantial fuel consumer in Puget Sound. In March 2008, Washington State Ferries began testing the use of biodiesel in the marine environment. Using biodiesel instead of traditional petroleum-based fuels reduces emissions of particulate matter and greenhouse gases, improving both local air quality and the earth's climate.

In addition to working to reduce emissions on the transportation network, WSDOT is also taking action to reduce emissions. Steps include the following:

- **No idle policy.** In 2006, WSDOT adopted a no-idle policy to reduce fuel use and vehicle emissions. WSDOT estimated that by reducing vehicle idling by 50 percent, as much as $500,000 annually in fuel costs could be saved.
- **Reducing diesel emissions.** In 2005, WSDOT started using 5 percent biodiesel mixed with regular diesel in maintenance vehicles operating in the Central Puget Sound area. Currently, 25 WSDOT fueling stations have 10 percent biodiesel available and WSDOT us working towards using 20 percent biodiesel, depending on availability.

WSDOT and its partners are also actively implementing the 2005 Transportation Partnership Act, a 16-year plan to meet Washington state's most critical transportation needs. Many of these local, regional, and statewide transportation system improvements, in conjunction with ongoing programs, help to reduce the number of miles that vehicles need to travel each year. Together these efforts combine to create more efficient driving conditions, offer mode choices, and help move us toward state greenhouse gas reduction goals.

How did WSDOT calculate greenhouse gas emissions for project construction and operation?

Energy use during site and pontoon construction will be the main source of greenhouse gas emissions from this project. Emissions will be proportional to the amount of energy used and are the basis of this analysis. Small amounts of greenhouse gas emissions could also come from fugitive gases unintentionally released, such as coolant leaking from air conditioners. Fugitive emissions are not included in this analysis.

For this analysis, site construction energy needs were assumed to be met with diesel-fuel only (no electricity). Project engineers expect energy needs during pontoon construction to be met with a combination of approximately 80 percent electricity and 20 percent diesel fuel. Actual use may vary from these estimates based on specific equipment and construction methods. The results of the energy analysis were converted to gallons of diesel fuel and kilowatt hours of electricity based on the factors of 139,000 Btu per gallon of diesel and 3,412 Btu per kilowatt-hour (EIA 2009e) and on the energy source assumptions above (Exhibit 16). The results of the energy analysis include fuel needed to transport materials to the site and remove excavated materials. The quantity of diesel fuel needed to tow the built pontoons to moorage sites was calculated separately in the energy analysis.

EXHIBIT 16
Onsite Energy Use

	Site Construction		Pontoon Construction		
Site	**MBtu**	**Diesel Fuel (gallons)**	**MBtu**	**Diesel Fuel (gallons)**	**Megawatt-hours**
CTC[a]	-	-	256,000	369,000	60,000
Anderson & Middleton	1,722,000	12,416,000	1.060,000	1,529,000	249.000
Aberdeen Log Yard	1,630,000	11,753,000	1,060,000	1,529,000	249.000

[a]CTC site construction is not part of this project because it already exists.

Carbon dioxide, nitrous oxide, and methane emissions from each fuel source were calculated by applying the appropriate emission factor (Exhibit 17). Because nitrous oxide and methane are more potent greenhouse gases than carbon dioxide, the quantities of nitrous oxide and methane were multiplied by their global warming potentials to convert to carbon dioxide equivalents. Global warming potentials express the ability of different compounds to warm the atmosphere compared to carbon dioxide. Carbon dioxide equivalents represent the warming potential of gases in terms of the amount of carbon dioxide that would cause the same level of warming. For example, nitrous oxide is 310 times more potent than carbon dioxide at warming the earth's atmosphere. One kilogram of nitrous oxide has the same warming power same as 310 kilograms of carbon dioxide equivalents.

EXHIBIT 17
Emissions Factors

	Diesel[a]	Electricity[b]	Global Warming Potential
Carbon dioxide	10.15 kilograms per gallon	408.19 kilogram per megawatt-hour	1
Nitrous oxide	0.26 grams per gallon	6.77 kilogram per gigawatt-hour	310
Methane	0.58 grams per gallon	8.69 kilogram per gigawatt-hour	21

[a]The Climate Registry (2008).
[b]EPA (2008).

What effect would this project have on greenhouse gas emissions?

Exhibit 18 lists the estimated carbon dioxide equivalents emissions from each alternative for this project. The total emission released from the project would be the sum of emissions from the CTC site and one of the Grays Harbor sites because pontoons will be built at both locations. At the Grays Harbor locations, site construction would release about half of the emissions of this project; the other half would be emitted during pontoon construction. Once the pontoons for the SR 520 Bridge Replacement and HOV Project are built, the site could be used to construct pontoons needed elsewhere.

EXHIBIT 18
Project Greenhouse Gas Emissions in Metric Tons Carbon Dioxide Equivalents[a]

Site	Site Construction	Pontoon Construction	Pontoon Transport to Moorage Site	Total Emissions (metric tons of carbon dioxide equivalents)
CTC	-	27,000	103	27,000
Anderson & Middleton	127,000	118,000	41	245,000
Aberdeen Log Yard	120,000	118,000	66	238,000

[a]Totals may not add up due to rounding.

Project engineers provided preliminary estimates of the number of truck trips that will be needed for this project and potential sources and dumpsites for materials. Based on these estimates, material transport is expected to make up about 5 percent of site construction emissions and less than 1 percent of pontoon construction emissions. Exhibit 19 puts these emission quantities in perspective by comparing the project totals to annual emissions from passenger vehicles.

EXHIBIT 19
Project Greenhouse Gas Emissions – Comparisons

Site	Total Project Emissions (metric tons of carbon dioxide equivalents)	Number of Passenger Vehicles that Produce Annual Greenhouse Gas Emissions Equivalent to Project Emissions*
CTC	27,000	4,900
Anderson & Middleton	245,000	45,000
Aberdeen Log Yard	238,000	44,000

[a]EPA (2009).

What potential measures would WSDOT propose to minimize emissions?

Total greenhouse gas emissions from each build alternative depend on a number of variables:

- Energy used in construction of the site
- Energy used to construct the pontoons
- Distance of truck trips transporting materials
- Fuel used to transport the finished pontoons to the moorage site

Because fuel use is directly related to greenhouse gas emissions, any steps taken to minimize fuel use would also reduce greenhouse gas emissions. All efforts to reduce energy use would also reduce greenhouse gas emissions. WSDOT could seek to set up active construction areas, staging areas, and material transfer sites in ways that reduce equipment and vehicle idling. WSDOT could also work with its partners to promote carpooling and other commute trip reduction efforts for employees working on the project.

Did the project consider future conditions related to climate change?

Governor Gregoire committed the state to preparing for and adapting to the effects of climate change as part of Executive Order 07-02. An Ecology (2008b) focus sheet entitled *Preparing for Impacts* provides a brief summary of the key climate changes that Washington is likely to experience over the next 50 years:

- Increased temperature (heat waves, poor air quality)
- Changes in volume and timing of precipitation (reduced snow pack, increased erosion, flooding)
- Ecological effects of a changing climate (spread of disease, altered plant and animal habitats, negative impacts on human health and well-being)
- Sea-level rise, coastal erosion

The pontoon construction project has incorporated features as part of its design that will help protect the site from storm damage and offer resilience to the potential effects of climate change. These are as follows:

- Protecting the site from damage resulting from wave action during large storm events.
- Protecting the surrounding harbor from potential contamination with waters from inside the casting basin. Care will be taken to avoid mixing waters. Containing compromised waters in the casting basin with exterior walls tall enough to keep water in the basin from mixing with outside water during large storm events.
- Using native vegetation, driftwood, and other natural materials to protect and stabilize the shoreline in locations exposed to low wave energy, minimizing erosion, and colonization by non-native, invasive plant species.

6. References

CALTRANS. 1983. Energy and Transportation Systems. California Department of Transportation.

Climate Registry, The. 2008. General Reporting Protocol for the Voluntary Reporting Program, Version 1.1. Table 13.1. May.

Ecology. 2007. Washington State Greenhouse Gas Inventory and Reference Case Projections, 1990 to 2020. http://www.ecy.wa.gov/climatechange/docs/ WA_GHGInventoryReferenceCaseProjections_1990-2020.pdf. Washington State Department of Ecology, Olympia, Washington.

Ecology. 2008a. 2008 Climate Action Team. http://www.ecy.wa.gov/climatechange/ 2008CAT_overview.htm. Accessed September 11, 2009. Washington State Department of Ecology, Olympia, Washington.

Ecology. 2008b. Responding to the Climate Change Challenge, Focus on: Preparing for Impacts. http://www.ecy.wa.gov/pubs/0801003.pdf, January. Accessed April 1, 2009. Washington State Department of Ecology, Olympia, Washington.

EIA. 2009a. Distillate Fuel Oil Consumption Estimates by Sector, 2007. http://www.eia.doe.gov/emeu/states/sep_fuel/html/pdf/fuel_use_df.pdf. Accessed August 18, 2009. U.S. Department of Energy, Energy Information Administration.

EIA. 2009b. Motor Gasoline Consumption, Price, and Expenditure Estimates by Sector, 2007. Available at http://www.eia.doe.gov/emeu/states/sep_fuel/html/pdf/fuel_mg.pdf. Accessed August 18, 2009. U.S. Department of Energy, Energy Information Administration.

EIA. 2009c. Total Energy Consumption, Expenditures, and Intensities, 2005. http://www.eia.doe.gov/emeu/recs/recs2005/c&e/summary/pdf/tableus1part1.pdf. Accessed August 18, 2009. U.S. Department of Energy, Energy Information Administration.

EIA. 2009d. Energy Consumption Estimates by Source and End-Use Sector, 2007. http://www.eia.doe.gov/emeu/states/sep_sum/html/pdf/sum_btu_1.pdf. Accessed on September 18, 2009. U.S. Department of Energy, Energy Information Administration.

EIA 2009e. What is a Btu? http://www.eia.doe.gov/emeu/cbecs/pba99/office/officebtu.html. Accessed February 13, 2009. U.S. Department of Energy, Energy Information Administration.

EPA. 2008. eGRID2007, Version 1.0, NWPP, page 4. September 2008. U.S. Environmental Protection Agency.

EPA 2009. Greenhouse Gas Equivalencies Calculator. http://www.epa.gov/RDEE/energy-resources/calculator.html. Updated February 17, 2009. Accessed June 22, 2009. U.S. Environmental Protection Agency.

Grays Harbor County PUD. 2006a. 2006 Annual Report. https://www.ghpud.org/index.php?option=com_docman&task=cat_view&gid=75&Itemid=143. Updated 2006. Accessed March 5, 2008.

Grays Harbor County PUD. 2006b. 2006 Bond Official Statement. https://www.ghpud.org/index.php?option=com_docman&task=doc_download&gid=95&Itemid=143. Updated November 28, 2006. Accessed March 5, 2008.

Tacoma Power. 2007a. Power Service Area. http://www.mytpu.org/tacomapower/power-service/Default.htm. Updated 2007. Accessed October 21, 2008.

Tacoma Power. 2007b. Power Sources. http://www.mytpu.org/tacomapower/power-system/power-sources.htm. Accessed October 21, 2008.

Tacoma Power. 2008. 2007 Annual Report. http://www.mytpu.org/files/library/annual-report-2007.pdf, Last updated May 2008. Accessed October 21, 2008.

Washington State Department of Commerce. 2009. Energy Indicators and Data: 2009 Biennial Energy Report with Indicators. http://www.commerce.wa.gov/DesktopModules/CTEDPublications/CTEDPublicationsView.aspx?tabID=0&ItemID=6814&MId=863&wversion=Staging. Accessed September 22, 2009. Washington State Department of Commerce, Energy Policy Unit, Olympia, Washington.

WSDOT. 2005. Tow Cost Model, V4-1-1. SR 520 Bridge Pontoon Tow. Washington State Department of Transportation.

WSDOT. 2008. Environmental Procedures Manual, Chapter 440, Energy. Publication M31-11. Washington State Department of Transportation, Environmental Services Office, Engineering and Regional Operations Division, Olympia, Washington.

WSDOT. 2009. Description of Alternatives and Construction Techniques Discipline Report, Pontoon Construction Project, SR 520 Bridge Replacement and HOV Program. Washington State Department of Transportation, Olympia, Washington.

GIS References

Grays Harbor County. 2006. Roads GIS data download. http://www.ghc-gis.org/info/GIS/download.html. Accessed December 21, 2006. Grays Harbor County, Geographic Information Systems Department, Montesano, Washington.

USDA-FSA. 2006. Pierce County aerial photograph. http://rocky2.ess.washington.edu/data/raster/naip2006/Pierce/. Accessed September 2009. U. S. Department of Agriculture, Farm Services Agency, Aerial Photography Field Office, Salt Lake City, Utah.

WSDOT. 2005. Aberdeen graving dock orthophotograph. Accessed May 29, 2008. Washington State Department of Transportation Aerial Photography Branch, Olympia, Washington.

WSDOT. 2006. SR101 City of Aberdeen orthophotograph. Accessed May 29, 2008. Washington State Department of Transportation Aerial Photography Branch, Olympia, Washington.