Large Coal Releases in Extreme, Difficult-to-Anticipate Events

By Michael Riordan, Ph.D., 106 Hilltop Lane, Eastsound, WA 98245

In two previous comments, #5517 and #7362, I discussed likely releases of coal into the waters of Cherry Point Aquatic Reserve and Georgia Strait during normal terminal operations. But these by no means include all possibilities. There are a variety of ways in which coal could enter these waters during events whose frequency or extent cannot be so reliably predicted. Such unusual events include the collisions and allisions of bulk coal carriers, hurricane-force winds at Cherry Point, and a powerful earthquake and resulting tsunami. Large and potentially catastrophic coal releases could occur during these and other extreme, difficult-to-anticipate events. Although they have low likelihoods and large uncertainties, such events cannot be ignored due to the tremendous adverse impacts they may have upon local marine ecosystems in the Cherry Point Aquatic Reserve, Georgia Strait, and around the San Juan Islands — where I live, love, work and paddle.

Collisions and Allisions of Bulk Coal Carriers

At about 1 a.m. on the morning of 7 December 2012, the bulk carrier Cape Apricot was attempting to dock at Westshore Terminals berth #2. Even though a licensed pilot was apparently aboard at the time, the carrier drifted wide of its mark and plowed through the causeway and conveyor belt linking Westshore's coal-storage facilities to its berth #1. The coal-conveyor system was completely severed in operation, while loading another carrier. About 300 to 400 feet of it was wiped out; somewhere between 30 to 120 tons of coal spilled into the waters of Georgia Strait near Roberts Bank before the system could be halted.[1] A video of the severed trestle and conveyor belt, taken at least six hours later, showed pulverized coal still streaming into the surrounding waters (see Fig. 1). The cause of this incident is under investigation by Canada's Surface Transportation Board, but it can only be due to one of — or a combination of — three possible reasons: gross human error, equipment malfunction, or severe weather conditions.

[1] See Gordon Hamilton and Tiffany Crawford, "Ship crashes into dock at Westshore Terminals, spilling coal into water," *Vancouver Sun*, 9 December 2012 , in which Terminals spokesman Ray Dykes estimated that one third of a railcar's worth of coal was lost, or 30 to 40 (short) tons. Other, later accounts put the coal losses at a full railcar, which could be up to 120 tons worth.

Figure 1. Aerial view of the severed Westshore Terminals causeway on 7 December 2012. (Credit: Christopher Reynolds, Global BC)

This unfortunate incident provides a graphic, extremely relevant example of what can — and is likely to — happen during the multi-decade lifetime of the proposed Gateway Pacific Terminal, should it be permitted to proceed. Pilots are human, sophisticated equipment fails, and weather conditions can unexpectedly worsen. According to a few nearby weather stations, southerly winds suddenly increased to over 20 mph between 1 and 2 a.m. that morning[2]; they could have driven a large carrier attempting to dock off course and into the trestle, especially if captain or pilot misjudgment was also involved.[3] Much stronger south and SSE winds will be encountered at Cherry Point (see my EIS comment #7362, on wind-blown coal dust from the proposed Cherry Point Terminal, Table 1), where gale-force winds often arise from October through April. If bulk carriers are not aided

[2] At the Sand Heads buoy (weather station CYVR) about 10 miles NW of Westshore Terminals, southerly winds increased from 16 to 25 mph between 1 and 2 a.m. At a Saturna Island station (CWEZ) about 17 miles to the SSE, they increased from 18 to 21 mph during the same period. At Sandy Point Shores about 20 miles away, south winds briefly exceeded 30 mph during that hour.

[3] The Westshore Terminals management has in fact claimed in a lawsuit that the Cape Apricot was operated "in a grossly negligent manner by her owners, pilot and crew." See Jenny Wagler, "Westshore Terminals files lawsuit after ship collision," *Business Vancouver*, 12 December 2012, available at: *http://gvweb.gl.atl.publicus.com/article/21021212/BIV0110/121219980/0/BIV020505.*

by tugs in docking and undocking, they can be blown into the wharf, other ships or possibly the coal-conveyor system, as may have happened at Westshore. (It is important to follow this accident and its resolution, to learn from the experience.) In a worst-case scenario, a large bulk carrier might even be driven into adjacent tidelands, spilling coal or leaking diesel or bunker fuel into Cherry Point Aquatic Reserve waters, which would be disastrous for the local marine ecology.

These few suggested examples of coal carrier collisions and allisions that might occur are meant only to be illustrative. They by no means exhaust all the possibilities for unusual accidents that could result in coal releases into Cherry Point waters. But because of the tremendous losses of coal (or diesel or bunker fuel) that can result from such incidents, they should be exhaustively modeled; stringent standards must be imposed in order to minimize chances that they may occur and spill large amounts of coal into the surrounding waters. For example, the wharf and the coal-delivery equipment on it should be able to withstand a Capesize coal carrier ramming into it at speeds up to 5 knots.[4] Given projections of almost 500 bulk carriers per year visiting the terminal, even a 0.1% chance of a Westshore-like accident would result in *one occurrence every other year*. That's far too often. Measures should be taken to reduce the likelihood of such incidents well below that level. One measure would be to permit docking to proceed only when the wind speed falls below a safe level, say 10 knots. But that would cause another major problem: strings of carriers anchored off shore, waiting for wind speeds to reach an acceptable level before docking. Records reveal that Cherry Point winds can arise unexpectedly and remain greater than 20 mph for days in winter.

Hurricane-Force Winds at Cherry Point

In my previous comment #7362, which focused on gale-force winds at Cherry Point, I noted that hurricane-force winds can occur in the vicinity every 5–10 years, according to UW meteorologists led by Clifford F. Mass who have

[4] According to elementary physics, however, a 200,000 ton Capesize carrier traveling at 5 knots would have an energy exceeding a gigajoule, or a billion joules; it would exert forces of about a billion newtons on the wharf. It is difficult to comprehend how any structure standing on stilts in 70–80 foot deep waters could withstand such a force and survive without extensive damages.

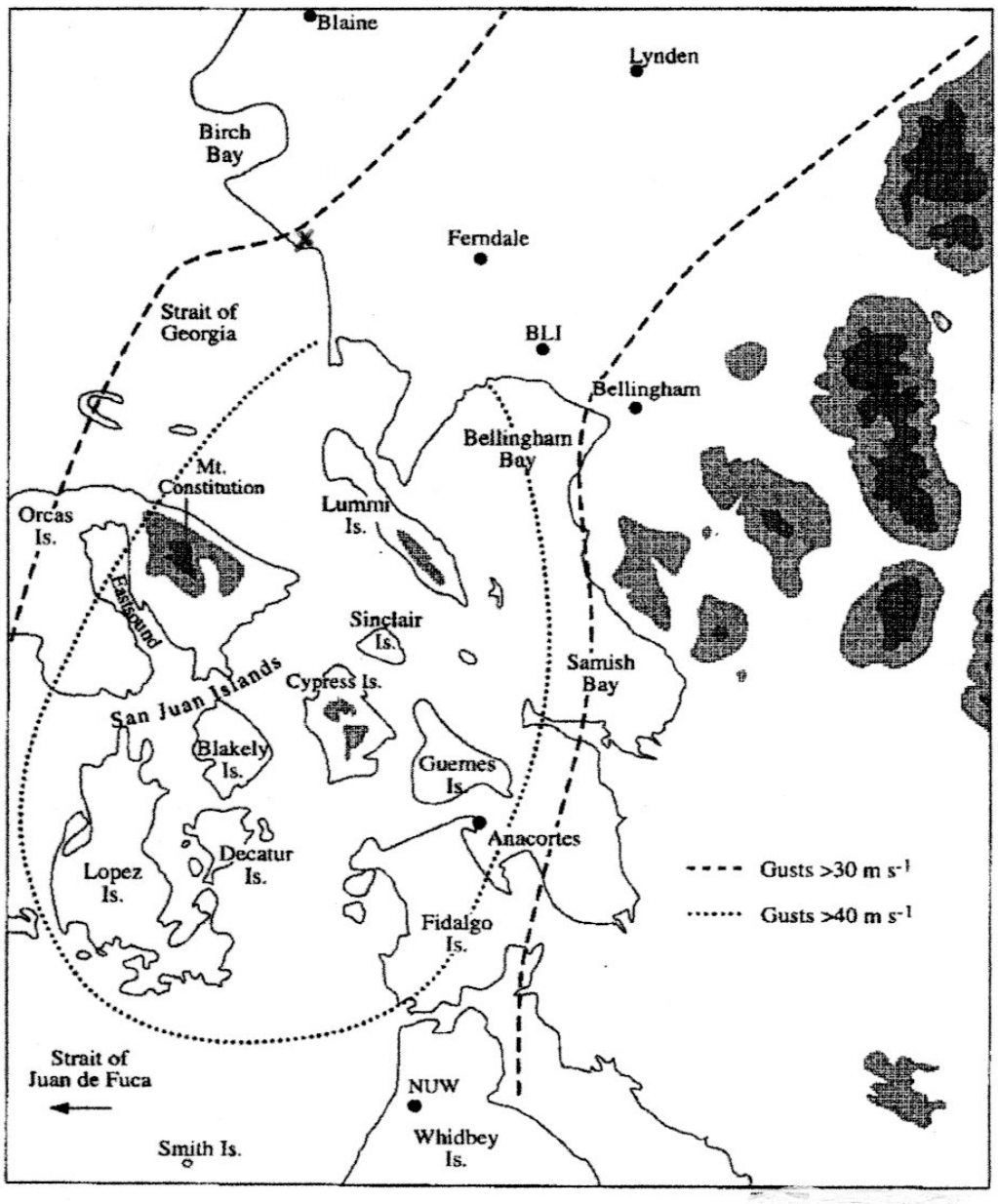

Figure 2. Hurricane-force Fraser Gap winds on 28 December 1990 (Source: Mass et al., reference 5). Cherry Point is located approximately at the "x" west of Ferndale.

examined these Fraser Gap winds.[5] They in fact occurred in 1983 and three times in 1990 — or four times in 20 years, at the high end of this frequency range. Mass and his colleagues have studied the most recent episode (see Fig. 2) in detail. On

[5] Clifford F. Mass, *et al.*, "A Windstorm in the Lee of a Gap in a Coastal Mountain Barrier," *Monthly Weather Review* (February 1995), pp. 315–331. See also Brian A. Colle and Clifford F. Mass, "Windstorms along the Western Side of the Washington Cascade Mountains," *Monthly Weather Review* (January 1998), pp. 53–71. For a general overview of Fraser Gap winds, see "The Fraser Gap Wind," available online at *http://cliffmass.blogspot.com/2009/01/fraser-gap-wind.html*.

28 December 1990, northeast winds exceeding 90 mph caused extensive damage in Whatcom and San Juan Counties, blowing down many barns, sheds and trees. Cherry Point sits within the area that experienced winds gusting over 30 meters per second — corresponding to 68 mph, or close to hurricane-force winds.

According to Mass and colleagues, such conditions can be expected to occur *several times* during operations of the proposed Gateway Pacific Terminal. The entire facility should therefore be designed to cope with extreme NE winds, if possible, in order to prevent or at least limit releases of coal into Cherry Point waters. In particular, the coal-conveyor belt over these waters and coal-delivery systems on the wharf must be able to withstand NE winds of 100 mph without major coal releases. Computer modeling of the aerodynamic lift and drag forces that occur in such winds, which are proportional to the *square* of the wind speed, will be required to fully understand the nature and strength of these forces upon coal-handling systems near the water. And since these extreme winds will also severely impact a bulk carrier docked at the wharf when they happen to arise, blowing directly against its broad port or starboard sides, procedures should be established in advance regarding how to deal with this event. Should the carrier be released from the wharf to weather the storm in Georgia Strait waters? This difficult decision should be made well in advance based on extensive, credible simulations of the possible adverse consequences of the available alternatives.

Such extreme NE winds will also severely impact the coal storage piles (or the covered storage facilities suggested in my comment #7362). A 100 mph wind exerts *over ten times* the forces experienced in a 30 mph wind, so their effects will be correspondingly greater. If open coal-storage piles are used, for instance, more than ten times as much coal dust will be blown into Cherry Point waters during such an event. If covered storage facilities are employed instead, they should be designed to survive hurricane-force winds, perhaps by building dome structures as used at the Hsin-Ta Fossil Power Station in Kaohsiung, Taiwan.[6] Whatever kind of storage is used in the proposed project, extensive computer simulations will be needed to understand these forces and the likely coal losses due to them.

[6] Victor Cavazos, "Coal Storage Domes for Taiwanese Power Company," (4 September 2008), available online at *http://www.powderandbulk.com.*

Earthquake and Tsunami Risks

The Pacific Northwest is one of the most seismically active regions in the contiguous United States, according to geologists and seismologists at the US Geological Survey. Especially worrisome is the potential of a magnitude 8 to 9 earthquake occurring in the near future along the Cascadia fault off Oregon and Washington coastlines.[7] According to the USGS estimates, ground accelerations of up to 3.2 meters per second-squared can be expected near Cherry Point if such a big megathrust earthquake occurs. A series of smaller faults from Seattle north to Vancouver can also lead to damaging earthquakes of magnitude 6 to 7, which could cause similar shaking in the Cherry Point vicinity. Based on experiences from the 1989 Loma Prieta and the 1994 Northridge earthquakes in California, major damage can occur many miles from the quake epicenter (e.g., collapse of the Cypress Freeway structure in Oakland) in areas characterized by minor faults or loosely compacted soils, which can liquefy due to the intense shaking. Thus the possible adverse impacts of such earthquakes — and a subsequent tsunami — must be addressed in the design and operating procedures of the proposed Gateway Pacific Terminal, especially given the potential for large coal releases into Cherry Point waters that can occur in such events.

During the back-and-forth ground motions that would occur in a major quake, the coal-conveyor belt extending over the water and the ship-loading system on the wharf will be especially vulnerable to resonant shaking that could cause these structures to collapse or plummet into the water, carrying with them all the coal then in transit. Thus their designs must include features to limit and damp out such resonance motions. In addition, the resonant frequencies of the coal-conveyor system, wharf, and ship-loading equipment may differ from one another, which could cause these structures to draw apart and thereby release significant amounts of coal into the water below. Finally, the wharf will probably vibrate substantially relative to the carriers being loaded at the time, introducing another likely mode of coal release.

[7] See, for example, Lori Tobias, "Big earthquake coming sooner than we thought, Oregon geologist says," *The Oregonian*, 19 April 2009, updated 23 March 2011. For scientific details, see Chris Goldfinger, *et al.*, "Turbidite Event History — Methods and Implications for Holocene Paleoseismicity of the Cascadia Subduction Zone," USGS Professional Paper 1661-F, 17 July 2012, available online at: *http://pubs.usgs.gov/pp/pp1661f/*.

The design and construction of the Gateway Pacific Terminal must pay careful attention to these probabilities, especially in the structures situated on or above Cherry Point waters. It will probably not be sufficient merely to engineer them according to standard building codes, given the potential adverse impacts of large coal releases during a major quake. Extensive computer simulations will be required to predict relative shaking and resonant behavior of these structures in the earthquake scenarios that have a fair probability of happening during the terminal lifetime.

Parallel studies should also be made of the local geology around Cherry Point, both on land and in near-shore underwater areas, to identify the locations of nearby faults or loose soils that could amplify local ground accelerations.[8] A recent peer-reviewed article identified two nearby active faults: the Sandy Point fault a few miles off shore of the proposed site, and the Birch Bay fault inland of it. According to the authors, "These faults are capable of producing earthquakes in the 6.0–6.5 moment magnitude range and may pose a seismic hazard to the lowland urban corridor between Vancouver, Canada, and Bellingham."[9] Impacts of these local geological features upon the ground motions at the terminal should therefore be included in the computer simulations and terminal design. These studies should also address the possibility that a megathrust Cascadia quake off the Oregon or Washington coast could trigger lesser quakes along the Birch Bay or Sandy Point faults, amplifying the overall impacts.

A large quake on the Cascadia or Seattle faults will likely be followed by a tsunami reaching Cherry Point 1 to 3 hours later and lasting several hours, as predicted in recent computer simulations by state and national agencies.[10] After a magnitude 9 Cascadia earthquake, for example, waters will rise by up to 2 meters

[8] According to Dr. Gary Greene, a marine geologist (and former Director of Moss Landing Marine Laboratory) who has been studying the sea floor around the San Juan Islands (and submitted EIS comment #5913 on possible impacts of coal on forage fish), the North Puget Sound area is laced with previously little-known faults that could sustain signifiant earthquakes. One of these faults, the recently discovered Skipjack fault, wraps around Sucia Island north of Orcas Island and may extend toward Cherry Point. Gary Greene, personal communication, 16 January 2013 email.

[9] Harvey M. Kelsey, *et al.*, "Holocene faulting in the Bellingham forearc basin: Upper-plate deformation at the northern end of the Cascadia subduction zone," *Journal of Geophysical Research*, Vol. 117, B03409 (2012); quote on p.26.

[10] Timothy J. Walsh, *et al.*, "Tsunami Hazard Map of the Bellingham Area, Washington: Modeled Tsunami Inundation from a Cascadia Subduction Zone Earthquake," WA Division of Geology and Earth Resources Open File Report 2004-15 (June 2004).

at Sandy Point Shores, only four miles SSE of Cherry Point.[11] Similar tidal waves can be expected to occur at the coal-terminal wharf, with currents sloshing back and forth at up to 3 knots. Unless measures are taken to counteract such abrupt changes, a bulk carrier could be torn from its moorings at the stationary wharf — or rammed into it — by the surging waters. Large coal releases from the vessel and delivery system would be likely to occur. If the carrier is overturned, coal losses would be disastrous, in the thousands of tons. Because the probability of a magnitude 8 to 9 Cascadia earthquake and its resulting tsunami occurring in the possible terminal lifetime exceeds 10 percent according to recent analyses,[12] the Gateway project should not be allowed to proceed unless demonstrably effective measures and procedures are implemented to deal with this eventuality.

Smaller tsunamis are also possible in the Cherry Point area. According to marine geologist Gary Greene, large rock slides have occurred in the past from the steep cliff face along the northeast shore of Orcas Island, probably resulting in tsunamis, which can happen again.[13] As this shore is located about 10 miles from Cherry Point, with no islands intervening, any such tsunami would hit the terminal in minutes, without warning. In addition, a tsunami could result from an undersea quake along the Birch Bay or Sandy Point faults.[14] It would strike the wharf and any vessels docked there without much warning, since it would arrive less than a minute after the quake erupted. It is difficult to perceive what possible mitigations could be helpful in such a locally generated tsunami.

Studies and Actions Requested

Although some of these extreme events may have low probabilities of occurring during the anticipated terminal lifetime, perhaps a few percent or so, the chances of a major earthquake and tsunami impacting it are on the order of 10 percent, and it is virtually *certain* that hurricane-force winds will eventually

[11] Preliminary figures from an updated simulation currently being conducted by NOAA and the WA Division of Natural Resources. Timothy J. Walsh, email communication 16 January 2013.
[12] Goldfinger *et al.*, "Turbidite Event History" gives a 21% probability of an M8 quake in 50 years; for an M9 quake corresponding to a full rupture of the Cascadia fault, the probability is 7–12%.
[13] Gary Greene, email communication, 16 January 2013.
[14] According to Kelsey *et al.*, "Holocene faulting," an M6 or greater earthquake along the Birch Bay fault "could deform the seafloor and generate tsunami, especially given that the western part of the Birch Bay fault is offshore." Quote on p. 23.

lash the facility.[15] Thus I respectfully request that the following questions be addressed in the Environmental Impact Statement prepared for this project:

1. What are the chances that a bulk carrier will collide with the wharf, the coal-delivery system, or another vessel during a typical year of operations? (What, in fact, happened in the 7 December 2012 Westshore incident, including causes and amount of coal released?) How many tons of coal will likely enter Cherry Point waters in such accidents? What mitigations and procedures — for example, requiring tug assistance in *all* cases and prohibiting carrier dockings when wind speeds are high — can be adopted to lower the chances of such collisions and the ensuing associated releases of coal?

2. What is the probability that hurricane-force winds will occur at Cherry Point in a given year? What will be their likely impacts upon the coal-delivery system, the bulk carriers docked at the wharf, and the coal-storage facilities? How many tons of coal may be released into Cherry Point waters in such an event, from both the delivery system and storage piles, if used? How much further into Georgia Strait will coal dust travel, both on the winds and in the waters, during such extreme winds? What measures or procedures can be implemented to lessen the chances of such releases and reduce their amounts? What procedures can be established for bulk carriers docked at the wharf to follow during extremely wind events to minimize the chances they will also release coal into Cherry Point waters?

3. What are the chances that a magnitude 6 or greater earthquake, whether on the Cascadia fault, the Seattle fault, or the faults north of Seattle, will occur during the lifetime of the terminal? What are the probable impacts of the corresponding ground shaking on the parts of the coal-delivery system located over the water? What amounts of coal are likely to be released into Cherry Point waters during these seismic events? What measures can be adopted and procedures enforced to reduce these coal losses and mitigate the likelihood that they will occur?

4. In the event of such a major earthquake, whether on the Cascadia fault, Seattle fault, or the faults north of Seattle, what are the likely tsunami scenarios that can

[15] If the annual average probability for hurricane-force winds at Cherry Point is 15 percent, for example, the chances they will happen during a 30-year terminal lifetime exceed 99 percent.

be expected to occur at Cherry Point? If measures are not adopted to prevent or mitigate their impacts, what are the likely releases of coal that will occur during these tsunamis, both from the coal-delivery system and the bulk carriers being loaded at the time? What measures can be adopted and procedures required — such as undocking vessels from the wharf — to reduce the chances of major coal releases during such events? What measures, if any, can be adopted to lessen the chances of and reduce the amount of coal released in locally generated tsunamis?

5. What are the probable impacts upon marine life in the Cherry Point Aquatic Reserve and Georgia Strait of the large releases of coal that are likely to occur in the extreme events outlined in this document? What are the probable cumulative impacts, especially upon forage fish, bottom feeders and eelgrass beds of all such coal releases, when added to the potential coal releases during the ship-loading process and due to wind-blown coal from the storage piles and other operations? How much further into Georgia Strait and the Salish Sea will suspended particles of coal drift due to currents and winds, and what sea-floor accumulations can be expected to occur within 10 miles of the terminal? In the event of a large release of coal during such extreme events, including but not limited to those outlined in this comment, what measures can be taken to remove a portion of it from the sea floor? What fraction of the coal so deposited can be removed without further disturbing the sea-floor ecosystem and the marine life present therein?

Thank you for your serious consideration of these questions and impacts, which I — and many others — consider highly significant. Without satisfactory resolutions of these important questions, the proposed Gateway Pacific Terminal project should not be permitted to proceed.