Safe and Effective Threshold Determination Report for the Vancouver, WA Terminal

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Change Log

Date	Reviewer	Changes
Apr 16, 2007	Entrix	Initial Publication
November 2022	ERM	Updated meteorological and hydrological data and evaluated against conclusions. Removed references to NuStar.
August 2026	ERM	Updated to address comments received from Ecology in their 14 April 2026 email.

Executive Summary

This report provides the NuStar Person in Charge (PIC) for oil transfer operations at the Vancouver Terminal (the Terminal) with the threshold values for environmental conditions that allow the safe and effective deployment of oil boom.

As of 26 October 2006, Washington State rules were adopted for *Facility Oil Handling Standards* (WAC 173-180) and *Vessel Oil Transfer Advance Notice and Containment Requirements* (WAC 173-184). These rules require that Class 1 facilities such as NuStar Vancouver Terminal develop guidance on criteria and threshold values for the safe and effective deployment of oil boom for oil transfer operations.

Safe and Effective Threshold Values

The following are threshold values for environmental conditions above which NuStar PIC will consider not safe and/or effective to pre-boom:

- **Water current speed > 1.5 knot** will be the effective threshold value.
- **Wave heights >2.0-2.5 feet** will be the safe and effective threshold value.
- **Sustained wind speed greater than 30 knots (~35 mph)** will be the safe and effective threshold value.
- **Low visibility** resulting from fog, heavy precipitation, or snow at the dock and/or boom deployment vessel that, in the opinion of the NuStar PIC, jeopardizes the safety of personnel involved in pre-booming. Visibility conditions are considered unacceptable when personnel cannot maintain visual contact with other crew members, observe the boom configuration and attachment points, or safely navigate the boom deployment vessel. In such cases, the Terminal PIC, in consultation with the Vessel PIC and boom deployment contractor, will determine that conditions are not safe for pre-booming.
- **Freezing and icy conditions** that, in the opinion of the NuStar PIC, jeopardize the safety of personnel involved in pre-booming. Conditions are considered unacceptable when ice accumulation or cold weather conditions prevent personnel from safely accessing work areas, handling boom deployment equipment, maintaining footing, or performing pre-booming activities in accordance with established safety procedures. In such cases, the Terminal PIC, in consultation with the Vessel PIC and boom deployment contractor, will determine whether conditions are safe for pre-booming.
- **Presence of large floating/barely submerged debris** that, in the opinion of the NuStar PIC, jeopardizes the safety of personnel involved in pre-booming. Conditions are considered unacceptable when the presence of large floating or partially submerged debris that, due to its frequency, size, or distribution, may reasonably be expected to compromise personnel safety, interfere with boom deployment, or significantly reduce boom effectiveness.

Section 1 Introduction

1.1 PURPOSE

The purpose of this report is to provide the NuStar PIC for oil transfer operations at the Vancouver Terminal (the Terminal) with the threshold values for environmental conditions that allow the safe and effective deployment of oil boom around vessels prior to and during oil transfer operations (also referred to as *pre-booming*). See Section 1.3 for company details.

1.2 OBJECTIVES

The objectives of the analysis and report are to:

- Comply with the *Safe and Effective Threshold Determination Report* requirements of the Washington State *Facility Oil Transfer Regulations* (WAC 173-180-224).
- Identify personnel safety conditions and provide guidance on threshold criteria and values.
- Identify oil boom oil retention efficacy under a range of environmental conditions.
- Provide guidance on criteria and threshold values for environmental conditions affecting personnel safety and oil retention efficacy.

1.3 LOCATION OF TERMINAL DOCK

The dock is located on the Columbia River on Port of Vancouver property at Port Site #2211 (latitude 45º38’5” N; longitude 122º42’10” W) at River Mile 104.8 and about one mile downriver of the Interstate 5 Bridge (Figure 1). The NuStar Terminal address is 2562 NW Harborside Drive, Vancouver, WA 98660. This Terminal is rated as a Class 1 Rate A bulk loading facility which receives and discharges refined oil products from and to ships and barges via the docking facility. Product offloaded at the dock includes Jet A fuel and sodium hydroxide. Jet A fuel is also loaded. Other products loaded and offloaded may include ethanol, biodiesel, renewable diesel, and conventional diesel.

1.4 BACKGROUND

As of 26 October 2006, Washington State rules were adopted for *Facility Oil Handling Standards* (WAC 173-180) and *Vessel Oil Transfer Advance Notice and Containment Requirements* (WAC 173-184). These rules require that Class 1 facilities such as NuStar Vancouver Terminal develop guidance on criteria and threshold values for the safe and effective deployment of oil boom around vessels prior to and during oil transfer operations.

The rule requires pre-booming of: (a) any bulk oil transfer operation greater than 500 gallons per minute from a vessel to a non-recreational vessel or facility; or (b) oil transfer from a Class 1 facility to a vessel “when it is safe and effective to do so.” The rule provides guidance on the determination of when it is or is not safe and effective to pre-boom the oil transfer vessel and facility. Products loaded are sodium hydroxide 50 percent at a rate of 1,200 barrels per hour (bph) and Jet A at a rate of 4,000 bph.

This report provides the personnel safety and environmental criteria and threshold values for determination of when it is safe and effective to pre-boom at the Vancouver Terminal dock. The analyses are based on data available from a variety of sources including National Oceanic and Atmospheric Administration (NOAA), the National Weather Service (NWS), United States Geological Survey (USGS), weather stations near the Terminal, boom manufacturers' technical specifications for their products, experience of the oil spill response contractors retained by NuStar for the Vancouver Terminal, other contractors retained by NuStar to handle normal docking and oil transfer operations at the dock, and onsite observations and experience of the dock operators and other NuStar personnel.

Figure 1 *NuStar Vancouver Dock in Vancouver, WA*

Section 2 Site-Specific Safety and Environmental Conditions

2.1 PERSONNEL SAFETY CONDITIONS

The NuStar PIC at the Terminal dock has the ultimate responsibility and authority to determine if it is safe for personnel to deploy oil boom to meet the pre-booming requirement. That is, the PIC may determine that, even though the threshold values described later in this report are not exceeded, there are other factors that render the pre-booming operation unsafe for personnel and therefore the PIC may terminate the pre-booming operation. In this situation and any other situation where the PIC determines that pre-booming is not safe and/or effective, the PIC will document the circumstances supporting the decision to not pre-boom and to proceed with alternative measures discussed in Section 3.8 as required in WAC 173-180-221 and WAC 173-180-222.

Personnel safety may be compromised by one or more of the following conditions:

- High winds that affect the docking of the vessel or maintaining its position at the dock during transfer operations, even if these winds do not result in large waves
- Waves, especially high, choppy (i.e., short-period) waves that affect the stability and maneuverability of the vessels deploying the boom
- Icy conditions that make the dock and/or boom deployment vessel slippery
- Heavy fog, rain, or other conditions that reduce visibility to unsafe levels for the boom deployment crew
- High river flow (e.g., flood conditions) carrying large debris, flotsam, and jetsam that could make small vessel operations unsafe (and likely render the boom ineffective if not completely inoperative)
- Other conditions as determined and documented by the PIC, or NuStar response or other contractor responsible for deploying the boom

Personnel conducting pre-booming operations are equipped with appropriate personal protective equipment (PPE) and response equipment in accordance with Terminal procedures and the Emergency Response Action Plan (ERAP). Minimum PPE includes safety toe boots with defined heel, hard hats, safety glasses, personal flotation devices (PFDs) with attached strobe light and whistle, fit-for-purpose gloves (cut resistant and/or thermal based on task and weather conditions), and flame-resistant (FR) clothing. Additional PPE may be utilized based on weather and site conditions, including waterproof gloves, waterproof footwear, float coats, cold-weather flotation gear, and other protective equipment necessary to safely conduct operations.

During cold weather, freezing conditions, or periods of elevated precipitation, additional cold-weather protective equipment may be required, including insulated waterproof gloves, waterproof boots, float coats, flotation coveralls, or equivalent equipment. The PIC and boom deployment contractor will evaluate conditions and determine whether available PPE is sufficient to safely conduct pre-booming activities.

2.2 DEPLOYMENT METHOD AND VESSEL CONSTRAINTS

Boom deployment is conducted using a 17-foot aluminum vessel (1990 model) powered by a 130-horsepower outboard motor. The vessel is equipped with standard marine safety and communication equipment, including a marine radio, navigation lights, an air horn, and a first aid kit, as well as support equipment such as lines, a pike pole, paddles, and flotation/throw devices. The vessel provides sufficient deck space for personnel, handling gear, and anchor boxes during boom deployment. The vessel and associated equipment have been subject to inspection by local port or U.S. Coast Guard personnel and determined to be appropriate for intended operations. Operationally, boom is deployed using both conventional and deflection configurations (e.g., angled or “V”-shaped alignment) to reduce hydraulic loading and take advantage of reduced current velocities in nearshore and shallower areas. Vessel size, maneuverability, onboard equipment, and prevailing conditions are considered by the PIC when evaluating whether deployment and retrieval of containment boom can be conducted safely.

2.3 ENVIRONMENTAL CONDITIONS

2.3.1 Sea State

The Terminal dock is generally well-protected from significant wind-driven wave action under most conditions. Because the fetch (the uninterrupted distance over water from the dock to land or large structures such as the I-5 Bridge) is short, waves are typically not a limiting factor for oil transfer operations. Even from southeasterly and northwesterly wind directions, which align with the Columbia River channel and present the longest fetch, the dock remains partially sheltered. Upstream and downstream features, including bridges and shoreline infrastructure, help break up wave energy, further reducing the impact of wind-generated waves on the dock.

Whitecaps provide an early visual indication of increasing wind-driven wave energy and typically begin forming in open-water conditions when winds reach approximately 7 to 10 knots (about 8 to 12 mph). At these speeds, corresponding to a gentle breeze (Beaufort Force 3), wave crests may begin to break intermittently, producing scattered foam patches as short-period wind waves develop. As wind speeds increase above about 11 to 16 knots (13 to 18 mph), whitecaps become more frequent and widespread, indicating more persistent breaking and higher wave energy (NOAA 2022). These thresholds are based on open-water conditions and may vary in areas of limited fetch, such as the Port of Vancouver. At the Terminal dock, we would expect similar wind thresholds for initial whitecap formation, but lower frequency and persistence of whitecaps due to limited fetch and partial sheltering. Whitecaps may represent an early indication of increasing wave energy, although operational thresholds for personnel safety and boom effectiveness occur at higher wind speeds and wave heights.

In the Port of Vancouver area, wave height and period (time between wave crests passing a fixed point) do not appear to have been continuously recorded, or such data is not publicly available. Although continuous site-specific wave period data are not available, the limited fetch and sheltered riverine setting indicate that locally generated wind waves at the Terminal would be expected to have relatively short periods, generally on the order of a few seconds. These short-period waves can create steep, choppy conditions that may affect small vessel maneuverability, personnel stability, line handling, and boom deployment activities. Because wave period measurements are not routinely available, the PIC relies on direct observation of wave conditions, including wave height, wave steepness, whitecap formation, vessel motion, and anticipated operating conditions, when evaluating whether conditions are safe and effective

for pre-booming operations. Based on long-term operational experience at the Terminal, southeasterly and northwesterly winds exceeding 25 knots (~29 mph) can occur and may generate waves greater than 2–2.5 feet (ft) high, which could impact the safety and effectiveness of pre-booming during the oil transfer operations.

Additionally, bow waves and wakes from large commercial or recreational vessels traveling on the Columbia River can occasionally exceed 2–2.5 ft. These waves may temporarily reduce boom effectiveness and pose safety risks to contractors deploying or maintaining the boom. Although these effects are brief, typically lasting about a minute, they require visual monitoring to ensure safe operations.

2.3.2 Water Currents

Currents are not recorded by NuStar at the dock. However, based on field experience, the current generally flows downriver (east to west), suggesting that while tidal influence reaches the Port of Vancouver and may affect current speed, it has little effect on the direction.

USGS collects continuous river velocity data from their station 14144700 Columbia River at Vancouver which is approximately 2 miles southwest of the NuStar dock. Index river velocity is a function of streamwise velocity, stage, cross-stream velocity, and velocity head. For this evaluation, continuous data were downloaded and processed by calculating monthly average values, followed by averaging each month across the period of record from 2018 through 2024 to characterize typical seasonal conditions. These average monthly average values at this station are included in Table 1 (USGS 2025).

Regional river velocity data are presented to provide seasonal and hydrologic context for current conditions in the vicinity of the Terminal. The dock's sheltered location in shallow water likely results in slower currents than those measured at the referenced station which is likely near the center of the channel. Actual current velocities at the dock face may differ from upstream averages due to localized bathymetry, dock structures, vessel effects, and tidal influence. Accordingly, real-time current conditions at the dock are evaluated by the PIC using float-based measurements and direct observation of surface flow, debris movement, and vessel response, recognizing that localized currents at the dock face may differ from upstream USGS averages.

The river data show a clear seasonal trend in discharge, gage level, and velocity. Peak flow occurs in late spring, with May showing the highest average discharge (296.01 thousand cubic feet per second [kcfs]), gage level (8.21 ft above mean sea level [AMSL]), and velocity (1.78 knots [~2.05 mph]), likely due to snowmelt or seasonal runoff. Flow and velocity decline during the summer months, reaching the lowest values in September and October, when discharge drops below 100 kcfs and velocity falls to around 0.76 knots (~0.88 mph). Winter months maintain moderate flow and velocity, with a slight increase in December and January. Overall, the data reflect a typical hydrologic cycle, with spring peaks and late summer lows.

Table 1 *River Flow and Elevation*

Month	Average River Discharge (kcfs)	Average Gage Level (ft AMSL)	Average River Velocity (knots)	Average River Velocity (mph)
January	166.53	5.98	1.14	1.31
February	167.93	5.05	1.18	1.36
March	152.04	4.32	1.11	1.28
April	195.64	5.39	1.34	1.54
May	296.01	8.21	1.78	2.05
June	254.99	6.92	1.64	1.88
July	175.14	3.94	1.30	1.50
August	142.85	3.09	1.11	1.28
September	95.08	2.13	0.79	0.91
October	91.8	2.15	0.76	0.88
November	136.32	3.54	1.04	1.20
December	144.03	4.66	1.05	1.21

*Data processed from USGS continuous river data from 2018 through 2024 at station 14144700.

2.3.3 Weather Conditions

The wind velocity and precipitation data presented in Tables 2 and 3 were collected at Pearson Field Airport, located approximately 1.5 miles upriver of the dock in southeast Vancouver, WA. The data were gathered by the NWS and accessed through the NOAA's National Centers for Environmental Information (NOAA 2025). Appendix A includes the full data set from 2018 to 2024.

The climate data show seasonal variation in both wind and precipitation patterns. Average wind speeds remain relatively steady throughout the year, ranging from 3.0 knots (~3.4 mph) in October to 4.7 knots (~5.4 mph) in July. Wind speeds peak up to 14.8 knots (~17 mph) in February and September. Wind direction shifts seasonally, blowing from the southeast in winter (approximately 155–194 degrees) and from west-northwest in summer (approximately 287–294 degrees).

Precipitation is highest in winter months, peaking at 0.20 inches in December. Precipitation decreases significantly in summer, with July and August each recording only 0.01 inches, consistent with the dry season typical of temperate oceanic climates. Most precipitation in the area is rainfall, though occasional snowfall and rare hail or sleet storms occur in winter. Rainfall is possible year-round, with the wettest period extending from late September through April. While rainfall can be intense at times, it is usually not heavy or prolonged enough to affect the safety of pre-booming operations.

Table 2 *Climate Data (Knots)*

Month	Average Wind Speed (knots)	Max Sustained Wind Speed (knots)	Peak Wind Speed (knots)	Wind Direction (degrees)	Average Precipitation (inches)
January	4.6	27	11.2	164	0.19
February	4.3	26.1	14.8	194	0.1
March	4.1	24.3	14.5	206	0.09
April	4.2	25.3	10.1	236	0.09
May	4.1	21.8	10.9	268	0.06
June	4.4	20.8	9.1	287	0.06
July	4.7	19	7.6	294	0.01
August	4	17.3	6.8	293	0.01
September	3.3	27.8	14.8	259	0.06
October	3.0	24.3	10.7	215	0.09
November	3.5	24.3	11.5	187	0.16
December	4.3	22.5	14.3	155	0.2

* Data processed from NOAA historical data from 2018 to 2024 for the Pearson Field Airport weather station.

Table 3 *Climate Data (MPH)*

Month	Average Wind Speed (mph*)	Max Sustained Wind Speed (mph)	Peak Wind Speed (mph)	Wind Direction (degrees)	Average Precipitation (inches)
January	5.3	31.1	12.9	164	0.19
February	4.9	30	17	194	0.1
March	4.7	28	16.7	206	0.09
April	4.8	29.1	11.6	236	0.09
May	4.7	25.1	12.5	268	0.06
June	5.1	23.9	10.5	287	0.06
July	5.4	21.9	8.7	294	0.01
August	4.6	19.9	7.8	293	0.01
September	3.8	32	17	259	0.06
October	3.4	28	12.3	215	0.09
November	4.0	28	13.2	187	0.16
December	4.9	25.9	16.5	155	0.2

* mph = miles per hour

* Data processed from NOAA historical data for the Pearson Field Airport weather station.

Section 3 Safe and Effective Threshold Values

3.1 PRIORITY OF SAFE AND EFFECTIVE THRESHOLD VALUES

Safety of the personnel assigned to the pre-booming of barges or ships is the first and highest priority for the NuStar PIC. This priority will supersede all environmental threshold values (though it may be influenced by one or more of these environmental conditions).

Once the safety of the personnel is assured to the PIC's satisfaction, the PIC will then evaluate the environmental factors that affect the efficacy of oil retention by the deployed boom. If these conditions, primarily surface water currents or sea state (e.g., wave height and period), exceed the threshold values provided here as guidance, the PIC will make and document the decision to pre-boom or not.

Pre-booming operations are conducted using response vessels identified in the Terminal's ERAP and maintained by the designated spill response contractor. Response vessels are selected and operated based on prevailing environmental conditions, including wind, wave height, current velocity, visibility, and debris conditions. The PIC and response contractor will evaluate whether the vessel being used is suitable for anticipated conditions before initiating pre-booming operations. Equipment specifications and vessel inventories are maintained in the current ERAP and supporting contractor response plans.

3.2 PERSONNEL SAFETY

The primary environmental conditions that generally influence personnel safety at the NuStar dock during oil transfer operations are high winds, sea state, and presence of large debris. Low visibility or ice formation is infrequent but create possible limitations from a safety perspective.

High winds can negatively impact pre-booming and other oil transfer activities. For the safety of dock personnel and contractors deploying the boom, the PIC may use Small Craft Advisory (SCA) conditions as an initial reference when deciding whether to authorize the launch or use of company-owned and -operated oil spill response equipment for pre-boom deployment. These SCA conditions may be either present or forecasted.

According to the NWS, SCA conditions refer to sustained winds in excess of 22 knots (~25 mph) or frequent gusts of 25 knots (~29 mph) or greater that may pose hazards to small vessels. NuStar recognizes that even when an SCA is issued or applicable to the region, local conditions may vary. In some cases, the PIC may determine that pre-booming can proceed safely based on real-time assessment of wind direction, shelter at the dock, and other site-specific factors. This decision must be based on documented conditions and mutual agreement between the NuStar PIC and the contractor.

The following wind guidelines presented in Table 4 apply to all vessels at the Terminal dock. The wind speeds referenced are sustained, meaning the wind maintains a consistent speed for more than 5 minutes. The table provides guidance on appropriate actions to consider when sustained wind speeds are elevated. For safety purposes, a sustained wind greater than 22 knots (~25 mph) will serve as the safety threshold for evaluating pre-boom feasibility at the Terminal.

Table 4 *Advisory for Oil Transfer Operation Actions Related to Wind Speed*

Wind Speed (mph)	Wind Speed (knots)	Action Required
0–25	0–22	Monitor vessel tie-up lines and hose connections as normal.
26–38	23–33	Shutdown oil transfer operations and drain hoses.
Over 38	Over 33	Disconnect and stow hoses, if safe to do so.
Over 45	Over 39	Request vessel to prepare and sail if the vessel or dock is in jeopardy of sustaining damage. If safe to do so, sail the vessel.

Note: Wind speeds presented in this table represent sustained wind speeds. Short-duration wind gusts may produce higher localized wind forces and wave conditions, which can adversely affect boom deployment, stability, and personnel safety even when sustained wind speeds remain below the identified thresholds.

Sea state (wave height and period) is primarily driven by wind speed and direction. Southeasterly or northwesterly winds tend to produce the highest wave conditions. If wave heights exceed approximately 2.0–2.5 ft in a choppy sea (short-period wind chop superimposed on longer-period swells), the PIC may deem it unsafe for personnel to deploy the boom, regardless of its potential effectiveness in retaining oil.

From a personnel safety perspective, the presence of scattered to frequent whitecaps is considered a threshold condition, as it indicates active wave breaking and short-period, steep chop that can reduce vessel maneuverability, increase deck instability, and complicate line and anchor handling.

Water currents. The Terminal must consider pre-booming when water currents are 1 knot (~1.2 mph) or less. Other conditions should be considered when determining whether it is safe to pre-boom when water currents are over 1 knot (~1.2 mph).

Current at the time of transfer is determined by the barge tankerman. A floating object is placed in the water and then timed between the measurements marked on the deck of the barge. The feet per second measurement is then converted to knots to determine current velocity using the following equation:

$$\text{knots} = \text{feet per second} \times 0.59$$

When conditions are safe to boom, the PIC directs personnel to place the boom angled slightly with the current to maintain proper tension, reduce entrainment, and preserve boom shape. The angle will be adjusted based on observed current direction and speed at the time of deployment.

3.3 OTHER CONDITIONS THAT INFLUENCE OIL TRANSFER OPERATIONS

Low visibility resulting from fog, heavy precipitation, or snow at the dock and/or boom deployment vessel may jeopardize the safety of personnel involved in transfer operations. Low visibility is considered a threshold condition when visibility is insufficient for personnel to safely navigate the boom deployment vessel, monitor boom deployment activities, maintain visual communication with crew members, or detect hazards and vessel traffic within the operational area.

Freezing conditions that result in ice buildup on the dock and/or boom deployment vessel may jeopardize the safety of personnel involved in pre-booming operations. Freezing conditions

resulting from cold temperatures, freezing precipitation, snow, or ice accumulation may jeopardize the safety of personnel involved in pre-booming operations. Potential hazards include slippery walking and working surfaces, reduced personnel dexterity, ice accumulation on vessels and boom equipment, and cold-water immersion risks should a worker fall into the water.

The Columbia River remains cold throughout much of the year, and accidental immersion may result in cold shock, loss of dexterity, and hypothermia. Appropriate PPE, including PFDs and other cold-weather protective equipment, will be utilized in accordance with Terminal and contractor safety procedures. The PIC will consider water temperature, weather conditions, available rescue resources, and anticipated recovery time when evaluating whether conditions are safe for pre-booming.

Large floating/barely submerged debris is generally associated with high water flows and strong currents. The combination may pose a safety hazard to the pre-booming vessel as well as to the boom and lines used to secure the boom. Large floating or partially submerged debris is generally associated with periods of elevated river flow and may pose a hazard to boom deployment vessels, boom anchoring systems, and deployed boom.

In all instances, close consultation between the NuStar PIC**,** Transfer Vessel PIC, and the contractor deploying the boom will be undertaken to determine if conditions are unsafe for personnel to pre-boom the transfer vessel.

3.4 EFFICACY OF OIL BOOM UNDER RANGE OF ENVIRONMENTAL CONDITIONS

The Vancouver Terminal will deploy up to 2,000 feet of 8 inch by 12 inch internal foam curtain boom, commonly referred to as 20-inch contractor boom.

The 20-inch contractor boom is a standard type of boom best suited for use in semi-protected environments such as Vancouver dock where moderate currents and winds are the normal condition. Ideal performance conditions for 20-inch contractor boom are:

- Surface current speeds <1.0 knot perpendicular to the boom and up to 5 knots depending upon the angle of the boom relative to the current direction
- Wave heights <1.5-2 feet
- Wind speeds <20 knots (~23 mph)

In addition to the contractor boom used for pre-booming operations, the Terminal utilizes 12-inch containment boom in 100-foot sections. Each section is equipped with 6-inch closed-cell foam floats, a 6-inch skirt depth, and a 5/16-inch galvanized chain ballast enclosed within a double-fabric sleeve to provide stability and maintain boom profile in current and wave conditions. Boom sections are connected using ASTM aluminum Z quick-latch connectors. Anchor attachment points are provided at each end of the boom section and at 25-foot intervals to facilitate deployment and secure anchoring.

A stationary containment boom is maintained across the face of the dock by Tesoro, which shares use of the berth. This boom provides an additional layer of protection in the immediate vicinity of the dock during transfer operations. Because the boom is owned and maintained by

Tesoro, detailed specifications, performance characteristics, inspection records, and maintenance procedures are not maintained by NuStar and are therefore not evaluated in this report. The safe and effective threshold determinations presented herein are based on the boom and response equipment utilized by NuStar for pre-booming operations.

As currents pushing against the boom exceed ideal operating conditions, the boom becomes subject to hydraulic failure, commonly referred to as *entrainment,* and the oil product may begin to slip under the boom skirt. Entrainment is common to all types of booms regardless of size or design. Entrainment does not indicate a complete failure of the boom but does impact the efficacy of the boom.

It is difficult to establish exact limits of current speed to boom efficacy. A generally accepted rule among the emergency response industry is that current speeds >0.8-1.0 knot perpendicular to the long axis of the boom will begin to result in product loss and current speed >1.5 knots will result in significant or complete product loss. As the boom angle is adjusted toward parallel with the current direction, the entrainment is reduced for a given current speed. However, as current speed approaches 5 knots, boom effectiveness approaches zero regardless of boom configuration. (Mark Ploen, Quali-tech, personal communication).

Modifying the boom configuration under different current regimes can have a dramatic impact on efficacy and in many cases can improve the capability to control product into a collection point. However, for oil transfer pre-booming where the boom needs to surround a vessel, the opportunity to develop alternative configurations is limited. In the pre-booming configuration, some portion of the downstream end of the boom will be at or near perpendicular to the current thereby reducing overall effectiveness of oil retention at high current velocity at that location (Mark Ploen, Quali-tech, personal communication).

Another generally accepted rule among the response industry is that waves > 1.5-2 feet high will result in splash over of water or product causing the boom effectiveness to be reduced by 10 - 20%. Waves > 2 feet in height will dramatically decrease the effectiveness of the boom through wash over, and waves > 2.5 feet will render the boom essentially useless for retaining oil, even if the water current speeds are essentially zero (Ploen n.d.).

Large debris that gets entangled in the boom or in the lines attaching boom to shore, other fixed points, or vessels generally presents a large surface to the water currents. The resulting force drags the boom underwater or otherwise compromises the boom configuration to the extent the boom no longer retains oil. Large debris is typically present when current velocity is high, and the combination will almost always result in the boom efficacy being essentially zero.

3.5 EFFECTIVE THRESHOLD CONDITIONS FOR OIL BOOM

3.5.1 Surface Water Currents

Based on years of experience at the dock and data presented in Section 2.3.2, NuStar expects surface current speed to exceed 1 knot on a frequent basis all months of the year and occasionally to exceed 3-5 knots during spring flood flows of the Columbia River. NuStar anticipates that current speed will be a deterrent to effective pre-booming at this Terminal for a substantial portion of the year. *Therefore, the effective threshold value for current speed will be 1.5 knots at this Terminal.*

3.5.2 Sea State (Wave Height and Period)

Sea state will occasionally be a factor limiting oil boom effectiveness during oil transfer operations at this Terminal, based on the long-term experience and observations of the Terminal Manager, dock operations personnel, and contractors supporting NuStar in oil transfer operations.

They indicate that wave action may be a factor on those occasions when sustained southeasterly or northwesterly winds exceed about 15 knots (~17 mph) and may cause waves from 1.5–2 feet high. Under these conditions, sea state will begin to exceed the capabilities of the boom to retain oil. At sustained easterly wind speeds greater than about 20–25 knots (~23-29 mph), wave height may exceed 3 feet which will render the oil boom almost completely ineffective in retaining oil*. Therefore, wave heights greater than 2.0-2.5 feet will be the effective threshold value for waves at this Terminal.*

3.5.3 Wind

As noted in Section 3.2, if SCA conditions (i.e., sustained winds up to 33 knots [~38 mph]) that may pose a hazard for small vessel operators are posted or similar winds are measured at the NuStar Terminal, the PIC will evaluate potential for impacts to personnel safety and to effectiveness of boom deployment. The PIC may make a real-time determination that, because of the wind direction and shelter at the dock, it is safe to pre-boom the vessel and continue with oil transfer operations.

As also noted in Section 3.2, wind speed >30 knots (~35 mph) for longer than 5 minutes will exceed the personnel safe operating limit and booming as well as oil transfer operations will be terminated. *Therefore, sustained wind speed greater than 30 knots (~35 mph) will be the effective threshold value for wind at this Terminal.*

3.6 SAFE AND EFFECTIVE THRESHOLD VALUES

The following are threshold values for environmental conditions above which NuStar PIC will consider pre-booming not safe and/or effective:

- **Water current speed > 1.5 knot** will be the effective threshold value.
- **Wave heights >2.0-2.5 feet** will be the safe and effective threshold value.
- **Sustained wind speed greater than 30 knots (~35 mph)** will be the safe and effective threshold value.
- **Low visibility** resulting from fog, heavy precipitation, or snow at the dock and/or boom deployment vessel that, in the opinion of the NuStar PIC, jeopardize the safety of personnel involved in pre-booming. Visibility conditions are considered unacceptable when personnel cannot maintain visual contact with other crew members, observe the boom configuration and attachment points, or safely navigate the boom deployment vessel. In such cases, the Terminal PIC, in consultation with the Vessel PIC and boom deployment contractor, will determine that conditions are not safe for pre-booming.
- **Freezing and icy conditions** that, in the opinion of the NuStar PIC, jeopardize the safety of personnel involved in pre-booming. Conditions are considered unacceptable when ice

accumulation or cold weather conditions prevent personnel from safely accessing work areas, handling boom deployment equipment, maintaining footing, or performing pre-booming activities in accordance with established safety procedures. In such cases, the Terminal PIC, in consultation with the Vessel PIC and boom deployment contractor, will determine whether conditions are safe for pre-booming.

- **Presence of large floating/barely submerged debris** that, in the opinion of the NuStar PIC, jeopardize the safety of personnel involved in pre-booming. Isolated debris, such as individual logs or woody material drifting through the navigation channel, is common on the Columbia River and does not necessarily preclude pre-booming operations. However, debris conditions may be considered unacceptable when the frequency, size, or distribution of floating debris creates a reasonable likelihood of debris striking the boom, fouling boom lines, interfering with vessel maneuvering, or otherwise compromising personnel safety or boom effectiveness. In such cases, the Terminal PIC, in consultation with the Vessel PIC and boom deployment contractor, will determine whether conditions are safe for pre-booming.

3.7 PRE-BOOMING DECISION AND MONITORING CHECKLIST

Prior to initiating pre-booming operations, the Terminal PIC shall evaluate site conditions and complete the following assessment:

- ☐ Verify current weather conditions and forecasted conditions during the anticipated transfer period.
- ☐ Confirm sustained wind speeds are below the established threshold of 30 knots (35 mph).
- ☐ Evaluate wave conditions, including wave height, wave steepness, whitecap formation, and vessel motion.
- ☐ Confirm wave heights are below the established threshold of 2.0 to 2.5 feet.
- ☐ Evaluate current velocity using float-based measurements and direct observations.
- ☐ Confirm current velocity is below the established threshold of 1.5 knots or determine that boom deployment remains effective under observed conditions.
- ☐ Assess visibility conditions and verify personnel can safely navigate the boom deployment vessel, monitor boom deployment activities, maintain visual communication, and identify hazards within the operational area.
- ☐ Assess for freezing conditions, ice accumulation, slippery surfaces, or other cold weather hazards that may affect personnel safety.
- ☐ Assess the presence, frequency, size, and distribution of floating debris and determine whether debris could interfere with boom deployment, impact boom effectiveness, or create hazards for personnel.
- ☐ Confirm appropriate PPE and cold-weather protective equipment, if required, are available and being utilized.
- ☐ Verify the boom deployment vessel and response equipment are suitable for anticipated environmental conditions.
- ☐ Conduct a pre-booming briefing with the Vessel PIC and boom deployment contractor to discuss environmental conditions, hazards, and planned operations.
- ☐ Document the environmental assessment and PIC determination.

During Oil Transfer Operations

- ☐ Continuously monitor wind, wave, current, visibility, and debris conditions.
- ☐ Inspect the deployed boom for proper configuration, tension, positioning, and evidence of damage or debris accumulation.
- ☐ Maintain communication between the Terminal PIC, Vessel PIC, and boom deployment contractor.
- ☐ Evaluate changing conditions that may affect personnel safety or boom effectiveness.
- ☐ Suspend or terminate pre-booming activities if environmental conditions exceed established thresholds or if conditions are determined to be unsafe.
- ☐ Document significant changes in environmental conditions and any operational decisions made by the PIC.

If Pre-Booming Is Determined to be Unsafe or Ineffective

- ☐ Document the specific environmental conditions supporting the decision.
- ☐ Implement alternative measures in accordance with WAC 173-180-221 and WAC 173-180-222 (See Section 3.8 below).

3.8 ALTERNATIVE MEASURES

If the PIC determines that it is not safe or effective to pre-boom a transfer, the PIC shall submit the Ecology Boom Reporting Form (ECY 070-215) via Ecology's website or email prior to the transfer or immediately upon a change in conditions. If pre-booming is not conducted or is interrupted due to unsafe or ineffective conditions, a Rate A deliverer must resume booming if conditions improve. If unsafe persist during a terminal transfer, Ecology Boom Reporting Forms must be submitted every 6 hours. The Terminal will confirm the following alternative measures are in place prior to conducting the transfer:

- Sufficient containment boom onsite always to surround the vessel and Terminal dock within 1 hour in the event of a spill. The boom must be at least four times the length of the largest vessel involved in the transfer, or 2,000 ft, whichever is less.
    - The dock is designed to accommodate a single vessel at a time. It can service vessels up to 700 ft in length and with a maximum draft of 40 ft at low water.
    - A supply of oil spill containment equipment is maintained at the dock, including 4,500 ft of Harbor and sorbent boom.
- Enough sorbent material and storage capacity for a 7-barrel (bbl) oil spill appropriate for use on water and land.
    - Fifteen bundles of 15-inch-by-20-inch absorbent pads, fifteen bags of 8-inch-by-10-ft sausage booms, and one bag of 8-inch-by-15-ft sausage boom are stored in the shoreline building.
- Non-sparking hand scoops, shovels, and buckets.
    - There are sufficient response tools and supplies at the Terminal.

- The Terminal is equipped with two tracking buoys with strobe lights to safely track spill trajectory in low visibility conditions and is ready to deploy within 30 minutes of being made aware of a spill.

- Within 1 hour of becoming aware of a spill, the Terminal will fully surround the vessel and the facility or Terminal dock area involved in the oil transfer operation with boom or enclose the portion that offers the greatest potential for containing spilled oil.

- Within 2 hours of being made aware of the spill, the Terminal will have additional boom four times the length of the largest vessel involved in the transfer or 2,000 ft, whichever is less, available for containment, protection, and recovery.

- A boathouse attached to the dock houses an 18-ft aluminum workboat equipped with a 130-horsepower outboard motor and functional communications equipment, along with 1,500 ft of containment boom. An additional 1,300 ft of containment boom is stored in the shoreline building. In the event of a spill, a response boat, anchor systems, and contracted oil spill response equipment are available.

References

National Oceanic and Atmospheric Administration (NOAA). (2025, August). *National Centers For Environmental Information*. Retrieved from Climate Data Online: www.ncei.noaa.gov/cdo-web

NOAA. (2022, May 12). *The Beaufort Wind Scale*. Retrieved from National Weather Service | Weather Prediction Center: https://www.wpc.ncep.noaa.gov/html/beaufort.shtml

Ploen, Mark. n.d. Personal communication.

The International Tanker Owners Pollution Federation. (n.d.). *Use Of Booms In Oil Pollution Response.* London: ITOPF.

United States Geological Survey. (2025, August). *Columbia River at Vancouver, WA - USGS-14144700*. Retrieved from Water Data for the Nation: waterdata.usgs.gov

Washington State Department of Ecology. (2023). *Pre-boom Requirements for Vessels and Facilities Delivering Oil.* Lacey: 06-08-031.

Washington State Department of Ecology. (2024, July 22). *Pre-booming, alternative measures, and equivalent compliance*. Retrieved from https://ecolgy.wa.gov/Regulations-Permits/Compliance-enforcement/Pre-booming-requirements

APPENDIX A Monthly precipitation and wind averages (2018-2024)

Year	Month	Average Wind Speed (mph)	Average Max Sustained Wind Speed (mph)	Average Peak Wind Speed (mph)	Average Wind Direction (degrees)	Average Precipitation (inches)
2018	January	5.1	21.90	9.17	168	0.18
	February	3.7	23.90	8.50	215	0.06
	March	3.8	21.00	8.95	209	0.09
	April	5.2	23.00	10.51	212	0.11
	May	4.9	18.10	8.28	304	0.00
	June	4.8	21.00	7.38	288	0.03
	July	5.4	21.00	8.72	300	0.00
	August	4.2	17.00	5.82	299	0.00
	September	3.9	17.00	6.49	275	0.04
	October	3.0	17.00	6.26	216	0.11
	November	4.1	23.00	10.29	205	0.08
	December	4.9	23.00	11.18	160	0.16
2019	January	4.2	25.10	10.29	150	0.09
	February	5.7	30.00	13.42	164	0.15
	March	4.6	25.90	13.65	163	0.05
	April	4.6	23.00	8.05	252	0.04
	May	4.3	21.90	6.26	253	0.05
	June	5.4	21.00	7.83	291	0.02
	July	4.7	21.90	7.83	283	0.03
	August	4.4	19.90	7.38	289	0.02
	September	3.5	16.10	6.93	247	0.14
	October	3.6	25.90	12.30	215	0.06
	November	3.0	28.00	10.74	178	0.05
	December	5.0	23.00	10.51	144	0.15
2020	January	8.2	23.90	12.75	183	0.24
	February	6.5	29.10	12.75	210	0.06
	March	6.5	28.00	16.78	219	0.08
	April	5.1	21.00	8.28	238	0.03
	May	4.5	25.10	12.53	244	0.09
	June	4.9	18.10	8.50	283	0.11
	July	5.2	18.10	7.83	298	0.00
	August	5.0	18.10	6.71	296	0.01
	September	4.0	32.00	17.00	214	0.04
	October	3.3	23.00	10.07	247	0.06
	November	3.9	25.90	8.50	202	0.18
	December	4.9	25.10	12.75	150	0.17
2021	January	4.7	31.10	10.51	153	0.24
	February	5.1	23.90	10.74	195	0.14
	March	4.1	28.00	9.40	234	0.05
	April	4.6	21.00	8.28	252	0.01

Year	Month	Average Wind Speed (mph)	Average Max Sustained Wind Speed (mph)	Average Peak Wind Speed (mph)	Average Wind Direction (degrees)	Average Precipitation (inches)
	May	5.4	23.00	8.50	278	0.03
	June	5.1	18.10	8.05	267	0.05
	July	6.3	18.10	8.05	301	0.00
	August	5.2	17.00	7.83	312	0.00
	September	4.2	19.90	8.28	266	0.13
	October	4.7	28.00	12.30	184	0.12
	November	4.6	25.10	8.95	181	0.22
	December	5.1	23.90	10.29	185	0.22
2022	January	4.4	21.90	10.96	183	0.15
	February	3.9	25.10	13.87	189	0.11
	March	4.0	18.10	8.95	238	0.09
	April	4.9	29.10	11.63	222	0.18
	May	4.4	19.90	7.83	266	0.13
	June	4.7	23.90	8.28	279	0.11
	July	5.7	16.10	7.61	285	0.01
	August	4.7	17.00	7.38	283	0.00
	September	4.1	25.90	10.96	268	0.02
	October	2.9	21.90	6.04	238	0.09
	November	5.0	28.00	13.20	182	0.18
	December	5.3	25.90	16.55	143	0.23
2023	January	4.8	31.10	12.97	167	0.11
	February	4.8	25.90	17.00	205	0.06
	March	5.3	23.90	12.30	176	0.15
	April	5.8	21.00	9.62	210	0.17
	May	4.9	23.90	7.61	266	0.03
	June	5.6	21.90	10.51	306	0.03
	July	5.6	17.00	7.83	305	0.00
	August	4.8	18.10	6.93	296	0.02
	September	4.0	18.10	7.38	263	0.04
	October	3.4	19.90	7.83	202	0.08
	November	3.7	17.00	9.17	199	0.17
	December	4.4	23.00	9.84	161	0.27
2024	January	5.7	25.90	10.96	145	0.31
	February	5.1	25.90	14.09	181	0.14
	March	4.5	28.00	10.29	205	0.10
	April	4.5	23.90	11.41	259	0.07
	May	4.7	21.00	8.50	272	0.08
	June	5.3	21.90	7.61	300	0.04
	July	5.5	19.90	8.05	289	0.00
	August	4.2	19.90	7.16	279	0.02
	September	3.3	16.10	5.59	285	0.02
	October	3.3	17.00	6.93	204	0.10

Year	Month	Average Wind Speed (mph)	Average Max Sustained Wind Speed (mph)	Average Peak Wind Speed (mph)	Average Wind Direction (degrees)	Average Precipitation (inches)
	November	4.2	23.00	11.18	167	0.22
	December	4.9	23.00	10.51	148	0.21