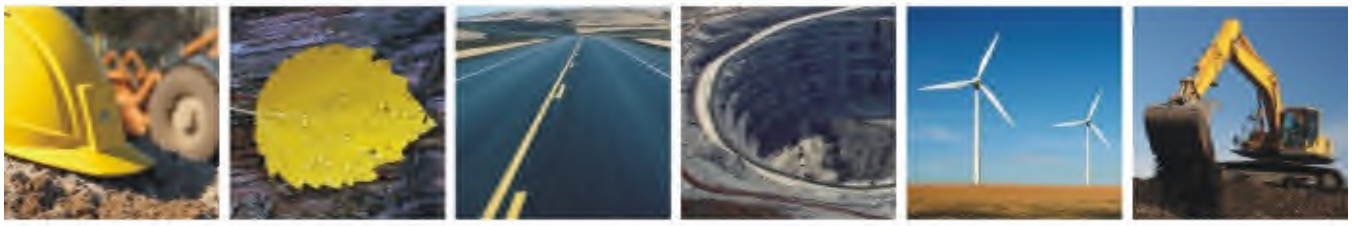
TRANS MOUNTAIN PIPELINE ULC

METEOROLOGICAL AND OCEANOGRAPHIC DATA RELEVANT TO THE PROPOSED WESTRIDGE TERMINAL SHIPPING EXPANSION



REPORT

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EXECUTIVE SUMMARY

Kinder Morgan has proposed an expansion of the Westridge Marine Terminal, located in Burrard Inlet east of Second Narrows, to increase the quantity of crude oil shipped through the Terminal. EBA Engineering Consultants Ltd., operating as A Tetra Tech Company (EBA), was engaged by Kinder Morgan Canada to assemble, organize and summarize relevant oceanographic and meteorological data to support the navigational, environmental, risk assessment and oil spill modelling studies that are required for permitting and design of terminal and shipping route.

The environmental parameters that will be utilized in the required studies include wind, air temperature, humidity, solar insolation, visibility, precipitation, water level, water salinity and temperature, current and wave climate. Data and information with respect to these parameters are obtained from sources ranging from government agencies to research organizations and universities.

The data presented in this report are divided into five main sections along the potential shipping route (Burrard Inlet, Strait of Georgia, Gulf and San Juan Islands, Juan de Fuca Strait, and Pacific Ocean) between the Pacific Ocean and the Westridge Terminal at Second Narrows. The data will be used in other studies to determine potential hot spots for shipping accidents, formulate oil spill scenarios and estimate potential environmental damage. This information will also be useful in strategizing the ship traffic management and scheduling in order to minimize accidents.

Hourly metocean data from 29 met stations and six buoys throughout the study area is presented in this report with analyses of the observed patterns. Wind roses for all 29 meteorological stations and time series plots of hourly winds for 2011 are contained in Appendix A. Wave roses for all six buoys are contained in Appendix B. Time series plots of hourly air temperature, dewpoint and visibility for 2011 are illustrated for each station in Appendix C. Hourly data files are contained on the data disk accompanying this data report.

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1.0 INTRODUCTION

Kinder Morgan has proposed an expansion of the Westridge Marine Terminal, located in Burrard Inlet east of Second Narrows, to increase the quantity of crude oil shipped through the terminal. EBA Engineering Consultants Ltd., operating as A Tetra Tech Company (EBA), was engaged by Kinder Morgan Canada to assemble, organize and summarize relevant oceanographic and meteorological data to support the navigational, environmental, risk assessment and oil spill modelling studies that are required for permitting and design of terminal and shipping route.

The environmental information and data pertinent to the required studies cover a wide range of meteorological and oceanographic parameters that include wind, air temperature, humidity, solar insolation, visibility, precipitation, water level, water salinity and temperature, water current and wave climate. These data are collected by an extensive network of coastal meteorological and buoy stations at various locations in the Strait of Georgia and Juan de Fuca Strait and on the shelf in the northeast Pacific Ocean, off the west coast of Vancouver Island.

Understanding the local weather and environmental conditions is crucial in assessing risks to the proposed marine shipping, especially during periods of less-than-ideal environmental conditions. This report will present and describe the aforementioned data, primarily along the potential shipping route, in support of various studies including the determination of areas where shipping accidents may have a higher probability of occurrence, and the formulation of spill scenarios for the oil trajectory modelling. These data will also be used as inputs for the hydrodynamic and oil trajectory modelling.

2.0 STUDY AREA AND SHIPPING CORRIDOR

The study area includes Burrard Inlet-Vancouver Harbour, the Strait of Georgia, Juan de Fuca Strait and the Pacific Ocean adjacent to Vancouver Island and Juan de Fuca Strait (Figures 2.1 through 2.4). The shipping corridor between the Trans Mountain Terminal and the open ocean can be divided geographically into five sections: 1) Burrard Inlet; 2) the Strait of Georgia; 3) the San Juan and Gulf Islands; 4) Juan de Fuca Strait; and 5) the northeast Pacific Ocean, adjacent to Vancouver Island, out to a distance of 12 nautical miles from shore. Along this entire corridor, the Canadian Coast Guard has established a traffic routing system. A significant component of this system is pairs of one way lanes and separation zones that are shown on nautical charts, and on Figures 2.1 through 2.4.

The shipping corridor begins at the terminal east of the Second Narrows, and heads through Burrard Inlet into Vancouver Harbour and through First Narrows into English Bay. The route then veers to the south, rounding Point Grey and continues along the eastern edge of the deep water areas in the Strait of Georgia off Sturgeon Bank. The route turns to the southeast near Sand Heads and continues the same bearing to the entrance of Boundary Pass near Saturna Island.

From Boundary Pass, two shipping routes to Juan de Fuca Strait are defined. The main corridor heads through Boundary Pass and Haro Strait and then follows the coastline of Vancouver Island past Discovery Island, Esquimalt, Royal Roads and Constance Bank, entering the Juan de Fuca Strait near Race Rocks. An alternate, somewhat longer, shipping route runs through Rosario Strait.

The route then follows the thalwag of Juan de Fuca Strait before entering the Pacific Ocean between Carmanah Point on Vancouver Island and Cape Flattery in Washington State.

2.1 General Meteorological and Oceanographic Conditions

2.1.1 Meteorology

In general, upper level wind patterns in the study area are the result of the relative positions of the Aleutian Low, which is located over the Gulf of Alaska and the Aleutian Islands, and the North Pacific High, located between Hawaii and California. The counter-clockwise circulation around the low and the clockwise circulation around the high produce a general westerly upper-level flow onto the Southern Coast of British Columbia.

At the surface, the two major pressure systems, the Aleutian Low and the North Pacific High, drive a general circulation characterized by southeasterly winds in the winter, and northwesterly winds in the summer. Additionally, migratory low and high pressure systems move through the area, producing day-to-day changes in weather and wind patterns. Low pressure systems can develop off-shore, more frequently during the winter, either originating from the Gulf of Alaska or as rapidly forming Coastal Lows, referred to as "Coastal Bombs" (Murty et al., 1983) because of their short time scale and high intensity winds. Ahead of these systems, strong south-easterly winds and rain are produced. Often, as the cold front passes, a second band of winds occur, originating from the west or northwest. These northwesterly winds can be particularly strong in spring and occasionally in summer as high pressure begins to rebuild and winds are funnelled down the Strait of Georgia (EC 1999). Often, there are few indicators of the onset of these winds.

On occasion during the winter, outflows occur as cold arctic air deepens over the interior of British Columbia and flows through the Coastal Mountain passes out over coastal waters. Such events can produce very strong localized winds, particularly through Howe Sound, but are generally infrequent events on the South Coast.

Typically during the summer, the presence of high pressure off the coast and a thermal low over the interior produce a general northwesterly flow. Winds are typically light and are replaced by strengthening onshore winds later in the day as a result of land-sea heating differences. These onshore winds produce inflow winds through Juan de Fuca Strait and Howe Sound. The occasional migration of the thermal low between the coast and the interior produces fluctuations between outflows which are gradual (migration west) and inflows (migration east) which can form abruptly.

Thunderstorms are infrequent in the study area, but form with very strong winds and dissipate quickly.

Wind patterns in this coastal region are complicated due to the mountains and coastal topography and the land-sea contrast. Topography heavily influences the winds by restricting and steering horizontal movement and can lead to hazardous conditions in passes or channels and in the vicinity of headlands and islands. During the passage of a storm, a particular location may experience rapid changes in wind direction and wind speed. The descriptions of winds provided hereinafter are informed by the general discussions in Thomson (1981) and two Environment Canada publications (Lange 1998 and 2003), as well as the data that is included in this report.

Precipitation (rain or snow) varies greatly throughout the region as a result of the topography. Precipitation in the region is generally associated with frontal systems, however ascending flow due to horizontal convergence of northwesterly and southeasterly winds over the Strait of Georgia can also lead to precipitation. The amount of precipitation is much higher on the windward (western) side of the

mountains where air is forced to ascend. Conversely, precipitation is typically lower on the leeward (eastern) side. As a result, relatively low amounts of precipitation fall over areas in the rain shadow of the Olympic Mountains in the eastern part of Juan de Fuca Strait, the southern part of the Strait of Georgia and the San Juan and Gulf Islands (Figure 2.5). The largest precipitation events occur during the passage of winter storms and during 'Pineapple Express' events, when persistent southwesterly flows bring warm and very moist air from the tropics or subtropics.

Fog, of varying degree, can form from a number of processes throughout the area of the study, affecting some areas more than others. Fog is most common at the western entrance of Juan de Fuca Strait between July and September (Section 4.5). Fog can also form over land, particularly in harbours, in the early morning and drift over the water under a light breeze. This type of fog dissipates in the sun quickly. Intense precipitation reduces visibility and can create fog by saturating the air. Fog can also form over water when high pressure builds in the region during winter when winds are light, particularly when the region is under the influence of a temperature inversion.

2.1.2 Oceanography

Patterns of currents and waves differ to various degrees from one area to another, due to the complexity of the physiographic, oceanographic and hydrographic settings. Currents are driven by the interaction of freshwater drainage from land, precipitation, the salty waters which originate from the Pacific Ocean, tidal fluctuations, winds and other physical processes. The general description of circulation and wave climate provided in this document is based on Waldichuk (1957), Thomson (1981), Labrecque (1994), Masson (2005).

Wave fields in the study area depend on local wind patterns as well as the degree and direction of exposure to wave attacks. Swell propagating from the Pacific Ocean also plays a major role in governing the wave climate in Juan de Fuca Strait and the Pacific Ocean off the west coast of Vancouver Island.

Water level and its fluctuations vary from one location to another as a result of the complex processes that are involved in the tidal wave propagation. Added to the tidal fluctuations in water level is storm surge, the difference in elevation between the observed water level and the predicted tidal water level resulting from disturbances propagating in from the open ocean, usually coupled with air pressure gradients. The specific information about water level at various locations provided herein is based on tide books and hydrographic charts published by the Canadian Hydrographic Services (CHS).

3.0 OBSERVATIONAL DATA

3.1 Meteorology and Wave Climate

Within the study area, 29 meteorological stations located near the coast were considered as representative of wind conditions over the water. Additionally, there are seven weather and wave buoys, two of which are operated by the National Oceanic and Atmospheric Administration (NOAA) and five are operated by Environment Canada. The locations of the representative buoy and coastal stations in the study area are shown in Figure 3.1.

There is a high density of stations along and in areas adjacent to the shipping corridor. Stations located in the northern part of the Strait of Georgia and off the northwest coast of Vancouver Island provide boundary conditions for modelling as well as assistance in indicating temporal and spatial patterns in wind behaviour associated with various meteorological events.

Although Environment Canada sites their stations in the most exposed location possible, coastal stations are inevitably subjected to shielding effects from the surrounding land which diminish or completely block winds from a particular direction. Shielding effects are discussed in more detail where required in Section 4.

Table 3.1 shows the parameters measured by each meteorological station. Table 3.2 shows the period of record of wind data measurement for each station. Table 3.3 shows the period of record of visibility measurement for the six stations with visibility data. Tables 3.2 and 3.3 do not indicate how complete the data is within a particular year, just that data was collected for at least part of that year. The data record appears quite short for many long-term stations. We assume that earlier data did not meet Environment Canada's current data quality standards, and for that reason is now withheld.

Table 3.1 indicates a limited availability of visibility data which may be problematic as there are extended periods of fog that can occur in these waters, especially in fall and winter. In the absence of such data, the dew point depression – the difference between the air temperature and the dew point temperature – may be used as an indicator of fog and hence, visibility. The dew point temperature, which can also be directly derived from relative humidity, is the temperature at which air has to be cooled to become saturated. The smaller the dew point depression, the closer is the air to reaching saturation, and thus to fog.

3.1.1 Winds

Regional wind patterns are considerably different in winter than in summer. To provide a more concise description of wind patterns, the data and its description hereinafter have been divided into winter (from October to March) and summer (from April to September).

A bivariate analysis of hourly wind data from each station was performed to determine the frequency of occurrence of winds originating from one of 16 cardinal directions at a particular speed range, for both summer and winter. The results of the analyses are presented in a summary table and shown graphically for each station and season as a wind rose in Figures A.1 through A.72 in Appendix A. The seasonal wind roses for Vancouver International Airport, located just onshore of the central portion of Georgia Strait, are also presented in Figures 3.2 and 3.3, as an example of the wind seasonality. The direction indicates the origin of the wind. The line thickness and colour, represents the percentage of time winds blew from that direction at a particular speed interval. Blue shades, which make up the majority of observations in Figures 3.2 and 3.3, indicate lower wind speeds. Green, orange and red shades are much less frequent and indicate higher wind speeds.

Appendix A also contains time series plots of wind speed and direction for all stations for the year 2011 (Figures A.73 through A.97). The year 2011 was selected because it represented the year with the most complete data set from the entire station network. The plots are meant to offer a general idea of the typical variation in winds at a particular location during the year and illustrate the temporal pattern of the predominant winds depicted in the wind roses. The 2011 time series for Vancouver International Airport is

shown in Figure 3.4 as an example. The stick plot in the upper panel illustrates the speed and direction to which the wind was blowing. The wind speed and direction are also shown as individual plots in the middle and lower panels.

The hourly wind data is contained in files representing the entire record for each station on the data CD provided with this report.

3.1.2 Waves

Hourly wave data are recorded by Environment Canada and NOAA buoys in the Strait of Georgia (Sentry Shoal and Halibut Bank), Juan de Fuca Strait (New Dungeness and Neah Bay) and the shelf waters of the northeast Pacific Ocean, off Vancouver Island (La Perouse Bank, South Brooks and East Dellwood). The locations of the buoys are shown in Figure 3.1. At each location, a bivariate analysis of the wave data was conducted to determine the predominant wave direction, presented in the form of a wave rose in Figures B.1 through B.14 in Appendix B. At all stations but Neah Bay and New Dungeness, non-directional wave sensors were deployed, and hence wave direction is absent from the data record. For this report, wave direction is inferred from the wind direction recorded at each location.

The wave climate at all buoys exhibits a very strong seasonality, mostly due to the seasonal changes in wind pattern. This is exemplified by the seasonal wave roses at Halibut Bank in the Strait of Georgia, presented as an example, which illustrate an inferred northwest predominance in summer (Figure 3.5) and a strong southeast predominance in winter (Figure 3.6).

In addition, frequency analyses were conducted on the wave height and direction data, according to the methodology developed by Goda (1988), to determine the return-period of a particular wave event (significant wave height and peak period). Significant Wave Height (Hs) is traditionally defined as the average of the highest 1/3 of the waves over a suitable averaging period, typically 20-30 minutes. Because of the specific nature of wave statistics, Significant Wave Height can also be determined as four times the square root of the variance of the wave spectrum, generally a simpler analysis. The Peak Period (Tp) is the period corresponding to the highest point in the wave energy versus frequency diagram. The Extreme Wave Height is about two times the Significant Wave height, although that ratio is not exact, and is geographically dependent.

The results of the analyses are shown in Tables 3.5 through 3.10. It is interesting to note the wide range of wave properties at different locations. At Halibut Bank, the two dominant directions, southeast and northwest, are characterized by 200-year storms of 5.2 m Hs and 9.0 s Tp, and 5.8 m Hs and 8.5 s Tp respectively. At East Dellwood, in the Pacific Ocean, Hs ranges up to 16.5 m, and Tp ranges up to 16.9 s.

3.1.3 Other Meteorological Parameters

Time series plots of air temperature and dew point temperature (also referred to as dewpoint) (Figures C.1 through C.23) and visibility (Figures C.24 through C.28) for 2011, are provided in Appendix C for coastal stations with available data. Figures 3.7 and 3.8 show an example of these plots: the 2011 time series observed at the Vancouver International Airport.

Hourly data files containing the aforementioned parameters, as well as relative humidity, mean sea level pressure and cloud opacity and amount are contained on the data CD.

3.2 Currents

Recent near-surface current data in the study area obtained from the Institute of Ocean Sciences (IOS) are summarized in terms of measurement depth, year and location in Table 3.4. Figures 3.9 through 3.12 illustrate the data contained in these files, showing time series for near-surface currents recorded in the Strait of Georgia, Haro Strait and Juan de Fuca Strait. In a similar fashion as the wind time-series plots, the top panel illustrates the direction and magnitude of the current, while the lower two panels show these variables individually.

Continuous CODAR (Coast Ocean Data Acquisition Radar) measurements are currently being collected and archived by the University of Victoria in the Strait of Georgia, near the mouth of the Fraser River. CODAR data are available on the website of the VENUS coastal network (http://venus.uvic.ca/data/data-archive/). Figure 3.13 depicts a snapshot of surface current velocity vectors derived from CODAR data. This snapshot corresponds to about two hours before high tide, i.e., towards the end of an ebb. The velocity field shows a general ebb flow, with some river influence along the Sand Heads Jetty. Winds were about 8 m/s from the south-southwest, and don't appear to be having a significant influence on surface currents. The geographic extent of the CODAR data is limited to the area just off the mouth of the Fraser River. However, since hourly maps of surface currents are available, the data will be very useful for validating oil spill models.

3.3 Water Properties

The physical properties of water within the Georgia Basin are complex, resulting from the interaction of freshwater inputs from rivers with the intrusion of salty waters from the Pacific Ocean, in addition to other physical processes. Numerous measurements of water temperature and salinity were made by various institute and research agencies, such as the IOS, the University of British Columbia, and the University of Victoria's VENUS and NEPTUNE underwater observation programs. Typical summer (solid line) and winter (dashed line) profiles of water temperature (Figures 3.14 and 3.15) and salinity (Figures 3.16 and 3.17) for various locations in the Georgia Basin are presented. The most striking aspect of these figures is the strong halocline near the surface in the Strait of Georgia and Burrard Inlet in the summer, a consequence of the large Fraser River flow. The resulting density stratification allows a similarly-patterned thermocline to develop in the summer in the Strait of Georgia and Burrard Inlet. The summer thermocline is considerably weaker in Juan de Fuca Strait, because it lacks the density stability that the Fraser River runoff provides directly to the Strait of Georgia. Boundary Pass and Haro Strait profiles are nearly uniform in the vertical, indicating the high rates of vertical mixing in these areas, resulting from the turbulence associated with the strong tidal currents that occur in these passes.

Of particular importance, temperature and salinity profiles in the Strait of Georgia off the mouth of the Fraser River exhibit a large degree of spatial and temporal variability depending on proximity to the river mouth, the river discharge, and the stage of tide, of which the latter two affect the behaviour of the Fraser River plume in the Strait (Stronach, 1977 and Thomson, 1981).

It should be noted in Figures 3.15 and 3.17 that the temperature and salinity profiles taken off Vancouver Island in the Pacific Ocean (blue solid line) in summer show a very thin mixed layer near the surface. This type of profile is typical after a few days of calm winds when solar insolation can establish thermal stratification near the surface. During a storm, the energy from the wind leads to mixing of waters, typically to a depth of tens or even hundreds of metres, resulting in the formation of a mixed layer with

more or less a uniform temperature and salinity profile. This process of wind mixing is illustrated by the progressive deepening of the upper layer during a storm event shown by the temperature profile plots in Figure 3.18 obtained at Ocean Station 'Papa', located about 1,300 km west of Vancouver Island.

3.4 Water Levels

Water levels fluctuate as a result of the combined influences from tides and surge. Tidal levels at a particular location have a regular periodicity and can be predicted from a set of harmonic constants specific to the location. Surge, on the other hand, varies with local weather and atmospheric conditions and is much more difficult to predict. Observed water levels are measured at tide gauges established at various coastal stations on the British Columbia coast. Along the shipping corridor, there are three tidal stations with long term records: Point Atkinson, Vancouver Harbour and Victoria. Water levels at Point Atkinson and Vancouver Harbour are very similar due to their proximity.

With the observed and predicted water levels known, surge – which is essentially the difference between the observed water level and the predicted tidal water level – can be calculated. Figures 3.19 and 3.20 present the observed (red) and predicted (black) water levels in the lower panel, and the calculated surge in the upper panel for the month of December 1982 at Point Atkinson and Victoria, respectively. This month was selected for presentation as the largest recorded surge occurred on December 16 of that year, reaching almost 1.0 m.

Table 3.11 summarizes the historical extreme water levels in the study area. The highest water level ever recorded at Point Atkinson occurred on December 16, 1982. On the same date, the water level at Victoria, although not the highest ever recorded, was much higher than the predicted level due to the greatest historical storm surge.

4.0 SYNTHESIS OF ENVIRONMENTAL CONDITIONS

4.1 Burrard Inlet

4.1.1 General Oceanographic Descriptions

Burrard Inlet is a glacier-carved fjord that runs east from the Strait of Georgia to Port Moody (Figure 4.2). The inlet is approximately 27 km long, bounded by the North Shore Mountains along its north shore and elevated terrain along the south shore of the inner harbour. The outer harbour is much wider and less constrained. This topographic alignment results in a predominantly east-west wind pattern through the inlet: Figures A.25 and A.26 (Point Atkinson); Figures A.53 and A.54 (Vancouver Harbour). Easterly winds are frequent year-round with westerly winds occurring more often in summer than in winter. Generally, wind speeds are greater in winter, however this is less observable in the inner harbour (Figures A.53 and A.54).

Tides in the inlet, similar to almost the entirety of the Strait of Georgia, are dominated by mixed, mainly semi-diurnal variations that display a distinct semi-diurnal inequality, that is, the range in successive high-low water pairs varies from day to day, due to the declination of the moon in its orbit of the earth. The tidal range increases only slightly eastward from Point Atkinson to Point Moody by 0.03 m.

Surface currents in the inlet are mostly tidally driven, especially in the inner basin of the inlet, east of the First Narrows. In the outer basin, influences from the Fraser River plume and wind forcing can modify the temperature and salinity structure as well as surface currents (Thomson, 1981).

Burrard Inlet receives considerable amount of freshwater from the Fraser River and, to a lesser extent, local runoffs from surrounding rivers (Seymour River, Lynn Creek, Capilano River and the Buntzen Powerhouse outflow into Indian Arm) and streams. These freshwater inputs lead to the formation of a multi-layer system in the inlet with fresher, less-dense waters near the surface and saltier, more-dense waters at depth.

Following the pattern of predominant winds, wind-generated waves in Burrard Inlet align east-west most of the time. Other waves can be generated locally, primarily boat wakes. Under certain conditions, particularly during calm periods, these non-wind-generated waves can be more significant than wind-generated waves.

4.1.2 Meteorology

The North Shore Mountains have a strong steering effect on the local winds through Burrard Inlet. The prevailing winds in the winter are easterly (Figures A.26 and A.54), and are less intense in the inner harbour, due to the proximity to land and the friction effects of the buildings of urban Vancouver. Winter winds at Vancouver Harbour have exceeded 6 m/s only 4.7% of the time, compared to 10% of the time at Point Atkinson.

Winter easterlies experienced through the inlet are typically southeasterly winds which are steered in advance of approaching frontal systems and on occasion can result from the northern extension of outflows from the Fraser Valley or from Indian Arm. These outflow winds are not as frequent nor as strong as the outflows through Howe Sound (Figure A.20) which spill into Georgia Strait and the western portion of the outer harbour of Burrard Inlet. Easterlies can also develop from drainage winds (the flow of dense air cooled over the valley slopes) at any time of the year.

During the summer, westerlies are more common as northwesterly winds over the Strait of Georgia are enhanced and drawn east near the mouth of Burrard Inlet when combined with the onshore sea breeze. The increase in frequency of westerly winds is very evident in the wind roses for Vancouver Harbour (Figure A.53) and Point Atkinson (Figure A.25), however easterly winds still dominate at the latter.

Fog can occur in Burrard Inlet when cold air draining from the neighbouring valleys settles into Burrard Inlet under light winds or calm conditions and reaches saturation over water. Fog, which occurs more often in fall and winter in Burrard Inlet, especially when high-pressure or inversions build over the region, is a much less common occurrence than in the more open waters of the Strait of Georgia and Juan de Fuca Strait.

4.1.3 Westridge Terminal (Second Narrows) – First Narrows

This section runs from the Trans Mountain Westridge Port terminal, located west of the Second Narrows Bridge, to the First Narrows. This part of Burrard Inlet is the enclosed, inner harbour, surrounded almost completely by land with only a narrow connection at the First Narrows to the outer harbour.

4.1.3.1 Tides and Water Level

The mean water level in Vancouver Harbour is 3.1 m above local Chart Datum (CD) with higher high water 5.0 m above CD and lower low water 0.1 m below CD. Typical tidal range varies from 3.3 m for mean tides to 5.1 m for large tides. With storm surge, water levels can increase by as much as 1.1 m relative to the predicted tide level (Table 3.11).

4.1.3.2 Currents

Surface currents in the area are mostly tidally driven, modulated by storm winds and outflows from Seymour River. Depending on the stage of the tide, funnelling effects can lead to very swift currents at First and Second Narrows which can attain a speed of 3.0 m/s during flood and ebb tides (FOC-1, 2012). The location of maximum current at the Second Narrows, as a result of adjustment to the pressure gradient at different tide stages, does not remain stationary; it typically shifts to the seaward side of the Second Narrows Bridge during ebb tide and to the inland side of the bridge during flood tide (EBA, 2011). Tidal currents, in terms of speed and direction, can vary significantly depending on the stage of the tide. Details of the tidal currents, divided into hourly stages of the tide, can be found in 'Vancouver Harbour Tidal Currents Atlas' (Canadian Hydrographic Services, 1981).

4.1.3.3 Wave Climate

No waves of appreciable significance can be generated by the local winds due to the limited fetch for wave development within the inner harbour of Burrard Inlet. In Vancouver Harbour, waves generated by moving vessels and float planes can be of similar, if not larger height, than wind-generated waves. Long-period swell-like waves can sometimes propagate through the First Narrows but dissipate rapidly to the east in the inner harbour. Very steep and dangerous waves can develop near and seaward of the First Narrows when combined with strong westerlies during ebb tides (Thomson, 1981).

4.1.4 First Narrows – Burrard Inlet Entrance

Westward of the First Narrows is the outer harbour of Burrard Inlet, defined as the water body between Point Atkinson to the north and Point Grey to the south.

4.1.4.1 Tides and Water Level

The mean water level is 3.1 m above local CD with higher high water 5.1 m above CD and lower low water at CD. Typical tidal range varies from 3.2 m for mean tides and 5.1 m for large tides. With storm surge, the largest measured range of water level fluctuation is 6.0 m (FOC-1, 2010) with high water at 5.6 m above CD.

4.1.4.2 Currents

During flood tides, the northerly flowing tidal stream in the Strait of Georgia enters Burrard Inlet with a northeasterly flow towards the First Narrows. Meanwhile, the freshwater plume originating from the Fraser River outflow deflects to the north as it enters the Strait of Georgia (Section 4.2.3) and enters the inlet due to both the flood current and Coriolis Force (Thomson, 1981). The flooding flow can attain a maximum speed of 0.25-0.5 m/s, producing a clockwise gyre in the area between Point Grey and Stanley Park, while a counter-clockwise gyre is formed at the north side of the basin, between Ambleside and Point Atkinson.

The main feature of the circulation pattern during ebb tide is the relatively concentrated and strong ebb flow that develops and often extends from the First Narrows to Point Atkinson. Combined with winds and the associated waves from the west, this ebb flow can generate very steep and dangerous rips along the north shore especially in the nearshore areas immediately east of Point Atkinson.

4.1.4.3 Wave Climate

This area is exposed to locally wind-generated waves and swells that are developed as they propagate across the Strait of Georgia. The semi-enclosed configuration of the water body limits the amount of wave energy entering Burrard Inlet and therefore offers mild protection from wave attack from the Strait of Georgia (Thomson, 1981). There are no long-term wave observation data available in this area. Short-term data were collected off West Vancouver in Burrard Inlet over a 17-month period from 1973 to 1974 (Thomson, 1981). Statistical analysis shows that roughly 12% of significant wave heights and 27% of maximum possible wave heights are above 0.33 m, and 0.5% of significant wave heights and 3% of maximum wave heights are above 1 m. During the 17-month period, the largest significant wave height and maximum wave height measured were approximately 2.0 m and 1.3 m respectively. Wave period is highly variable and it spans a wide range of 7 s.

4.2 Strait of Georgia

4.2.1 General Oceanographic Descriptions

The Strait of Georgia is a semi-enclosed water body that has a northwest to southeast orientation and is approximately 220 km long and 30 km wide on average (Figures 3.1, 4.2 and 4.3). The Strait receives freshwater runoff from the Fraser River and other smaller rivers and streams from the mainland and the east coast of Vancouver Island. Salt water from the Pacific Ocean enters the Strait through several long and narrow channels to the north and through wider channels between the San Juan and Gulf Islands from the Juan de Fuca Strait to the south (Waldichuk, 1957).

Predominant wind patterns vary seasonally as a result of the migration of the Aleutian Low and the North Pacific High (Section 2.1) and spatially as a result of the local topography. In general, the predominant winds in the Strait are from the southeast in winter and northwest in summer, however the passing of frontal systems through the region leads to frequent short-period deviation from these patterns. In the southern half of the Strait, the orientation of the various channels and passes dictate the wind direction on a local scale.

The tidal wave propagates into the Strait of Georgia through the Juan de Fuca Strait from the south and is reflected at its northern end, creating a standing wave pattern that strengthens slightly towards the north. Tides in the Strait are mixed and mainly semi-diurnal. Due to the sheer size of the area, the time of arrival of high tide and low tide vary depending on location, but the time difference between any two locations does not typically exceed 30 minutes (Thomson, 1981 and FOC-1, 2012).

The interaction between freshwater and salt water leads to a distinct multi-layer system in almost all parts of the Strait, albeit with temporally and spatially variable temperature and salinity gradients and, therefore, stratification stability. Most of the seasonal variations occur in the upper, fresher layers while the lower layers remain relatively stable. The lower layers do possess significant internal movements however, notably the movement of medium salinity water southward to become the surface outflow in Juan de

Fuca Strait, and the intrusion of saltier water near the bottom. This is the annual process of bottom water replacement as saline water intrudes from the Pacific along the Juan de Fuca Strait and into the Strait of Georgia.

Water in the Strait of Georgia varies in temperature and salinity depending on the season and depending on proximity to the Fraser River. In winter, the Strait of Georgia receives cold, fresh runoff from the Fraser River, therefore the lowest temperature and salinity in the upper layers are often found near the Fraser River mouth. In summer, lenses of relatively warm and fresh water in the upper layers are often associated with a large amount of warm Fraser River outflow during the annual freshet. In the lower layers, water temperature and salinity vary only slightly from season to season. Temperatures in the deeper waters remain relatively low throughout the year, typically below 10°C, although they are often colder in summer by 0.5 to 1°C, a result of summer upwelling along the coast of the Pacific Ocean, the cold water moving slowly into the bottom waters of the Strait of Georgia.

Wind-generated waves in the Strait are variable, depending on location. Locally wind-generated waves generally propagate in the direction of the predominant wind: from the southeast in winter and from the northwest in summer. Reflection, refraction and diffraction, however, continually modify the wave angle of approach as the waves shoal in shallow waters.

Navigational hazards in the Strait result from strong winds and waves interacting with the tidal stream. The Fraser River plume can also contain logs and trees, especially during freshet.

4.2.2 Meteorology

In addition to the general flow pattern, strong southeasterly winds occur over the Strait of Georgia when a front is approaching from the northwest or the west. Typically, these southeasterly winds start to develop first over the northern part of the Strait, gradually moving south as the front approaches the coast. Northwesterlies commonly develop behind the cold front as the system moves over the mainland.

During the winter, these systems are frequent and can produce high winds. During the summer, frontal systems are less intense, and the related winds are lighter, however northwesterlies behind the front can develop without much indication and be quite strong (Section 2.1.1). Large-scale circulation during the summer typically produces a northwesterly flow, with stronger onshore winds developing later in the day when the background wind is light.

On occasion, winter outflow winds pour into the Strait of Georgia, particularly from Howe Sound. Wind speeds exceeding 20 m/s can occur over the Strait during strong outflow events when northerly outflow winds converge with easterly outflows from the Fraser Valley, reaching as far as Saturna Island. Land breeze (or drainage winds), which develop due to night-time radiational cooling differences in the summer, produces light easterlies during the evening.

The seasonal wind roses at Sand Heads (Figures A.33 and A.34) illustrate these patterns. Its location at the end of the Steveston North Jetty exposes it to winds from all directions. Winter winds are more frequently stronger. Northwesterlies are more common in the summer, while easterlies and southeasterlies are more common in the winter. Stronger winter winds are also evident at Vancouver International Airport (Figures A.55 and A.56), however this is much less apparent for easterlies and southeasterlies due to friction over the land.

Fog is not a common occurrence, particularly in summer, however visibility can become reduced due to precipitation. Fog transported by westerly winds through Juan de Fuca Strait (discussed in Section 4.5.2) in late summer and early fall can occasionally reach the southern portion of the Strait of Georgia (EC 1999).

4.2.3 Point Grey – Sturgeon Bank – Sand Heads

4.2.3.1 Tides and Water Level

The mean water level at Sand Heads is 3.0 m above local CD with higher high water 4.9 m above CD and lower low water at CD. Typical tidal range varies from 3.1 m for mean tides and 4.8 m for large tides. Storm surge in the area can reach 1.1 m for positive surge and -0.6 m for negative surge (EBA 2011). Beside tidal effects and storm surge, the local water level can also be affected by flow from the Fraser River.

4.2.3.2 Currents

Currents in the area are the result of the combined influences of the Fraser River plume, the stage of the tide and the Coriolis force. In general, during flooding stage, the tidal wave propagating northward establish a downward water surface slope and therefore form a pressure gradient up the Strait, resulting in currents flowing north, parallel to the coastline, off Sturgeon Bank. During the flooding tide, water flowing from the Fraser River generally makes a broad turn to the north upon exiting the river at Sand Heads due to the northern flowing tidal stream as well as the Coriolis force. A clockwise gyre may develop over the waters off Sturgeon Bank as a result. During an ebbing stage, the opposite occurs: currents off Sturgeon Bank flow south, parallel to the shoreline. Instead of aligning with the tidal stream, the Fraser River outflow often keeps its flow direction at the mouth and continues to head southwest across the Strait, reaching as far as the Gulf Islands, as a result of a balance between the forcing from the tidal stream, the momentum and buoyancy of the river plume and the Coriolis force. Typically, the alongshore tidal stream reaches a velocity of 0.5-0.75 m/s. The outflow velocity of the Fraser River at the mouth can reach 2.5 m/s at low water during a large tide.

During slack water, when the tidal stream is weak or non-existent, winds can drive the surface current to approximately 1.0 m/s in accordance with the wind direction (Thomson, 1981).

4.2.3.3 Wave Climate

This area is exposed to wind-generated waves developed in and propagating along and across the Strait of Georgia. Waves approaching the mainland may further increase in height due to the steepening effects from the opposing current from the north arm of the Fraser River. There are no long-term wave observation data available for this area. Short term data were collected off Sturgeon Bank over a period of 26 months between 1974 and 1976 (Thomson, 1981). Analysis of the data shows that 39% of significant wave heights and 60% of maximum possible wave heights are above 0.33 m, and 4% of significant wave heights and 13% of maximum wave heights are above 1 m. During the entire period of measurement, the significant wave height did not exceed 2.7 m and the maximum wave height was always less than 4.0 m.

Wave period is variable at this location, but it tends to trend longer with wave height. A significant wave height of 0.5 to 1.0 m typically has a wave period of 5 s. Waves with a significant wave height up to 2.5 m typically have a wave period of 7 to 8 s. The longest probable wave period measured is 9 s (Thomson, 1981).

Dangerous rips have been observed near the Fraser River mouth during periods of strong winds from the west or northwest, especially during high flow season. Waves generated in this particular situation are further amplified by the rapid shoaling of the bottom bathymetry near the river mouth.

For comparison purposes, the results of the extreme event frequency analysis of waves at Halibut Bank are presented in Table 3.5 (refer to the summer and winter wave roses for Halibut Bank in Figures 3.5 and 3.6 respectively).

4.2.4 Sand Heads – Roberts Bank – Saturna Island

This section covers the large exposed area from the mouth of the main arm of the Fraser River, along Roberts Bank, past Tsawwassen and Point Roberts, to Saturna Island.

4.2.4.1 Tides and Water Level

The mean water level at Tsawwassen is 3.0 m above local CD with higher high water 4.8 m above CD and lower low water 0.1 m above CD. Typical tidal range varies from 3.0 m for mean tides to 4.7 m for large tides (FOC-1, 2012). Storm surge in the area can reach 1.1 m for positive surge and -0.6 m for negative surge (EBA 2011). Besides tidal effects and storm surge, the local water level can also be affected by flows from the Fraser River.

4.2.4.2 Currents

Near Roberts Bank, the tidal streams flow northwesterly during flood tide, and southeasterly during ebb tide (Section 4.2.3.2). Near Saturna Island, the effects of Boundary Pass, a major channel connecting Juan de Fuca Strait and the Strait of Georgia, becomes apparent as the currents during ebb tide turn to align with the orientation of the channel. During flood tide, the tidal streams coming out of Boundary Pass continue northeast then turn to the north and northwest as the currents enter the Strait of Georgia. During ebb tide, the opposite occurs as the northwesterly current funnels into Boundary Pass and gradually changes bearing to align with the tidal current. Tidal currents in the section near Roberts Bank typically attain a speed of 0.5 to 1.0 m/s. Tidal currents are stronger near Saturna Island as they funnel into or emerge from the narrow channels of the Gulf Islands and San Juan Islands and can reach 1.5-2.0 m/s, especially during flood tide.

4.2.4.3 Wave Climate

An analysis of the 26-month long wave measurement period between 1974 and 1976 shows that the wave climate is similar to but slightly less energetic than that at Sturgeon Bank (Thomson, 1981). Approximately 38% of significant wave heights and 62% of maximum possible wave heights are above 0.33 m, and 4% of significant wave heights and 10% of maximum wave heights are above 1 m. During the entire period of measurement, the significant wave heights did not exceed 2.1 m and the maximum wave heights were always less than 3.3 m.

The area near Saturna Island is exposed to waves developed by the down-Strait winds from the northwest. Very high and steep waves have been observed to form in rips during high winds from the northwest, coincident with flood tide, when waves are opposing the tidal currents (Thomson, 1981).

The observed wave periods are similar to those described in Section 4.2.3.3.

4.3 San Juan and Gulf Islands

4.3.1 General Oceanographic Descriptions

The San Juan and Gulf Islands are located at the junction of the Strait of Georgia and Juan de Fuca Strait (Figure 2.3). The islands together form a complicated network of channels of various lengths and widths. For ships travelling between the Pacific Ocean and the Port of Vancouver, the route along Boundary Pass and Haro Strait is normally used. However if this route is closed due to an accident or poor visibility, an alternate route through Rosario Strait is used.

The general wind patterns in this area are similar to those described for the Strait of Georgia in Section 4.2.2, however in winter, a small-scale enclosed anti-clockwise circulation pattern develops resulting in a typical northeasterly flow pattern along the southwest coast of Vancouver Island. This area also experiences strong summer inflows from the Juan de Fuca Strait as a result of the onshore flow cycle which develops off the mainland during the daytime. Wind direction is heavily influenced by channel orientation and wind speeds will vary from location to location due to shielding effects.

Mostly tidally driven currents in these channels can be very fast and become erratic when combined with waves and wind forcing, posing severe navigational hazards to vessels. Turbulence and eddies often form in the area, and vigorous tidal mixing of the top fresh layer water with the salty water at the bottom occurs as a result.

In general, water temperature decreases in summer and increases in winter toward Juan de Fuca Strait. Salinity increases regardless of season from the Strait of Georgia towards Juan de Fuca Strait due to the increasing proximity to the Pacific Ocean.

The numerous islands results in a small fetch for wave development reducing the likelihood of formation of large waves. Wakes originating from passing vessels however, can become as significant as wind-generated waves.

4.3.2 Meteorology

Some of the strongest winds in the region are the southeasterlies which occur in advance of a front during winter and originate from Puget Sound. The strong predominance of strong southeast winds recorded in winter at Smith Island (Figure A.46) and New Dungeness Buoy (Figure A.72) are indicative of this. The enclosed counter-clockwise circulation pattern which commonly develops over the area in winter results in a high occurrence of northeasterlies along the southeast coast of Vancouver Island. These winds flow through the island channels, changing direction with channel orientation through Boundary Pass and the northern part of Rosario Strait and are exemplified in the winter wind roses for Discovery Island (A.12) and Kelp Reefs (Figure A.22). They occur slightly more frequently than the general southeasterly circulation pattern but are much less intense.

Although divergence in this air flow near Port Angeles typically produces an easterly flow through Juan de Fuca Strait during the winter, westerly winds can also develop depending on the direction with which a frontal system approaches the coast. Westerly winds can become the dominant flow direction for a period of time depending on the easterly shift of the Aleutian Low. These strong westerlies are observed in the winter wind roses for Smith Island and New Dungeness Buoy (Figures A.46 and A.72). When they occur, these westerlies are steered northward through Haro Strait, resulting in strong southerly winds.

Northerly winds occur through Boundary Pass, Haro Strait and Rosario Strait when the northwest winds blowing over the Strait of Georgia are stronger than the winds in Juan de Fuca Strait, preventing the latter to enter Haro Strait from the south. The northerly winds in Boundary Pass and Haro Strait are mostly fed by northwest winds from the channels of the Gulf Islands, and are weaker than the northeasterly winds originating from the outflow winds (Lange 1998).

Winds with diurnal variation are typical for the summer season. Boundary Pass, Haro Strait and Rosario Strait lie where northwest winds over the Strait of Georgia meet southwesterly winds from Juan de Fuca Strait. As the sea breeze intensifies off-shore of the mainland later in the day, southwesterlies from Juan de Fuca Strait become stronger and are steered through the various channels and passes into the Strait of Georgia. This pattern is observed in the summer wind roses with a strong predominance of southwesterly winds at Discovery Island (Figure A.11) and Saturna Island (Figure A.37), southerly winds at Kelp Reefs (Figure A.21), westerly winds at Smith Island (Figure A.45) and southerly winds at Bellingham International Airport and Cherry Point (Figures A.3 and A.7).

Summer winds are light rarely exceeding 9 m/s.

Fog banks from over the coastal ocean and transported by westerly winds through Juan de Fuca Strait (discussed in Section 4.5.2) can reach this area and areas further up-Strait in late summer and early fall.

4.3.3 Boundary Pass

The northeast entrance to Boundary Pass is between Saturna Island and Patos Island. The seaward entrance is between Moresby Island and Stuart Island.

4.3.3.1 Tides and Water Level

The mean water level at Tumbo Channel, near the northeast entrance to Boundary Pass is 2.6 m above local CD with higher high water 4.8 m above CD and lower low water 0.1 m above CD. Typical tidal range varies from 3.0 m for mean tides and 4.7 m for large tides (FOC-1, 2012). Storm surge in the area further modifies the water level.

4.3.3.2 Currents

The entrance to Boundary Pass can have very erratic current patterns that result from the interaction of the tides with waves and local bathymetric features. Except during periods of slack water, tidal currents in the pass largely follow the channel alignment and can reach 1.5 m/s on an ebb tide and 2.0 m/s on a flood tide (CHS, 2005).

4.3.3.3 Wave Climate

Boundary Pass is protected from wave attacks developed in both the Strait of Georgia and Juan de Fuca Strait. The limited wind fetch in the Pass makes it impossible to generate waves of any significance. Ship wakes and waves generated by turbulent motions of water are the other types of waves present in the area.

4.3.4 Haro Strait

The waters between Moresby Island and Stuart Island mark the northern entrance to Haro Strait, which runs south-southeasterly between the Gulf Islands on the Canadian side and the San Juan Islands on the US side.

4.3.4.1 Tides and Water Level

The mean water level at Sidney is 2.0 m above local CD with higher high water 3.6 m above CD and lower low water 0.2 m below CD. Typical tidal range varies from 2.4 m for mean tides and 3.8 m for large tides (FOC-1, 2012). Storm surge in the area further modifies the water level.

4.3.4.2 Currents

Similar to the tidal currents in Boundary Pass, tidal currents in Haro Strait, except during periods of slack tide, largely follow the channel alignment and can reach 2.0 to 3.0 m/s on an ebb tide (CHS, 2005; Thomson, 1981; FOC-3, 2012). As in many tidal systems, currents during slack tide are weak and spatially relatively incoherent.

4.3.4.3 Wave Climate

Wind fetch in most parts of the Strait is rather limited and narrow, except near the southern end where wave attacks approach from Juan de Fuca Strait from the southwest and southeast. Wave conditions near the southern end of Haro Strait are illustrated in the wave roses at New Dungeness (Figures B.13 and B.14). The return periods of waves at New Dungeness are presented in Table 3.6.

4.3.5 Rosario Strait

Rosario Strait is narrower than Boundary Pass and Haro Strait. The northern entrance to Rosario Strait is at the extreme southern end of the Strait of Georgia, near the northern tip of Lummi Island, about 20 km southeast of the entrance to Boundary Pass. Rosario Strait then meanders in a general southern direction before entering the eastern basin of the Juan de Fuca Strait near Lopez Island and Whidbey Island.

4.3.5.1 Tides and Water Level

The mean water level at Bellingham is 1.6 m above local CD with higher high water 3.1 m above CD and lower low water 0.8 m below CD. Typical tidal range varies from 2.6 m for mean tides and 3.9 m for large tides (FOC-1, 2012). Storm surge in the area further modifies the water level.

4.3.5.2 Currents

Currents in Rosario Strait are mostly tidally driven. Tidal currents, except during periods of slack tide, largely follow the channel alignment and can reach 3.6 m/s during peak ebbing and flooding stages. During flood tides, the tidal stream tends to split around Cypress Island and rejoin south of Sinclair Island. (Thomson, 1981).

4.3.5.3 Wave Climate

The waters in Rosario Strait are protected from wave attacks from Juan de Fuca Strait and the Strait of Georgia by the San Juan Islands. The limited wind fetch make generation of waves of any significance impossible. Ship wakes and waves generated by turbulent motions of water are the other types of waves present in the area.

4.4 Juan de Fuca Strait

4.4.1 General Oceanographic Descriptions

Juan de Fuca Strait (Figure 2.4) is a long and narrow water body, bounded by Vancouver Island to the north and the Olympic Mountains to the south, connecting the Pacific Ocean to the Strait of Georgia. The Strait is 160 km long from Tatoosh Island on the Pacific Ocean side to Whidbey Island at its eastern end. The width varies from 25 km near the Pacific entrance, to 18 km at its narrowest point between Race Rocks and Angeles Point to 40 km eastward of Dungeness Spit and Discovery Island. The main bathymetric feature in the Strait is the sill, located in the general area between Esquimalt and Dungeness Spit, separating the deep basin to the west and the relatively shallow basin to the east.

Tides consist of mixed, semi-diurnal fluctuations with two high waters and two low waters daily. As is observed almost everywhere else in the Georgia Basin, the tidal signals display semi-diurnal inequality as a result of the relative contributions from the diurnal and semi-diurnal tide constituents. The tidal range decreases from the Pacific entrance to Victoria, and increases further east. As well, the tidal range is generally larger on the US side of the Strait than on the Canadian side. Both of these spatial patterns are a consequence of the Coriolis force on the propagation of the tidal wave.

Currents in Juan de Fuca Strait are the result of the combined influences from tidal, wind and estuarine processes. Tidal currents typically increase in speed from the Pacific entrance to Discovery Island. Due to the confined and narrow nature of the Strait, currents are typically in alignment with the general east-west orientation, with little rotary motion between flood and ebb tides. Exceptions to this trend can be found in the eastern portion where, during flood tide, the currents turn to align with the passages through the San Juan and Gulf Islands that lead to the Strait and, during ebb tide, residual flows originate from strong tidal currents in these same passages that intrude into the Strait. To a smaller degree, back eddies, deflection and expansion flows caused by irregularity of the coastline also contribute to deviation from the general current direction.

Circulation patterns characteristic of estuarine processes are apparent. In summer, there is a well-defined two layer system, with an outflow of fresher water occupying the top part of the water column, and an inflow of saltier water in the bottom part. This two-layer flow has a significant cross-channel structure, with the top layer being much thicker on the Canadian side than on the US side, a consequence of the Coriolis force.

Directly exposed to the relatively cold waters of the Pacific Ocean, water temperatures in most areas of the Juan de Fuca Strait, with the exception of a few pockets of protected bays and harbours, remain cold year-round. Strong tidal mixing in the passes and channels to the east constantly exchanges heat between the top and bottom layers. It is difficult to accumulate or even retain heat gained from solar heating in the surface layer. Therefore, regardless of season and depth, the water temperature rarely exceeds 13°C. Salinity generally increases towards the Pacific Ocean, especially at depths below 100 m when salty Pacific Ocean waters intrude, reaching as far east as the sill.

The wave field consists of seas generated by local winds and swells originating from distant locations in the Pacific Ocean which propagate into the Strait. Waves are generally higher near the mouth than in the inner basin. Two wave measuring buoys have been installed in the Juan de Fuca Strait, one in the mouth close to the Pacific Ocean (Neah Bay) and one in the inland section near Victoria (New Dungeness).

4.4.2 Meteorology

The prevailing winds in Juan de Fuca Strait exhibit strong seasonality, typically originating from the east during winter and from the west during summer. The wind roses in the western part of the Strait at Sheringham Point (Figures A.41 and A.42), Tatoosh Island (Figures A.49 and A.50) and Neah Bay (Figures A.69 and A.70) and in the eastern part of the Strait at Race Rocks (Figures A.31 and A.32) exemplify this strong seasonal trend. Wind speeds during the winter are more frequently higher at the exposed Pacific entrance of the Strait, exceeding 12 m/s over 20% of the time at Tatoosh Island, but are moderated away from the open ocean further up-Strait.

The predominance of easterlies during the winter are primarily the result of the aforementioned divergence of air flow down the Juan de Fuca Strait. These winds accelerate towards the mouth of the Strait, resulting in the high wind speeds observed for easterlies at Tatoosh Island. These winds are particularly strong on the rare occasions when the front approaches from the west or southwest. Being located at the exposed seaward entrance to the Strait, Tatoosh Island also experiences very strong southerly coastal winds which are less frequent in winter than in summer, but much stronger (Figure A.50).

Post-frontal westerlies vary in direction depending on the path of the system. It should be noted that westerly winds can be extremely dangerous, not only because of their strength, but also because of the suddenness of their onset (Lange 1998).

In summer, westerly winds are extremely predominant, due in part to the aforementioned compensation for the onshore air flow. These winds have a diurnal variation, becoming stronger during the late afternoon (sometimes exceeding 18 m/s; Figure A.31) and weakening during the night. Juan de Fuca Strait acts as a conduit for near-surface air which pushes from the Pacific High to areas of low pressure that develop over the interior of British Columbia.

The summer wind rose for Sheringham Point (Figure A.41) is a very good example of these winds. The magnitude of these summer westerlies increases down-Strait, illustrated by a higher frequency of more-intense summer winds at Race Rocks (Figure A.31). Further east, the winds fan out (airflow divergence) and weaken eastwards of Race Rocks as the Strait widens. This is illustrated in the summer wind roses for Port Angeles (Figure A.27), New Dungeness buoy (Figure A.71) and Discovery Island (Figure A.11). Closer to the coastline, the wind also has the tendency to flow towards land due to the effect of the local sea breeze.

4.4.3 Discovery Island – Race Rocks

Exiting Haro Strait, the shipping corridor turns to the southwest and follows the coastline of Vancouver Island, past Discovery Island, Esquimalt, Royal Roads and Race Rocks.

4.4.3.1 Tides and Water Level

The mean water level at Clover Point, located between Esquimalt and Discovery Island, is 1.9 m above local CD with higher high water 3.4 m above CD and lower low water 0.03 m above CD. Typical tidal range varies from 1.9 m for mean tides and 3.2 m for large tides (FOC-1, 2012). Storm surge in the area further modifies the water level.

4.4.3.2 Currents

Currents are significantly tidally driven, repeating the flood and ebb cycles semi-diurnally. The tidal currents flow northeast on a flood tide and southwest on an ebb tide. At maximum ebb and flood tides, the tidal currents typically reach 3.0 m/s, especially near Discovery Island and Race Rocks on the seaward side. Between these islands and the main part of Vancouver Island, tidal currents can reach as high as 3.8 m/s.

Currents in the Strait are also under the influence of winds and estuarine processes, although not as strongly as tides. Data from the measured record revealed the non-tidal currents flow towards the Pacific Ocean and can reach a maximum speed of 0.4 m/s in summer. In winter, non-tidal flows reverse in direction and can attain a speed of 0.5 m/s (Thomson 1981).

Tidal streams around Discovery Island form heavy rips, with easterly winds and choppy waves adding to the hazard (EC 1999).

4.4.3.3 Wave Climate

The wave field in the Strait is a consequence of the combined effects of swells and locally wind-generated waves. In the inland section of the Strait, the waters are more protected from wave attacks from the open Pacific Ocean, hence smaller wave heights. However, swells from the ocean can still enter and propagate along the Strait. When winds and waves counter the heavy tide rips which occur at Race Rocks, steep chaotic seas can be produced (EC 1999).

The wave climate in this area is measured at a wave buoy located near New Dungeness. The wave roses (Figure B.13 for summer; Figure B.14 for winter) show that waves typically approach from the southwest and west directions, likely due to westerly winds combined with the constant oncoming of swells from the Pacific Ocean. In winter, waves from the southeast become more significant.

Wave height, wave period and direction are measured at the wave buoy at New Dungeness. Table 3.6 details the results of the extreme event frequency analysis of the measured waves at New Dungeness.

4.4.4 Race Rocks – Neah Bay

From Race Rock to the Pacific entrance near Tatoosh Island, the Strait runs in a west-northwest alignment for approximately 100 km with a width ranging from 22 to 28 km.

4.4.4.1 Tides and Water Level

The mean water level at Point No Point, approximately 60 km from the Pacific entrance, is 1.9 m above local CD, with higher high water 3.6 m above CD and lower low water 0.34 m above CD. Typical tidal range varies from 2.0 m for mean tides and 3.2 m for large tides (FOC-1, 2012). At Neah Bay near the Pacific entrance, the mean water level is 1.3 m above local CD, with higher high water 3.3 m above CD and lower low water 0.6 m below CD (CHS, 2002).

4.4.4.2 Currents

The ebb and flood currents reach 1.3 m/s near Point No Point and 0.75 m/s near the Pacific entrance (Thomson, 1981). Otherwise, the general behaviour of the currents and the estuarine circulation processes are similar to what is described in Section 4.4.1.3.

4.4.4.3 Wave Climate

The wave field in this section of the Strait is the result of the combined effects of the short-period, locally generated wind-waves and long-period swells propagating from the Pacific Ocean. Near the Pacific entrance, waves from the ocean dictate the wave climate and greatly outnumber the waves approaching from the east. This is illustrated in Figure B.11 and B.12, showing the summer and winter wave roses, respectively, for the wave buoy located near Neah Bay. Table 3.7 details the return-period significant wave heights at the buoy.

4.5 Northeast Pacific Ocean

4.5.1 General Oceanographic Descriptions

The prevalent wind directions vary in accordance with the relative positions and strengths of the Aleutian Low and the North Pacific High. In winter, the Aleutian Low strengthens and migrates south, resulting in winds blowing over the open ocean in a counter-clockwise direction around the low pressure centre. In summer, the North Pacific High strengthens and advances north, resulting in winds blowing over the open ocean in a clockwise direction around the high pressure centre. Deviations from these open ocean wind patterns occur near the coast, mainly as a result of the blocking effect of the coastal topography. Deviations also occur during the passage of weather systems. These systems and the associated winds are generally stronger in winter and weaker in summer.

Currents are driven by tidal and non-tidal processes. Tidal streams are only significant near points of land, coastal bays and inlets as the strength of tidal current usually diminishes and non-tidal processes predominate away from the mainland seaward of the continental margin. Tidal currents typically flow northward during a flood tide and southward during an ebb tide. The non-tidal processes include freshwater-salt water interactions and synoptic ocean currents driven by prevalent winds and differential solar heating of the oceans. One of the main oceanographic phenomena in this region is the upwelling of deep cold waters along the coast driven by wind-generated currents with northwest winds in summer.

Unlike waves in the inland waters, waves in the open ocean are often much larger and higher in height. The open ocean offers tremendous depth and long fetch to support significant wave growth. Additionally, long period swells, propagating from many distant locations in the ocean, are able to further heighten the local wave field.

4.5.2 Meteorology

In winter, the typical counter-clockwise direction of air flow results in southwesterly winds over the offshore waters in the area. A scenario that emerged from ship observations is the combination of these southwest winds with the prevailing easterly winds blowing out of Juan de Fuca Strait in the vicinity of Vancouver Island to generate prevailing southeast winds in the area (Thomson 1981). This scenario is supported by the winter wind rose at La Perouse Bank (Figure A.64). Typically, southeast winds develop over the coastal waters off Vancouver Island in advance of approaching fronts. Representative of this are the high frequency of occurrence of strong southeasterly winds recorded at South Brooks (Figure A.66). However, the worst conditions in winter are usually associated not with the prevailing winds but with strong westerly winds developing behind fronts.

Winds are generally weaker in summer; predominantly from the northwest following the large scale, clockwise flow pattern around the North Pacific High, located to the west. The land topography also plays a role in steering these winds. Sea fog is frequently found in this area, especially close to the entrance to Juan de Fuca Strait. It persists over long periods of time from July to early September and owes its existence to the presence of cold waters in the region. Fog diminishes when the surface ocean water experiences an anomalous increase in temperature, during El Nino years for instance. Whenever onshore winds develop, offshore sea fog is pushed into the Juan de Fuca Strait, occasionally reaching as far as the southern Strait of Georgia and Vancouver (Klock 2000). Fog decreases in density and frequency of occurrence eastwards along Juan de Fuca Strait.

A common occurrence from May through September is the onshore (or marine) push of cool and cloudy marine air into Juan de Fuca Strait after a period of above-normal temperatures. The increased temperature of the near-surface air causes the surface pressure to drop and allows for the California low-pressure area to extend northwestward reaching southwestern British Columbia. This extension is accompanied by a tongue of cool coastal air that moves northward along the Oregon and Washington coast and generates a band of high pressure just offshore the coast. The onshore push starts when the low-pressure area moves eastwards along with high pressure east of it. When fog does not form in Juan de Fuca Strait during onshore pushes, visibility is still reduced due to the high humidity of the marine air combined with its content of salt particles.

4.5.3 Entrance to Juan de Fuca Strait – Exclusive Economic Zone Boundary

Upon exiting Juan de Fuca Strait, the shipping route leads to the northeastern part of the Pacific Ocean. This area is characterized by a continental margin that has a relatively shallow shelf (50-150 m depth) bordering the mainland, deepening waters across the continental slope about 90-100 km west from the mouth of Juan de Fuca Strait and deep water regions in the open ocean with depths exceeding 2000 m. Submarine canyons, which play a significant role in the oceanography of the Georgia-Fuca system are one of the most prominent features in the area.

Leading from the exit of Juan de Fuca Strait, before entering international waters, the route transits the Exclusive Economic Zone (EEZ). The EEZ of Canada along the coast of BC, defined by the United Nations Convention on the Law of Sea, extends 200 nautical miles or 370 km from the low water mark along the coast.

4.5.3.1 Tides and Water Level

The mean water level at Ucluelet, northwest of Barkley Sound, is 2.0 m above local CD, with higher high water 4.0 m above CD and lower low water 0.1 m below CD. Typical tidal range varies from 2.6 m for mean tides and 4.1 m for large tides (FOC-2, 2012). At Neah Bay near the Pacific entrance, the mean water level is 1.3 m above local CD, with higher high water 3.3 m above CD and lower low water 0.6 m below CD (CHS, 2002).

4.5.3.2 Currents

Near the coastlines, tidal currents can reach 1.0 to 1.5 m/s. Tidal currents greatly decrease seaward across the continental slope to about 0.01 to 0.05 m/s (Thomson, 1981). The coastal current, driven by prevalent ocean currents in the Pacific, can typically reach a speed of 0.25 m/s heading southeast in summer, and 0.8 m/s heading northwest in winter. The wind-driven alongshore currents correspond to the prevalent direction of coastal winds with speeds up to 5% of the wind speed (Thomson, 1981).

4.5.3.3 Wave Climate

Waves of significant size propagate from all exposed directions facing the open ocean (southeast, south, southwest, west and northwest directions), as exemplified by the wave measurements at La Perouse Bank (Figures B.5 and B.6). The wave roses indicate stronger wave conditions in winter than in summer, regardless of direction. Steep waves can form a hazard in this area as westerly seas steepen on ebb tidal current when combined with westerly winds (EC 1999). Waves from the northwest are predominant in summer, while waves from the southeast are prevalent in winter. The results of the extreme event frequency analysis of all waves, including sea and swell, at La Perouse Bank are presented in Table 3.8.

Measurements at La Perouse Bank, close to the potential shipping route, indicate that a significant wave height of 6.5 m is an annual occurrence for almost all the exposed wind-wave directions; a significant wave height of 10 m happens once every 10 to 50 years. These results are consistent with the wave measurements results presented by Thomson (1981).

For reference purposes, wave roses at South Brooks (Figures B.7 and B.8) and East Dellwood (Figure B.9 and B.10), both located west of Vancouver Island but at more northward locations, are also presented and the respective results of the return-period analysis are presented in Table 3.9 and Table 3.10.

Wave data at South Brooks and East Dellwood indicate wave heights are about 10 to 20% higher than waves at La Perouse Bank.

5.0 CLOSURE

We trust this report meets your present requirements. If you have any questions or comments, please contact the undersigned.

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REFERENCES

Canadian Hydrographic Services, 1981. Vancouver Harbour Tidal Current Atlas.

Canadian Hydrographic Services, 2002. Chart 3606.

Canadian Hydrographic Services, 2005. Chart 3462.

Cannon G.A. ed., 1978. Circulation in the Strait of Juan de Fuca. National Oceanic Atmospheric Admin. Tech. Rep. ERL 399-PMEL 29, p. 49.

EBA Engineering Consultants Ltd., 2011. Second Narrows Water Supply Tunnel–Preliminary Design: Scour and Deposition Study.

Environment Canada (EC), 1999. 'Marine Weather Hazards along the British Columbia Coast'.

Fisheries and Oceans Canada, 2012. Canadian Tide and Current Tables, Volume 5 – Juan de Fuca Strait and Strait of Georgia.

Fisheries and Oceans Canada, 2012. Canadian Tide and Current Tables. Volume 6 – Discovery Passage and West Coast of Vancouver Island.

Fisheries and Oceans Canada, 2012. Sailing Directions – Juan de Fuca Strait and Strait of Georgia.

Goda Y., 1988. On the Methodology of Selecting Design Wave Height, Chapter 67, Coastal Engineering.

Klock, R. and J. Mullock. The Weather of British Columbia – Graphic Area Forecast 31. Prepared for NAV Canada. 2000.

Labrecque, A.J.M., Thomson, R.E., Stacey, M.W. 1994. Residual Currents in Juan de Fuca Strait. Atmospheric Ocean. 32(2): 375-394.

Lange, O.S., 1998. The Wind Came All Ways. Environment Canada, Atmospheric Environment Service.

Lange, O.S., 2003. Living with Weather along the British Columbia Coast. Environment Canada.

Mass, C.F., D.A. Mark and J.B. Daniel, 1986: The Onshore Surge of Marine Air into the Pacific Northwest: A Coastal Region of Complex Terrain. Monthly Weather Review, 114, 2602–2627.

Masson, D., 2006. Seasonal Water Mass Analysis for the Strait of Juan de Fuca and Georgia. Atmospheric Ocean. 44(1): 1-15.

Murty, T.S., G.A. McBean and B. McKee. 1983. Explosive Cyclogenesis over the Northeast Pacific Ocean. Monthly Weather Review. Vol. 111, 1131-1135.

Stronach J.A., 1977. Observational and Modelling Studies of the Fraser River Plume. Ph.D. Thesis. University of British Columbia

Thomson, R.E., 1981. Oceanography of the British Columbia Coast. Canadian Special Publication of Fisheries and Aquatic Sciences, no. 56.

Waldichuk M., 1957. Physical Oceanography of the Strait of Georgia, British Columbia. J. Fish. Res. Board Can. 14(3): 321-486.

TABLES

Table 3.1: Meteorological Stations and Buoys (shaded box = data present)

Station	Shore Or Buoy	Latitude (North)	Longitude (West)	Wind	Air Temperature	Dew point or Humidity	Cloud Cover	Precipitation	Visibility	Sea Surface Temperature	Wave Conditions
Ballenas Island	Met	49° 21' 0"	124° 9' 36"	■	■	■					
Bellingham Int'l A	Met (US)	48° 47' 38.4"	122° 32' 13.2"	■	■	■	■		■		
Campbell River A	Met	49° 57' 0"	125° 16' 12"	■	■	■	■		■		
Cherry Point	Met (US)	48° 52' 1.2"	122° 45' 0"	■	■						
Comox A	Met	49° 43' 12"	124° 54' 0"	■	■	■	■		■		
Discovery Island	Met	48° 25' 12"	123° 13' 48"	■	■	■					
Entrance Island	Met	49° 12' 0"	123° 48' 0"	■	■	■					
Estevan Point	Met	49° 22' 48"	126° 33' 0"	■	■	■	■		■		
Grief Point	Met	49° 48' 0"	124° 31' 48"	■							
Howe Sound-Pam	Met	49° 29' 24"	123° 18' 0"	■	■	■					
Kelp Reefs	Met	48° 33' 0"	123° 14' 24"	■							
New Dungeness	Met (US)	48° 10' 1.2"	123° 6' 0"	■							
Point Atkinson	Met	49° 19' 48"	123° 15' 36"	■	■						
Port Angeles	Met (US)	48° 7' 58.8"	123° 25' 58.8"	■	■						
Port Townsend	Met (US)	48° 7' 1.2"	122° 45' 0"	■	■						
Race Rocks	Met	48° 18' 0"	123° 31' 58.8"	■							
Sand Heads	Met	49° 6' 0"	123° 18' 0"	■	■						
Sartine Island	Met	50° 49' 12"	128° 54' 36"	■	■	■					
Saturna Island	Met	48° 37' 12"	123° 12' 0"	■	■	■					
Sechelt	Met	49° 28' 12"	123° 46' 12"	■	■	■					
Sheringham Point	Met	48° 22' 48"	123° 55' 12"	■	■	■					
Sisters Island	Met	49° 29' 24"	124° 25' 48"	■	■	■					
Smith Island	Met (US)	48° 19' 1.2"	122° 49' 58.8"	■	■						
Solander Island	Met	50° 06' 36"	127° 56' 24"	■	■	■					
Tatoosh Island	Met (US)	48° 22' 58.8"	124° 43' 58.8"	■	■						
Tofino A	Met	49° 4' 48"	125° 46' 12"	■	■	■	■		■		
Vancouver	Met	49° 18' 0"	123° 7' 1.2"	■	■	■					
Vancouver Int'l A	Met	49° 12' 0"	123° 10' 48"	■	■	■	■		■		
Whidbey Island	Met (US)	48° 21' 0"	122° 40' 1.2"	■	■	■	■		■		
Sentry Shoal	EC Buoy	49° 54' 22"	124° 59' 6"	■	■					■	■
Halibut Bank	EC Buoy	49° 20' 24"	123° 43' 37"	■	■					■	■
New Dungeness	NOAA	48° 20' 8"	123° 9' 31"	■	■					■	■
Neah Bay	NOAA	48° 29' 37"	124° 43' 39"	■	■					■	■
La Perouse Bank	EC Buoy	48° 50' 6"	125° 59' 52"	■	■					■	■
South Brooks	EC Buoy	49° 44' 17"	127° 55' 51"	■	■					■	■
East Dellwood	EC Buoy	50° 52' 26"	129° 54' 57"	■	■					■	■

TABLE 3.2: WIND DATA COVERAGE (SHADED BOX = DATA PRESENT)

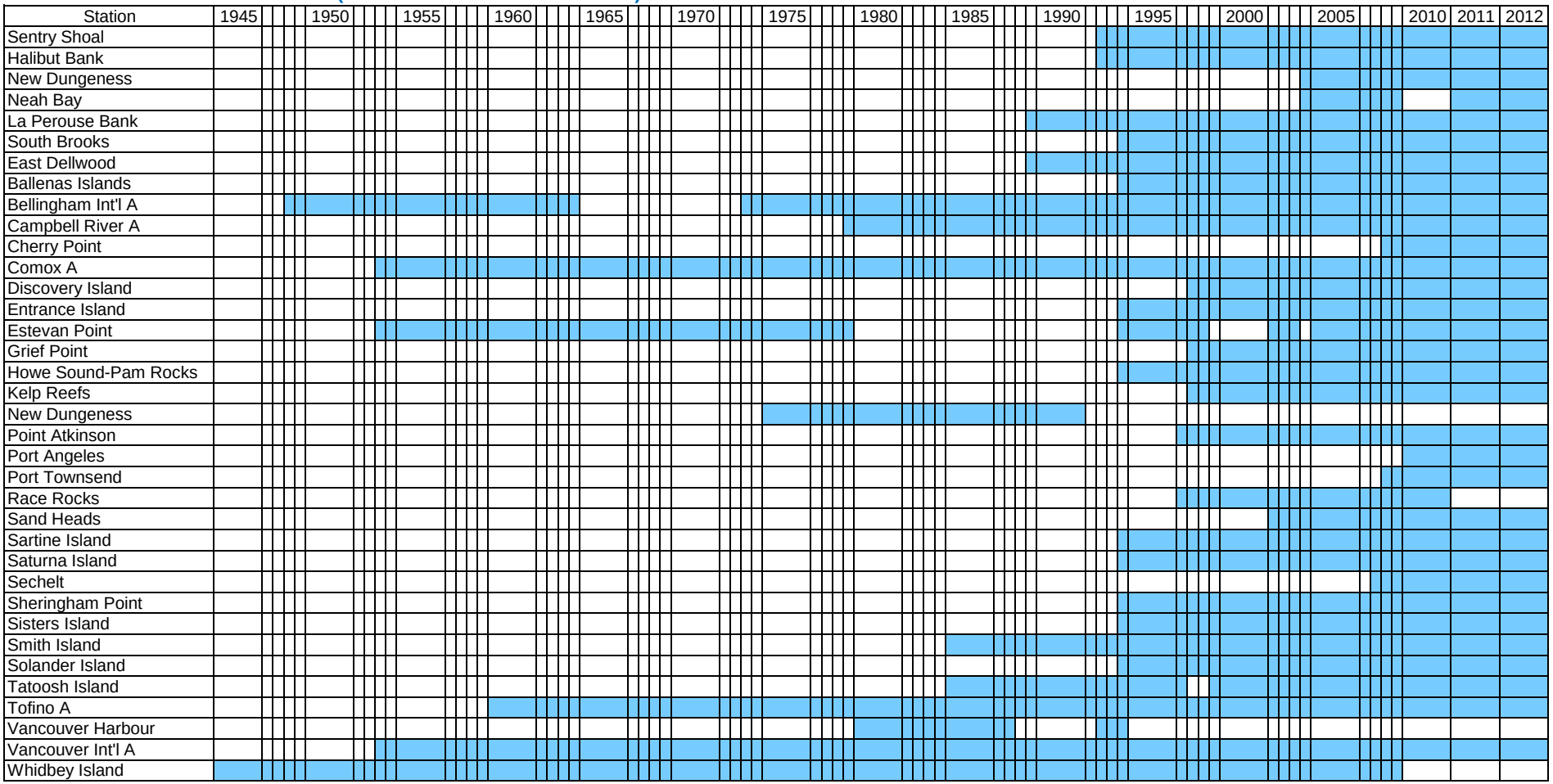


Table 3.3: VISIBILITY DATA COVERAGE (SHADED BOX = DATA PRESENT)

Station	1945	1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000	2005	2010	2011	2012
Bellingham Int'l A																
Campbell River A																
Comox A																
Tofino A																
Vancouver Int'l A																
Whidbey Island																

Table 3.4 Near-Surface Current Data Coverage

	Filename	Depth (m)	Year	Lat		Long		Geographic Area
1	A_0014.CUR	14	1978	48	41.33	-123	-29.45	Saanich Inlet
2	BVN010000c97107a.CUR	0	1997	48	39	-123	-24	Sidney, BC., Baven St. Pier
3	BU03_0015c75142a.CUR	15	1975	49	17.2	-123	-18.8	Burrard Inlet
4	CM1_0020.CUR	20	1989	48	34.78	-123	-30.71	Saanich Inlet
5	CM1_0020_2.CUR	20	1989	48	34.78	-123	-30.71	Saanich Inlet
6	CM2_0020.CUR	20	1989	48	34.8	-123	-30.25	Saanich Inlet
7	CM2_0020_2.CUR	20	1989	48	34.8	-123	-30.25	Saanich Inlet
8	CM3_0020.CUR	20	1989	48	34.7	-123	29.73	Saanich Inlet
9	CM3_0020_2.CUR	20	1989	48	34.7	-123	29.73	Saanich Inlet
10	E1A_0010.CUR	10	1995	48	40.9	-123	-29.9	Saanich Inlet - Coal Point
11	E1A_0020.CUR	20	1995	48	40.9	-123	-29.9	Saanich Inlet - Coal Point
12	E1B_0010.CUR	10	1995	48	40.9	-123	-30	Sannich Inlet
13	E1B_0020.CUR	20	1995	48	40.9	-123	-30	Sannich Inlet
14	FR1__0002c78063a.CUR	2	1978	49	6.2	-123	-17.5	Fraser River
15	FRA1_0013c77084a.CUR	13	1977	49	9.6	-122	-56.5	ANNACIS I. AT MUNGO CANNERY
16	FRA2_0012c77084a.CUR	12	1977	49	9.7	-122	-56.6	ANNACIS I. AT MUNGO CANNERY
17	H187_0010c76199a.CUR	10	1976	48	28.6	-123	-13.2	HARO STRAIT
18	H188_0020c76199a.CUR	20	1976	48	29.9	-123	-11.2	HARO STRAIT
19	IO00_0005c76139a.CUR	5	1976	49	12.2	-123	-18.2	IONA ISLAND
20	JB010010.CUR	10	1988	49	29.5	124	-43.1	J BUOY 88 MOORING JB01
21	JB010012.CUR	12	1988	49	29.5	-124	-43.1	J BUOY 88 MOORING JB01
22	JFE1_0018c71328a.CUR	18	1971	48	13.7	-123	-32.2	RACE ROCKS 4M SOUTH
23	JFE1_0018c71356a.CUR	18	1971	48	13.9	-123	-31.8	RACE ROCKS 4M SOUTH
24	JFE1_0018c72039a.CUR	18	1972	48	13.9	-123	-31.8	RACE ROCKS 4M SOUTH
25	JFE1_0018c72066a.CUR	18	1972	48	13.9	-123	-31.8	RACE ROCKS 4M SOUTH
26	JFE1_0018c72087a.CUR	18	1972	48	13.9	-123	-31.8	RACE ROCKS 4M SOUTH
27	JFE1_0018c72119a.CUR	18	1972	48	13.9	-123	-31.8	RACE ROCKS 4M SOUTH
28	JFE1_0018c72140a.CUR	18	1972	48	13.9	-123	-31.8	RACE ROCKS 4M SOUTH
29	JFE1_0018c72227a.CUR	18	1972	48	13.9	-123	-31.8	RACE ROCKS 4M SOUTH
30	JFE1_0018c72276a.CUR	18	1972	48	13.9	-123	-31.8	RACE ROCKS 4M SOUTH
31	JFE1_0018c72332a.CUR	18	1972	48	13.9	-123	-31.8	RACE ROCKS 4M SOUTH
32	JFE1_0018c73019a.CUR	18	1973	48	13.9	-123	-31.8	RACE ROCKS 4M SOUTH
33	JFE1_0018c73066a.CUR	18	1973	48	13.9	-123	-31.8	RACE ROCKS 4M SOUTH
34	JFE1_0018c73108a.CUR	18	1973	48	13.9	-123	-31.8	RACE ROCKS 4M SOUTH
35	JFE1_0018c73166a.CUR	18	1973	48	13.9	-123	-31.8	RACE ROCKS 4M SOUTH
36	JFE1_0018c73324a.CUR	18	1973	48	13.9	-123	-31.8	RACE ROCKS 4M SOUTH
37	JFE1_0018c74073a.CUR	18	1973	48	13.9	-123	-31.8	RACE ROCKS 4M SOUTH

Table 3.4 Near-Surface Current Data Coverage

	Filename	Depth (m)	Year	Lat		Long		Geographic Area
38	L062_0015c70075a.CUR	15	1970	48	52.1	-123	-9.1	ST OF GEORGIA
39	L062_0015c70091a.CUR	15	1970	48	52.1	-123	-9.1	ST OF GEORGIA
40	L062_0015c70105a.CUR	15	1970	48	52.1	-123	-9.1	ST OF GEORGIA
41	L063_0015c69238a.CUR	15	1969	48	53.9	-123	-7	ST OF GEORGIA
42	L063_0015c69269a.CUR	15	1969	48	54	-123	-6.6	ST OF GEORGIA
43	L064_0015c69234a.CUR	15	1969	48	55.8	-123	-4.9	ST OF GEORGIA
44	L065_0015c69233a.CUR	15	1969	48	57	-123	-3.1	ST OF GEORGIA
45	L080_0005c74063a.CUR	5	1974	48	45.5	-123	-5.1	BOUNDARY PASSAGE
46	L082_0005c74044a.CUR	5	1974	48	28	-123	-12.5	HARO STRAIT
47	L084_0006c74053a.CUR	6	1974	48	31	-123	-9.6	HARO STRAIT
48	L130_0020c75146a.CUR	20	1975	48	21.9	-123	-55.8	JUAN DE FUCA STRAIT
49	L131_0020c75146a.CUR	20	1975	48	20.1	-123	-58.4	STRAIT OF JUAN DE FUCA
50	L135_0020c75147a.CUR	20	1975	48	16.8	-124	-5.3	JUAN DE FUCA STRAIT
51	L136_0020c75147a.CUR	20	1975	48	14.4	-124	-8	JUAN DE FUCA STRAIT
52	L137_0020c75146a.CUR	20	1975	48	22.7	-124	-2.8	JUAN DE FUCA STRAIT
53	RB01_0003c70083a.CUR	3	1970	49	0.9	-123	-9.2	ROBERTS BANK
54	RB01_0003c70092a.CUR	3	1970	49	0.9	-123	-9.2	ROBERTS BANK
55	RB02_0003c70092a.CUR	3	1970	49	0.9	-123	-9.5	ROBERTS BANK
56	RB03_0003c70083a.CUR	3	1970	49	0.2	-123	-9.7	ROBERTS BANK
57	RB03_0003c70093a.CUR	3	1970	49	0.2	-123	-9.7	ROBERTS BANK
58	RB04_0015c70076a.CUR	15	1970	49	0.7	-123	-11	ROBERTS BANK
59	RB04_0015c70092a.CUR	15	1970	49	0.7	-123	-11	ROBERTS BANK
60	RB05_0015c70076a.CUR	15	1970	49	0.4	-123	-11.6	ROBERTS BANK
61	RB05_0015c70092a.CUR	15	1970	49	0.4	-123	-11.6	ROBERTS BANK
62	RB06_0015c70078a.CUR	15	1970	49	0.6	-123	-8.7	ROBERTS BANK
63	RB07_0015c70076a.CUR	15	1970	48	58.2	-123	-8.8	ROBERTS BANK
64	RB08_0015c70120a.CUR	15	1970	48	58.8	-123	-8	ROBERTS BANK
65	SG1__0010c87055a.CUR	10	1987	49	10.9	-123	-29.7	STRAIT OF GEORGIA
66	SG6__0017c78075a.CUR	17	1978	48	51.8	-123	-3.9	STRAIT OF GEORGIA
67	W2A__0002c95187a.CUR	2	1995	48	40.5	-123	-31.47	SAANICH INLET
68	W2A__0002c95216a.CUR	2	1995	48	40.5	-123	-31.47	SAANICH INLET
69	W2A__0002c95272a.CUR	2	1995	48	40.5	-123	-31.47	SAANICH INLET
70	W2A__0005c95187a.CUR	5	1995	48	40.5	-123	-31.47	SAANICH INLET
71	W2A__0005c95216a.CUR	5	1995	48	40.5	-123	-31.47	SAANICH INLET
72	W2A__0005c95272a.CUR	5	1995	48	40.5	-123	-31.47	SAANICH INLET
73	W2A__0008c95187a.CUR	8	1995	48	40.5	-123	-31.47	SAANICH INLET
74	W2A__0008c95216a.CUR	8	1995	48	40.5	-123	-31.47	SAANICH INLET

Table 3.4 Near-Surface Current Data Coverage

	Filename	Depth (m)	Year	Lat		Long		Geographic Area
75	W2A__0008c95272a.CUR	8	1995	48	40.5	-123	-31.47	SAANICH INLET
76	W2A__0015c95187a.CUR	15	1995	48	40.5	-123	-31.47	SAANICH INLET
77	W2A_0002.CUR	2	1995	48	40.5	-123	-31.47	SAANICH INLET
78	W2A_0005.CUR	5	1995	48	40.5	-123	-31.47	SAANICH INLET
79	W2A_0008.CUR	8	1995	48	40.5	-123	-31.47	SAANICH INLET
80	W2A_0015.CUR	15	1995	48	40.5	-123	-31.47	SAANICH INLET
81	W2B_0002.CUR	2	1995	48	40.5	-123	-31.47	SAANICH INLET
82	W2B_0005.CUR	5	1995	48	40.5	-123	-31.47	SAANICH INLET
83	W2B_0008.CUR	8	1995	48	40.5	-123	-31.47	SAANICH INLET
84	W2C_0002.CUR	2	1995	48	40.5	-123	-31.47	SAANICH INLET
85	W2C_0005.CUR	5	1995	48	40.5	-123	-31.47	SAANICH INLET
86	W2C_0008.CUR	8	1995	48	40.5	-123	-31.47	SAANICH INLET
87	WES__0004c84053a.CUR	4	1984	49	0.8	-123	-9.6	WESTSHORE TERMINAL
88	WES__0004c84144a.CUR	4	1984	49	0.8	-123	-9.6	WESTSHORE TERMINAL
89	WES__0004c84233a.CUR	4	1984	49	0.8	-123	-9.6	WESTSHORE TERMINAL
90	WES__0004c84325a.CUR	4	1984-85	49	0.8	-123	-9.6	WESTSHORE TERMINAL
91	WES__0004c85063a.CUR	4	1985	49	0.8	-123	-9.6	WESTSHORE TERMINAL
92	WES__0004c85206a.CUR	4	1985	49	0.8	-123	-9.6	WESTSHORE TERMINAL

Table 3.5: Extreme Event Frequency Analysis for Significant Waves (m) – Halibut Bank

	1-year		5-year		10-year		50-year		100-year		200-year	
	Hs (m)	Tp (s)	Hs (m)	Tp (s)	Hs (m)	Tp (s)	Hs (m)	Tp (s)	Hs (m)	Tp (s)	Hs (m)	Tp (s)
N	-	-	-	-	-	-	-	-	-	-	-	-
NE	-	-	-	-	-	-	-	-	-	-	-	-
E	-	-	-	-	-	-	-	-	-	-	-	-
SE	1.8	5.5	2.8	6.8	3.3	7.3	4.3	8.3	4.7	8.6	5.2	9.0
S	-	-	-	-	-	-	-	-	-	-	-	-
SW	-	-	-	-	-	-	-	-	-	-	-	-
W	-	-	-	-	-	-	-	-	-	-	-	-
NW	1.2	4.6	2.3	6.0	2.9	6.5	4.4	7.7	5.1	8.1	5.8	8.5

Table 3.6: Extreme Event Frequency Analysis for Significant Waves (m) – New Dungeness

	1-year		5-year		10-year		50-year		100-year		200-year	
	Hs (m)	Tp (s)	Hs (m)	Tp (s)	Hs (m)	Tp (s)	Hs (m)	Tp (s)	Hs (m)	Tp (s)	Hs (m)	Tp (s)
N	-	-	-	-	-	-	-	-	-	-	-	-
NE	-	-	-	-	-	-	-	-	-	-	-	-
E	-	-	-	-	-	-	-	-	-	-	-	-
SE	2.6	6.1	2.9	6.4	3.1	6.5	3.4	6.7	3.5	6.8	3.6	6.9
S	-	-	-	-	-	-	-	-	-	-	-	-
SW	2.3	6.4	2.9	7.0	3.1	7.2	3.7	7.7	3.9	7.9	4.2	8.1
W	2.6	6.3	3.1	6.7	3.4	6.9	3.9	7.2	4.1	7.3	4.3	7.4
NW	-	-	-	-	-	-	-	-	-	-	-	-

Table 3.7: Extreme Event Frequency Analysis for Wave (m) – Neah Bay

	1-year		5-year		10-year		50-year		100-year		200-year	
	Hs (m)	Tp (s)	Hs (m)	Tp (s)	Hs (m)	Tp (s)	Hs (m)	Tp (s)	Hs (m)	Tp (s)	Hs (m)	Tp (s)
N	-	-	-	-	-	-	-	-	-	-	-	-
NE	-	-	-	-	-	-	-	-	-	-	-	-
E	-	-	-	-	-	-	-	-	-	-	-	-
SE	2.3	9.7	2.8	10.4	3.0	10.7	3.4	11.2	3.6	11.4	3.8	11.6
S	-	-	-	-	-	-	-	-	-	-	-	-
SW	-	-	-	-	-	-	-	-	-	-	-	-
W	6.3	13.9	8.3	15.4	9.1	15.9	11.1	17.1	12.0	17.6	12.8	18.0
NW	-	-	-	-	-	-	-	-	-	-	-	-

Table 3.8: Extreme Event Frequency Analysis for Significant Waves (m) – La Perouse Bank

	1-year		5-year		10-year		50-year		100-year		200-year	
	Hs (m)	Tp (s)	Hs (m)	Tp (s)	Hs (m)	Tp (s)	Hs (m)	Tp (s)	Hs (m)	Tp (s)	Hs (m)	Tp (s)
N	-	-	-	-	-	-	-	-	-	-	-	-
NE	-	-	-	-	-	-	-	-	-	-	-	-
E	-	-	-	-	-	-	-	-	-	-	-	-
SE	6.2	12.8	7.3	13.5	7.7	13.7	8.4	14.1	8.7	14.2	9.0	14.4
S	6.7	12.9	8.3	13.7	8.9	14.0	10.4	14.6	11.1	14.8	11.7	15.0
SW	6.6	13.4	8.2	14.0	8.9	14.3	10.4	14.8	11.1	15.0	11.8	15.2
W	6.7	13.7	8.5	14.7	9.2	15.0	11.0	15.8	11.7	16.1	12.4	16.4
NW	5.8	12.2	7.0	13.0	7.6	13.4	8.8	14.1	9.4	14.4	9.9	14.6

Table 3.9: Extreme Event Frequency Analysis for Significant Waves (m) – South Brooks

	1-year		5-year		10-year		50-year		100-year		200-year	
	Hs (m)	Tp (s)	Hs (m)	Tp (s)	Hs (m)	Tp (s)	Hs (m)	Tp (s)	Hs (m)	Tp (s)	Hs (m)	Tp (s)
N	-	-	-	-	-	-	-	-	-	-	-	-
NE	-	-	-	-	-	-	-	-	-	-	-	-
E	-	-	-	-	-	-	-	-	-	-	-	-
SE	7.9	11.9	10.0	12.7	10.9	13.0	12.7	13.5	13.4	13.7	14.1	13.9
S	7.6	13.0	9.2	13.5	9.8	13.6	10.8	13.9	11.2	14.0	11.6	14.1
SW	7.6	14.8	9.5	16.1	10.1	16.4	11.2	17.0	11.7	17.3	12.1	17.5
W	6.8	14.7	8.9	15.8	9.6	16.1	10.9	16.7	11.4	16.9	11.9	17.1
NW	5.8	13.4	8.4	15.9	9.4	16.8	11.4	18.5	12.2	19.1	12.9	19.6

Table 3.10: Extreme Event Frequency Analysis for Significant Waves (m) – East Dellwood

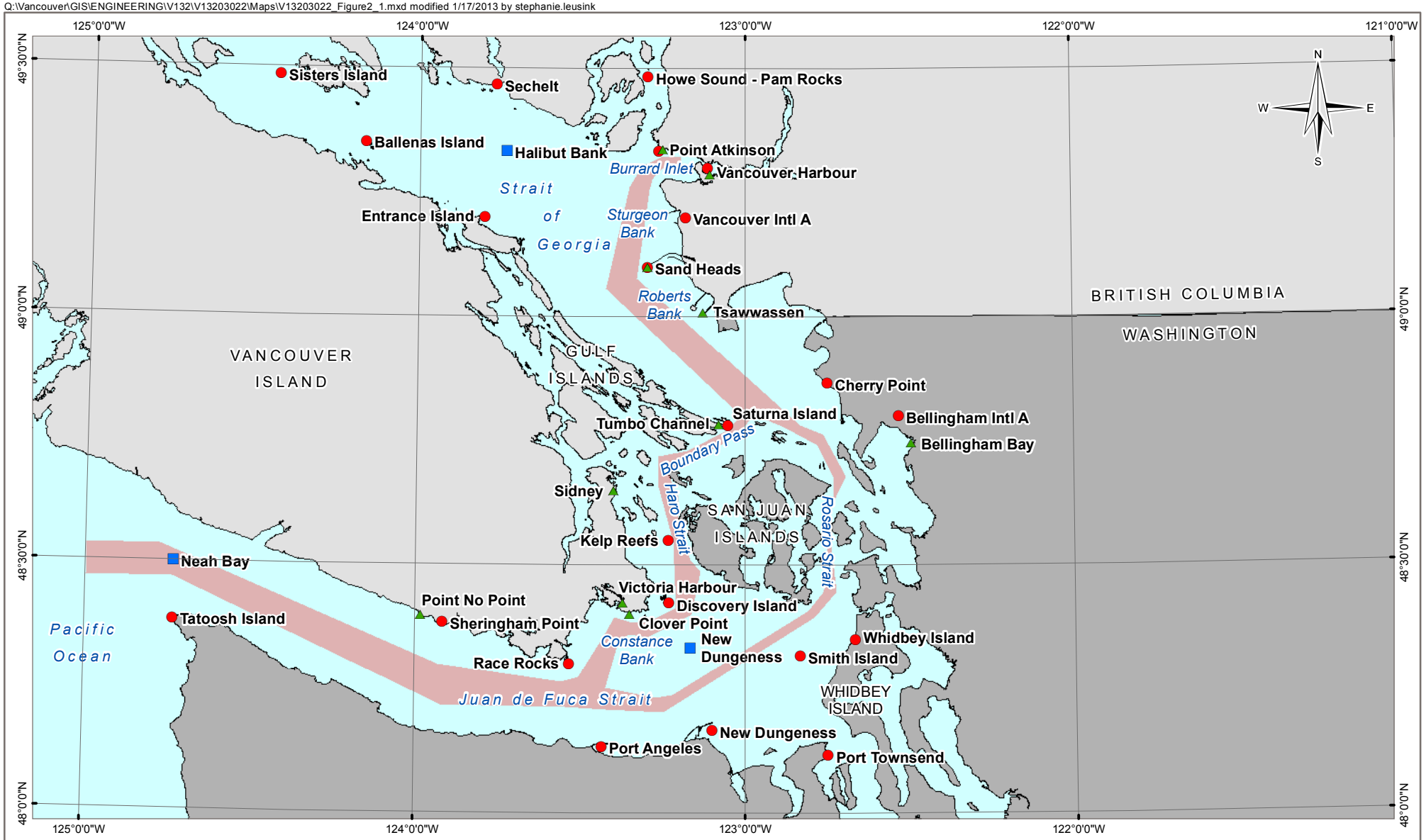
	1-year		5-year		10-year		50-year		100-year		200-year	
	Hs (m)	Tp (s)	Hs (m)	Tp (s)	Hs (m)	Tp (s)	Hs (m)	Tp (s)	Hs (m)	Tp (s)	Hs (m)	Tp (s)
N	7.3	12.3	9.0	12.8	9.6	13.0	10.7	13.3	11.2	13.5	11.6	13.6
NE	-	-	-	-	-	-	-	-	-	-	-	-
E	-	-	-	-	-	-	-	-	-	-	-	-
SE	8.6	11.8	10.7	12.7	11.4	13.0	12.9	13.5	13.5	13.7	14.0	13.9
S	8.0	12.7	10.2	13.2	10.9	13.4	12.5	13.7	13.0	13.8	13.6	13.9
SW	7.6	12.7	10.8	13.7	12.0	13.9	14.5	14.5	15.5	14.7	16.5	14.9
W	7.1	13.3	10.5	14.8	11.6	15.2	13.7	15.9	14.5	16.2	15.3	16.4
NW	6.5	12.5	9.2	14.1	10.4	14.7	13.2	15.9	14.4	16.4	15.6	16.9

Table 3.11: Maximum and Minimum Water Levels and Date of Events

Point Atkinson		
Highest Water Level	5.60 m above Chart Datum	December 16, 1982
Lowest Water Level	0.42 m below Chart Datum	December 29, 1932
Positive Surge	1.095 m	January 3, 1965
Negative Surge	1.211 m	January 20, 1948
Victoria		
Highest Water Level (m)	3.71 m above Chart Datum	January 2, 2003
Lower Water Level (m)	0.40 m above Chart Datum	December 12, 1985
Positive Surge (m)	0.839 m	December 16, 1982
Negative Surge (m)	0.669 m	December 31, 1978

FIGURES

Q:\Vancouver\GIS\ENGINEERING\V132\V13203022\Maps\V13203022_Figure2_1.mxd modified 1/17/2013 by stephanie.leusink



LEGEND

- Tidal Station
- Coastal Meteorological Station
- Weather and Wave Buoy
- Shipping Corridor [1]
- British Columbia
- Washington

NOTES
1. Shipping corridor as per Canadian Hydrographic Charts 3602, 3606, 3461, 3462, and 3463.
2. Base data source: ESRI Data and Maps.

STATUS
ISSUED FOR USE

Scale: 1:1,200,000
20 10 0 20
Kilometres

PROJECTION	DATUM
UTM Zone 10	NAD83

FILE NO. V13203022_Figure2_1.mxd

CLIENT KINDER MORGAN

eba A TETRA TECH COMPANY

METOCEAN DATA
TRANS MOUNTAIN PIPELINE PROJECT

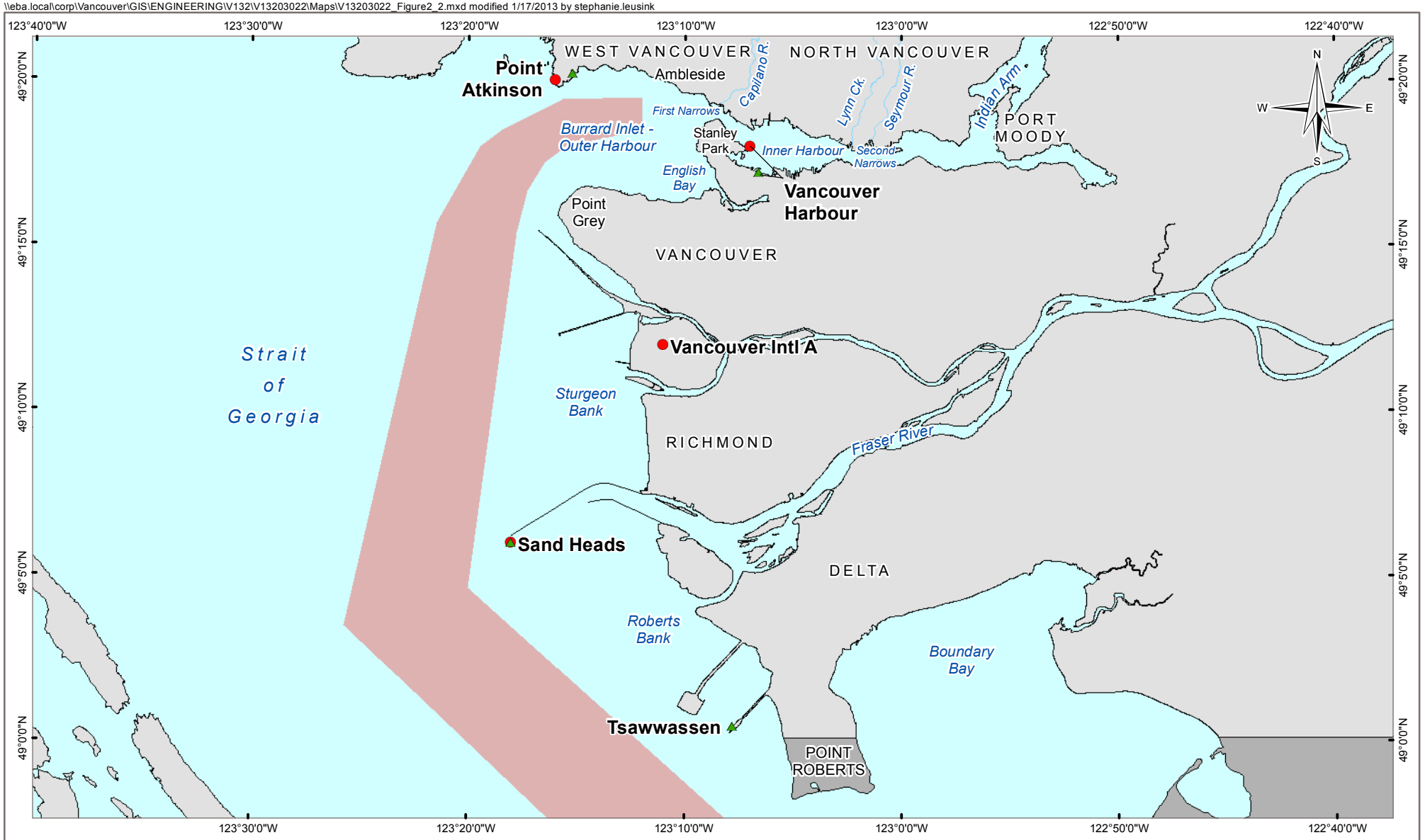
Geographic and Oceanographic Settings Georgia Basin

PROJECT NO.	DWN	CKD	APVD	REV
V13203022	SL	MEZ	TM	0

OFFICE	DATE
EBA-VANC	January 17, 2013

Figure 2.1

\\eba.local\corp\Vancouver\GIS\ENGINEERING\V132\V13203022\Maps\V13203022_Figure2_2.mxd modified 1/17/2013 by stephanie.leusink



LEGEND

- Tidal Station
- Coastal Meteorological Station
- Shipping Corridor [1]
- Watercourse
- British Columbia
- Washington

NOTES

1. Shipping corridor as per Canadian Hydrographic Charts 3602, 3606, 3461, 3462, and 3463.
2. Base data source: ESRI Data and Maps.

STATUS
ISSUED FOR USE

Scale: 1:300,000

5 2.5 0 5

Kilometres

PROJECTION	DATUM
UTM Zone 10	NAD83

FILE NO.
V13203022_Figure2_2.mxd

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A TETRA TECH COMPANY

METOCEAN DATA
TRANS MOUNTAIN PIPELINE PROJECT

Geographic and Oceanographic Settings
Burrard Inlet and Strait of Georgia

PROJECT NO.	DWN	CKD	APVD	REV
V13203022	SL	MEZ	TM	0

OFFICE	DATE
EBA-VANC	January 17, 2013

Figure 2.2

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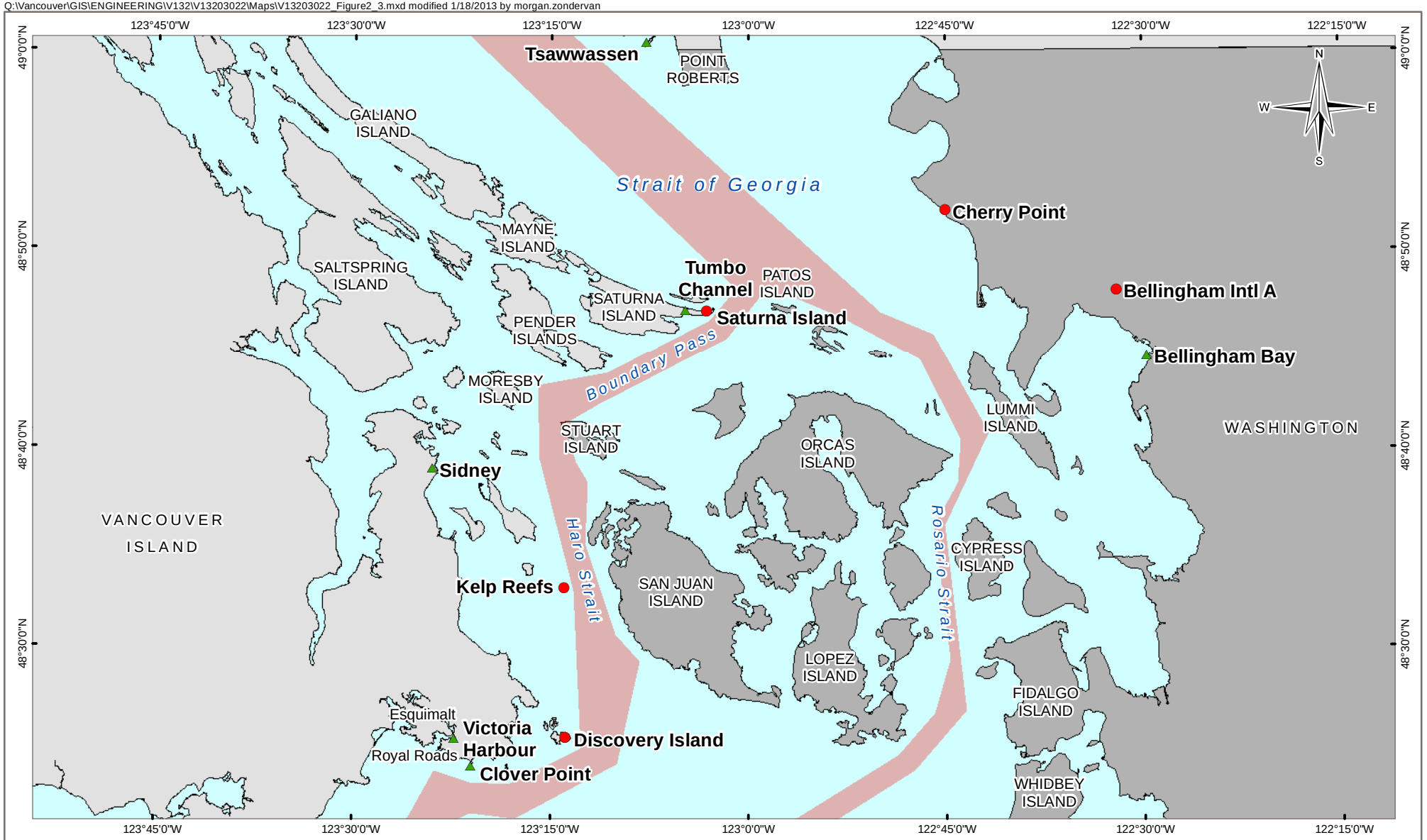

LEGEND

- Tidal Station
- Coastal Meteorological Station
- Shipping Corridor [1]
- British Columbia
- Washington

NOTES

1. Shipping corridor as per Canadian Hydrographic Charts 3602, 3606, 3461, 3462, and 3463.
2. Base data source: ESRI Data and Maps.

STATUS
ISSUED FOR USE

Scale: 1:500,000

10 5 0 10

Kilometres

PROJECTION	DATUM
UTM Zone 10	NAD83

FILE NO.
V13203022_Figure2_3.mxd

CLIENT
KINDER MORGAN

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A TETRA TECH COMPANY

METOCEAN DATA
TRANS MOUNTAIN PIPELINE PROJECT

Geographic and Oceanographic Settings
Gulft Islands and San Juan Islands

PROJECT NO.	DWN	CKD	APVD	REV
V13203022	SL	MEZ	TM	0

OFFICE	DATE
EBA-VANC	January 18, 2013

Figure 2.3

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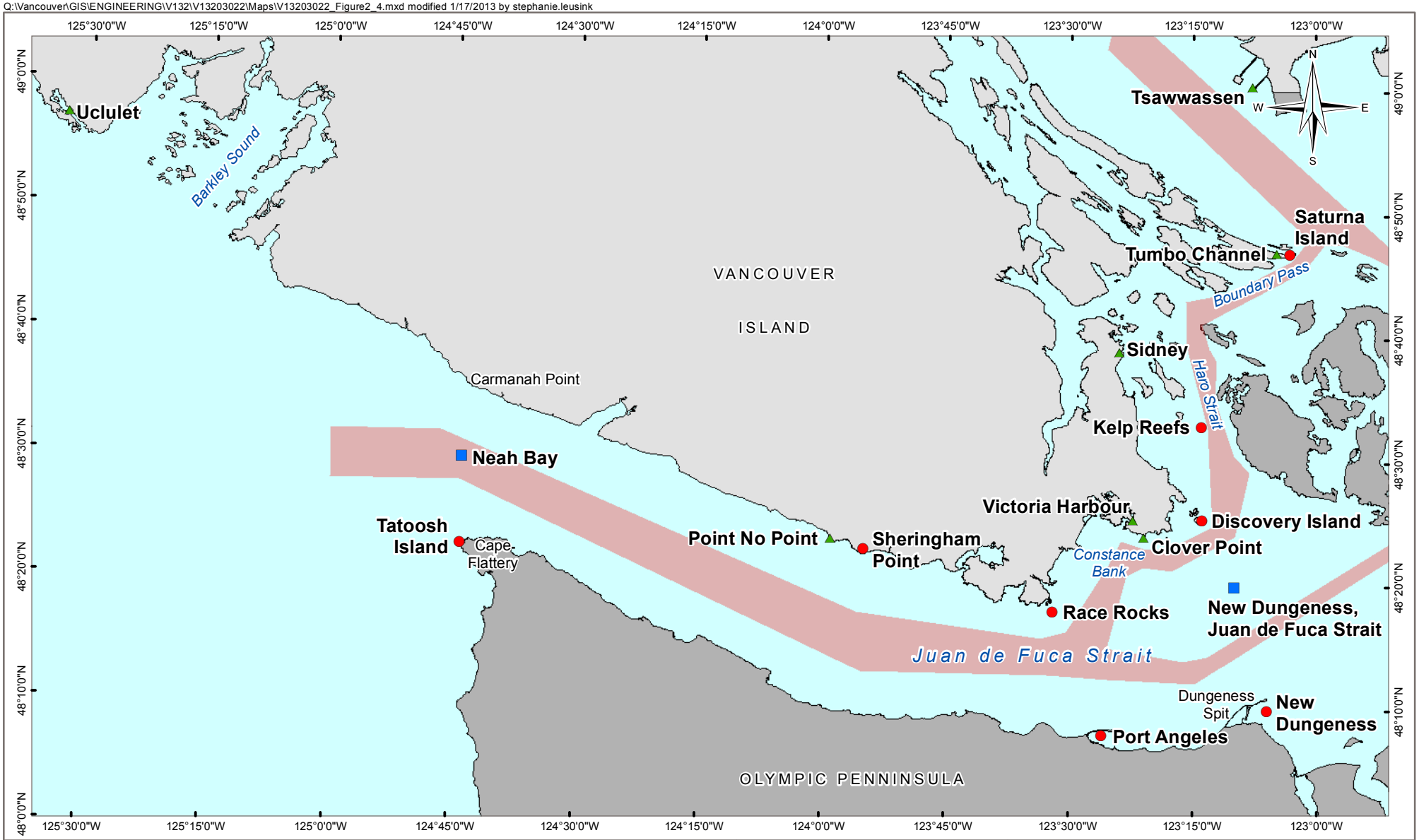

LEGEND

- Tidal Station
- Coastal Meteorological Station
- Weather and Wave Buoy
- Shipping Corridor [1]
- British Columbia
- Washington

NOTES
1. Shipping corridor as per Canadian Hydrographic Charts 3602, 3606, 3461, 3462, and 3463.
2. Base data source: ESRI Data and Maps.

STATUS
ISSUED FOR USE

Scale: 1:800,000
10 5 0 10
Kilometres

PROJECTION	DATUM
UTM Zone 10	NAD83

FILE NO. V13203022_Figure2_4.mxd

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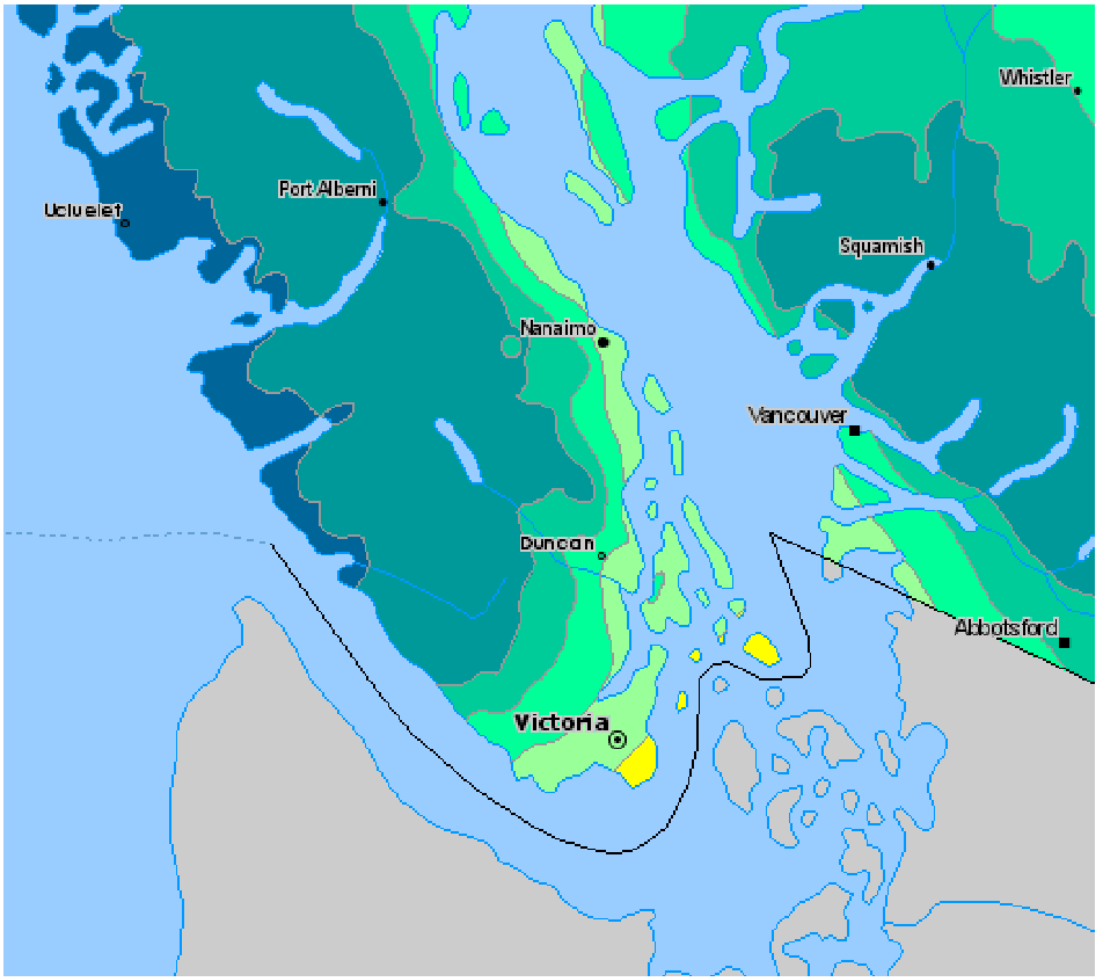
METOCEAN DATA
TRANS MOUNTAIN PIPELINE PROJECT

Geographic and Oceanographic Settings
Juan de Fuca Strait

PROJECT NO.	DWN	CKD	APVD	REV
V13203022	SL	MEZ	TM	0

OFFICE	DATE
EBA-VANC	January 17, 2013

Figure 2.4



NOTES

Source: The Atlas of Canada (http://atlas.nrcan.gc.ca)

STATUS
ISSUED FOR USE

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE PROJECT

Annual Mean Total Precipitation

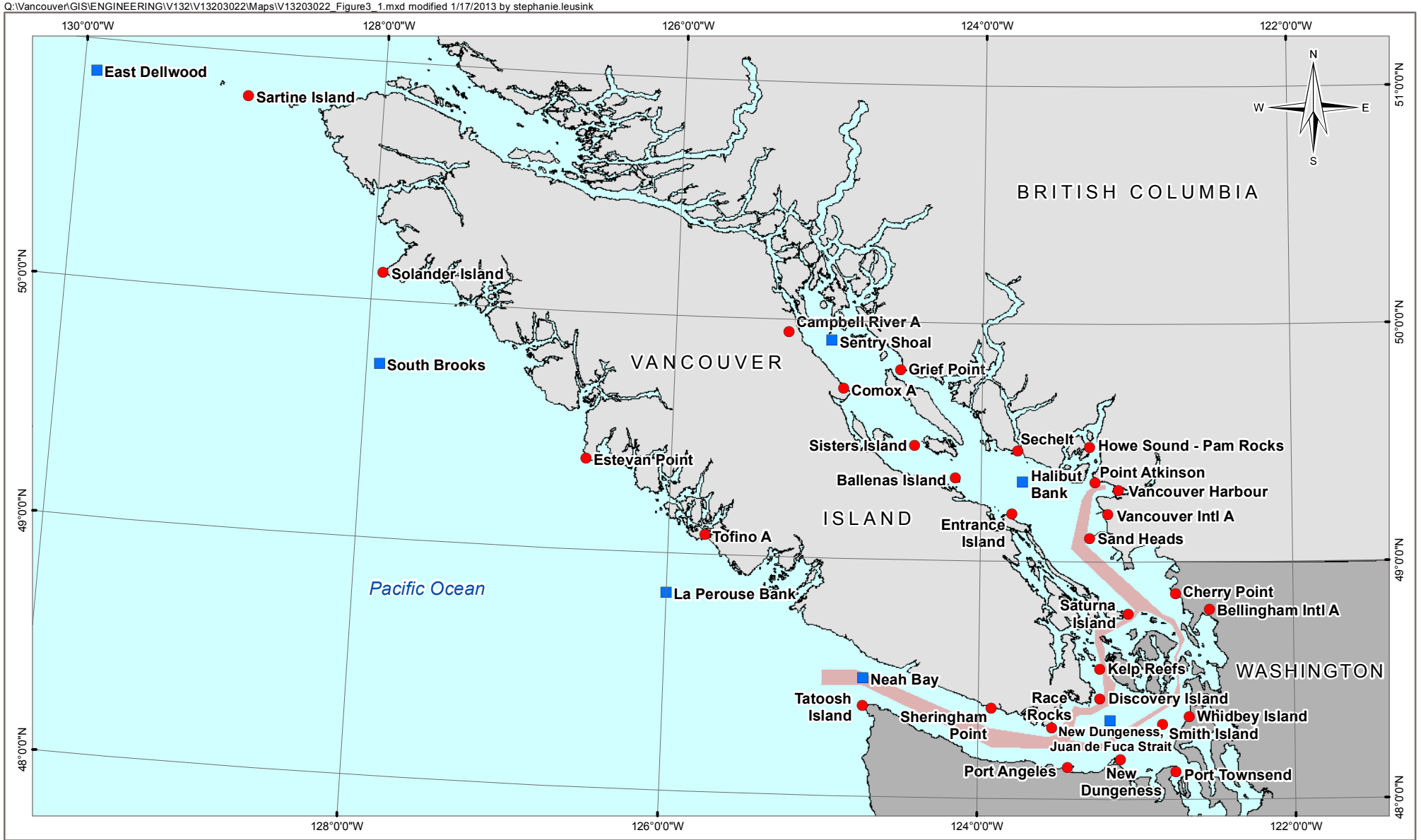
A TETRA TECH COMPANY

PROJECT NO.	DWN	CKD	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	January 17, 2013

Figure 2.5

Q:\Vancouver\GIS\ENGINEERING\V132\V13203022\Maps\V13203022_Figure3_1.mxd modified 1/17/2013 by stephanie.leusink



LEGEND

- Coastal Meteorological Station
- Weather and Wave Buoy
- Shipping Corridor [1]
- British Columbia
- Washington

NOTES
1. Shipping corridor as per Canadian Hydrographic Charts 3602, 3606, 3461, 3462, and 3463.
2. Base data source: ESRI Data and Maps.

STATUS
ISSUED FOR USE

Scale: 1:2,500,000
50 25 0 50
Kilometres

PROJECTION	DATUM
UTM Zone 10	NAD83

FILE NO.
V13203022_Figure3_1.mxd

CLIENT
KINDER MORGAN

eba A TETRA TECH COMPANY

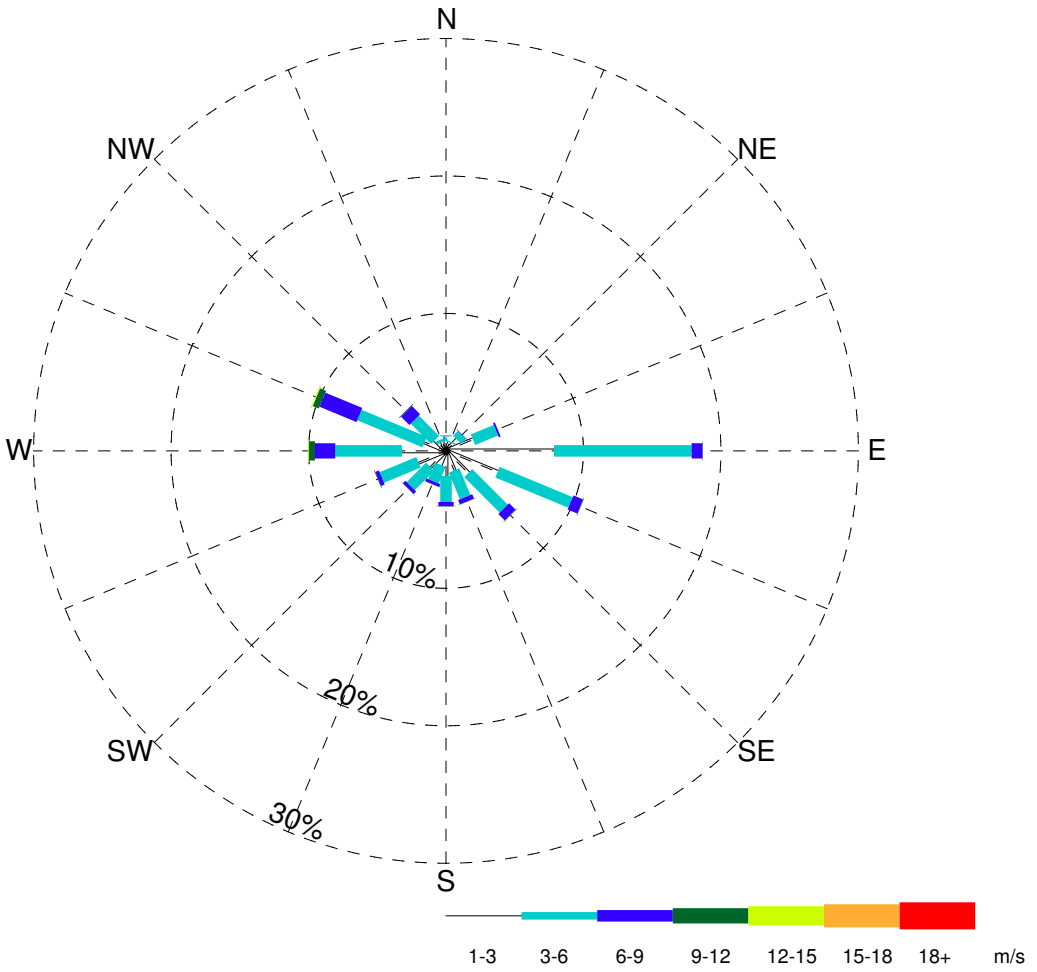
METOCEAN DATA
TRANS MOUNTAIN PIPELINE PROJECT

Coastal Meteorological Stations and Weather and Wave Buoys

PROJECT NO.	DWN	CKD	APVD	REV
V13203022	SL	MEZ	TM	0

OFFICE	DATE
EBA-VANC	January 17, 2013

Figure 3.1



Vancouver Intl Airport

Location:

N49° 12’ 0.0" W123° 10’ 48.0"

Elevation: 4.3 m

Sea level: -

Length of Record

Start Date: January 01, 1953

End Date: November 12, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	2.13	1.80	0.14	-	-	-	-	4.08
NE	-	1.14	0.49	0.04	-	-	-	-	1.67
NNE	-	0.66	0.10	-	-	-	-	-	0.76
N	-	1.05	0.09	-	-	-	-	-	1.14
NNW	-	0.67	0.21	0.02	-	-	-	-	0.91
NW	-	1.13	2.09	0.86	0.06	-	-	-	4.14
WNW	-	1.68	5.14	2.91	0.47	0.08	0.02	-	10.30
W	-	3.21	4.85	1.48	0.44	0.07	0.01	-	10.05
WSW	-	2.17	2.89	0.28	0.05	-	-	-	5.40
SW	-	1.63	2.00	0.25	0.02	-	-	-	3.90
SSW	-	1.10	1.30	0.23	0.02	-	-	-	2.64
S	-	1.83	1.88	0.32	0.02	-	-	-	4.06
SSE	-	1.55	2.10	0.34	0.02	-	-	-	4.01
SE	-	2.29	3.65	0.66	0.04	-	-	-	6.64
ESE	-	4.05	5.75	0.76	0.04	-	-	-	10.61
E	-	7.86	10.01	0.79	0.03	-	-	-	18.69
Calm	11.01	-	-	-	-	-	-	-	11.01
Total (%)	11.01	34.14	44.35	9.09	1.21	0.16	0.04	-	100.00

NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Summer: April-September
Vancouver Intl Airport

STATUS
ISSUED FOR USE

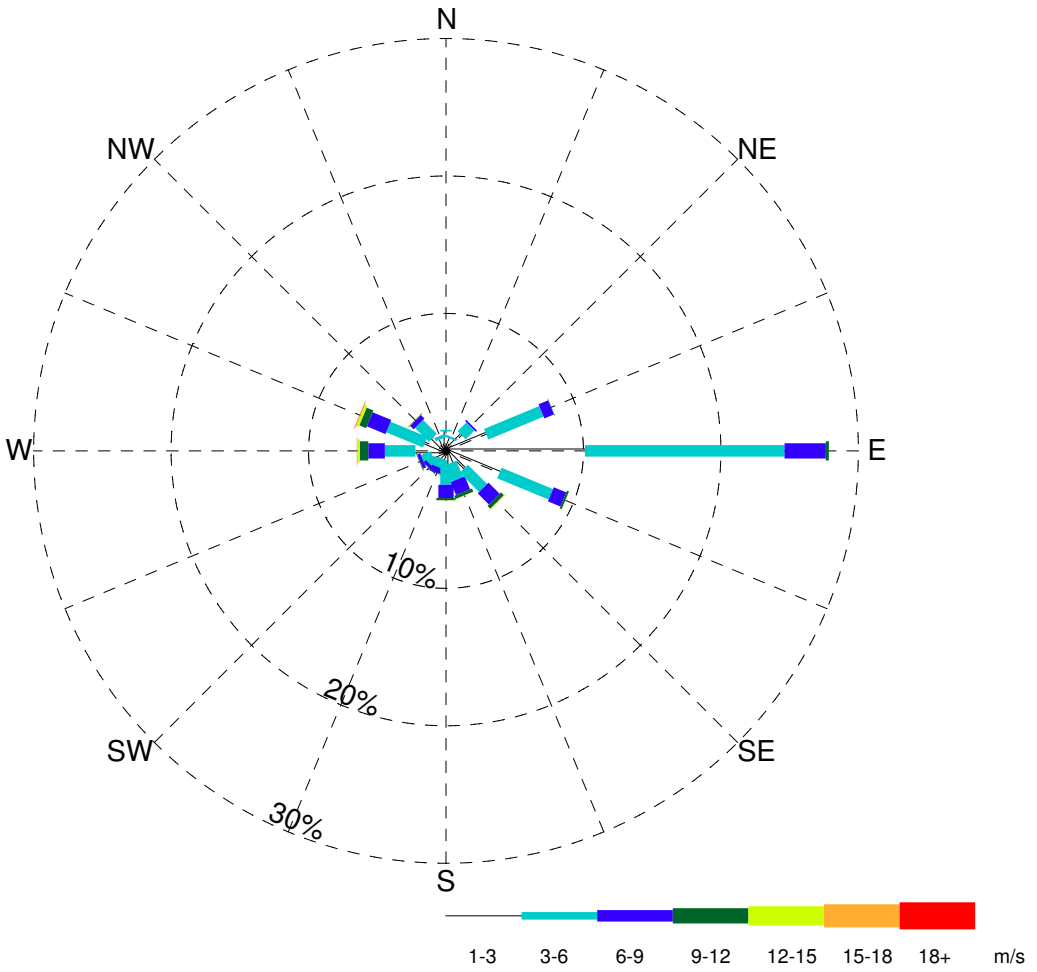
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 07, 2012

Figure 3.2



Vancouver Intl Airport

Location:

N49° 12’ 0.0" W123° 10’ 48.0"

Elevation: 4.3 m

Sea level: -

Length of Record

Start Date: January 01, 1953

End Date: November 12, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	3.16	4.35	0.76	0.03	-	-	-	8.30
NE	-	1.60	0.92	0.13	-	-	-	-	2.65
NNE	-	0.93	0.15	0.02	-	-	-	-	1.09
N	-	1.41	0.11	-	-	-	-	-	1.53
NNW	-	0.92	0.24	0.02	-	-	-	-	1.18
NW	-	1.35	1.43	0.36	0.05	0.01	-	-	3.20
WNW	-	1.64	2.90	1.47	0.53	0.19	0.06	0.02	6.82
W	-	2.22	2.23	1.21	0.61	0.17	0.05	0.01	6.49
WSW	-	1.06	0.75	0.23	0.06	-	-	-	2.10
SW	-	0.88	0.63	0.23	0.04	-	-	-	1.79
SSW	-	0.62	0.70	0.40	0.05	-	-	-	1.77
S	-	1.09	1.38	0.97	0.16	0.01	-	-	3.61
SSE	-	0.94	1.29	1.02	0.26	0.03	-	-	3.54
SE	-	1.84	1.98	1.15	0.29	0.05	0.02	-	5.33
ESE	-	4.21	4.05	0.98	0.16	0.02	-	-	9.42
E	-	10.11	14.51	3.01	0.22	-	-	-	27.86
Calm	13.33	-	-	-	-	-	-	-	13.33
Total (%)	13.33	33.98	37.61	11.93	2.46	0.51	0.14	0.04	100.00

NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Winter: October-March
Vancouver Intl Airport

STATUS
ISSUED FOR USE

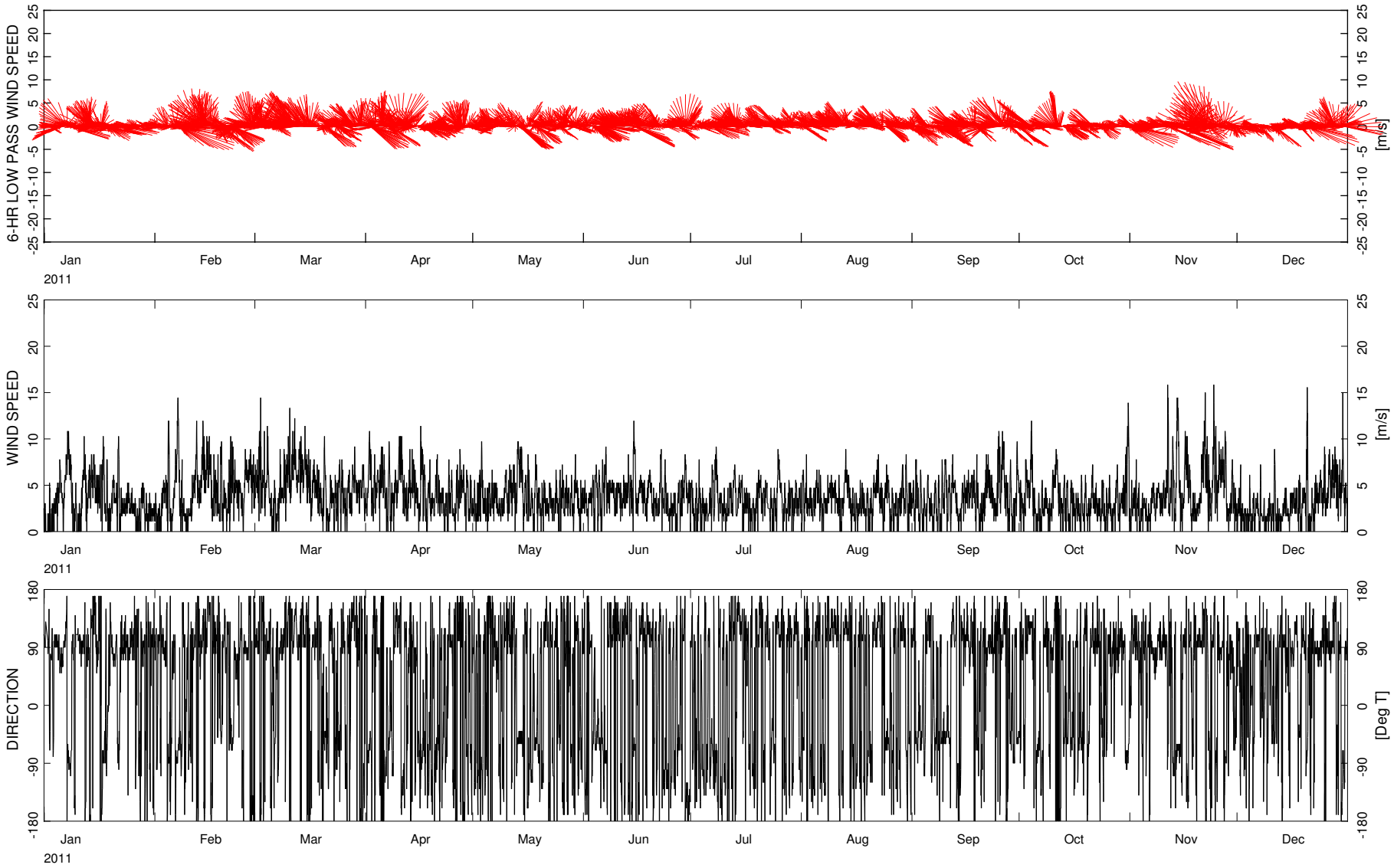
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 07, 2012

Figure 3.3



NOTES

- 6-hour low pass hourly wind sticks are shown in the top panel
- Hourly wind speed and direction are shown in the middle and bottom panels

STATUS
ISSUED FOR USE

CLIENT

Kinder Morgan

A TETRA TECH COMPANY

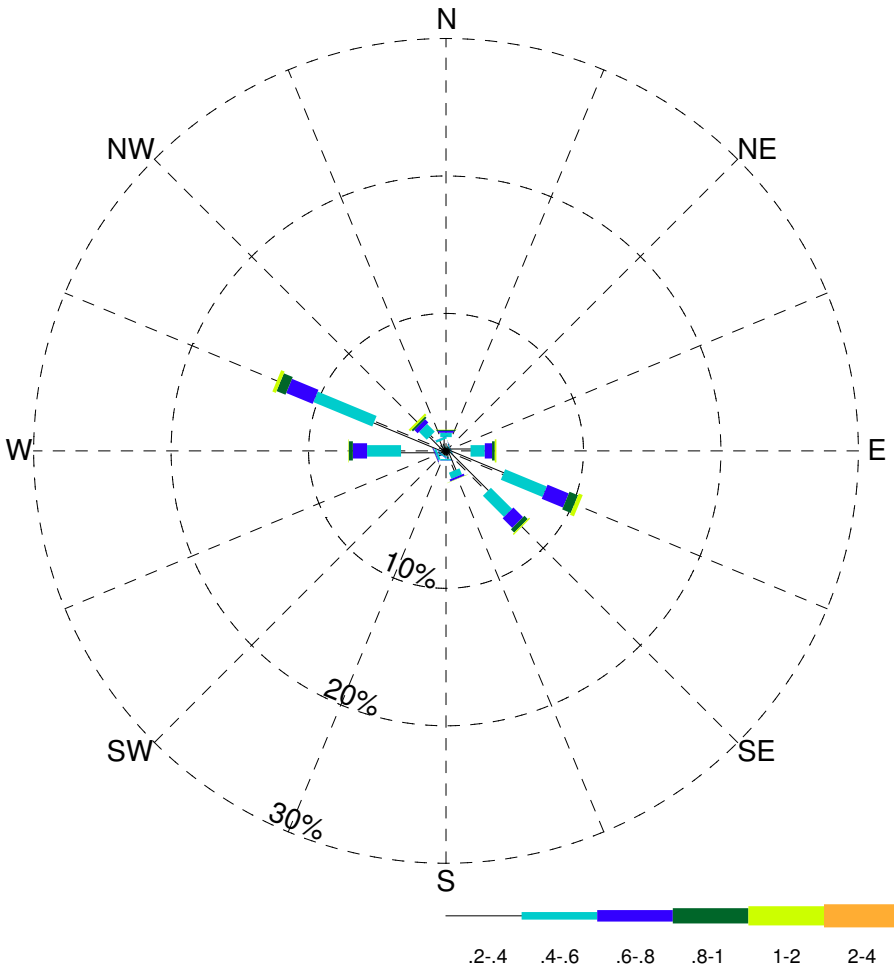
METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Wind speed and direction at Vancouver Intl Airport: 2011

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 11, 2012

Figure 3.4



Canadian Buoy C46146
Location:Halibut Bank, SOG
N49° 20' 24.0" W123° 43' 48.0"
Elevation: Sea Level
Sea level: -
Length of Record
Start Date: Mar 13, 1992
End Date: Nov 12, 2012
Comment: -

Wave Height & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	**0-.1 m**	**.2-.4 m**	**.4-.6 m**	**.6-.8 m**	**.8-1 m**	**1-2 m**	**2-4 m**	**4+ m**	**Total (%)**
ENE	-	0.29	0.06	0.02	0.01	-	-	-	0.38
NE	-	0.18	0.02	-	-	-	-	-	0.19
NNE	-	0.23	0.02	-	-	-	-	-	0.26
N	-	1.00	0.32	0.13	0.07	0.02	-	-	1.54
NNW	-	0.82	0.16	0.01	-	-	-	-	1.00
NW	-	1.57	0.80	0.34	0.15	0.16	-	-	3.02
WNW	-	5.64	4.64	2.08	0.70	0.27	-	-	13.33
W	-	3.27	2.47	1.03	0.29	0.04	-	-	7.11
WSW	-	0.60	0.17	0.06	0.02	-	-	-	0.85
SW	-	0.34	0.05	0.03	-	-	-	-	0.42
SSW	-	0.35	0.07	0.01	-	-	-	-	0.45
S	-	0.60	0.11	0.02	-	-	-	-	0.74
SSE	-	1.55	0.48	0.15	0.01	0.02	-	-	2.21
SE	-	4.21	2.17	0.99	0.34	0.10	-	-	7.81
ESE	-	4.49	3.28	1.67	0.68	0.31	-	-	10.43
E	-	1.79	1.04	0.53	0.20	0.12	-	-	3.67
Calm	46.60	-	-	-	-	-	-	-	46.60
Total (%)	46.60	26.91	15.86	7.08	2.48	1.05	0.02	-	100.00

NOTES

- Measurement of wave direction is absent; as a result, wave direction is assumed the same as wind direction
- The wave direction shown is the direction the waves are coming from

STATUS
ISSUED FOR USE

CLIENT
Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

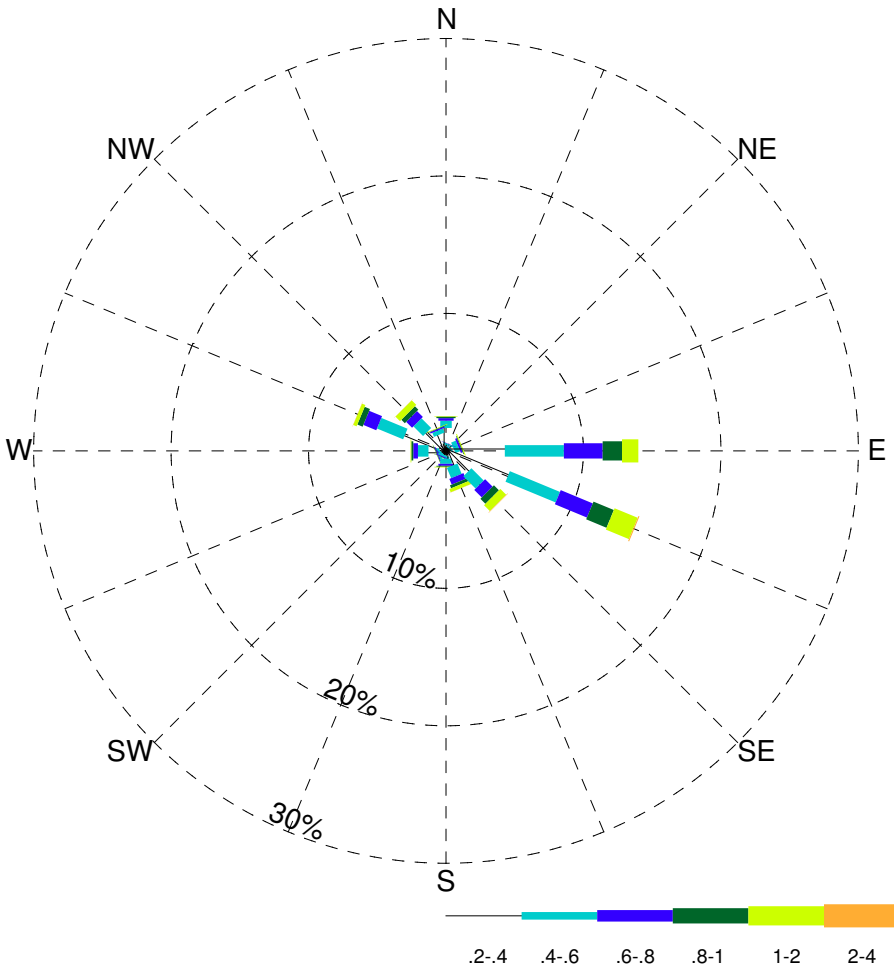
Summer Waves: April-September
Halibut Bank, Strait of Georgia

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	AL	JAS	JAS	1

OFFICE	DATE
EBA-VANC	November 14, 2012

Figure 3.5

eba A TETRA TECH COMPANY



Canadian Buoy C46146
Location:Halibut Bank, SOG
N49° 20' 24.0" W123° 43' 48.0"
Elevation: Sea Level
Sea level: -
Length of Record
Start Date: Mar 13, 1992
End Date: Nov 12, 2012
Comment: -

Wave Height & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-.1 m	.2-.4 m	.4-.6 m	.6-.8 m	.8-1 m	1-2 m	2-4 m	4+ m	Total (%)
ENE	-	0.57	0.37	0.14	0.06	0.07	-	-	1.21
NE	-	0.25	0.10	0.02	-	0.01	-	-	0.39
NNE	-	0.43	0.09	0.02	-	-	-	-	0.55
N	-	1.66	0.53	0.19	0.12	0.04	-	-	2.54
NNW	-	1.27	0.32	0.11	0.04	0.05	-	-	1.79
NW	-	1.94	0.99	0.61	0.36	0.47	0.01	-	4.38
WNW	-	3.20	2.06	1.01	0.41	0.27	0.01	-	6.97
W	-	1.27	0.77	0.34	0.14	0.06	-	-	2.58
WSW	-	0.43	0.18	0.08	0.04	0.01	-	-	0.74
SW	-	0.30	0.12	0.06	0.02	-	-	-	0.50
SSW	-	0.32	0.14	0.06	0.02	0.01	-	-	0.55
S	-	0.56	0.38	0.14	0.07	0.05	-	-	1.21
SSE	-	1.17	0.81	0.45	0.23	0.26	0.01	-	2.93
SE	-	2.20	1.27	0.77	0.51	0.60	0.04	-	5.39
ESE	-	4.86	3.95	2.52	1.60	1.82	0.08	-	14.83
E	-	4.28	4.30	2.82	1.41	1.19	-	-	14.00
Calm	39.44	-	-	-	-	-	-	-	39.44
Total (%)	39.44	24.73	16.38	9.32	5.05	4.89	0.17	-	100.00

NOTES

- Measurement of wave direction is absent; as a result, wave direction is assumed the same as wind direction
- The wave direction shown is the direction the waves are coming from

STATUS
ISSUED FOR USE

CLIENT
Kinder Morgan

A TETRA TECH COMPANY

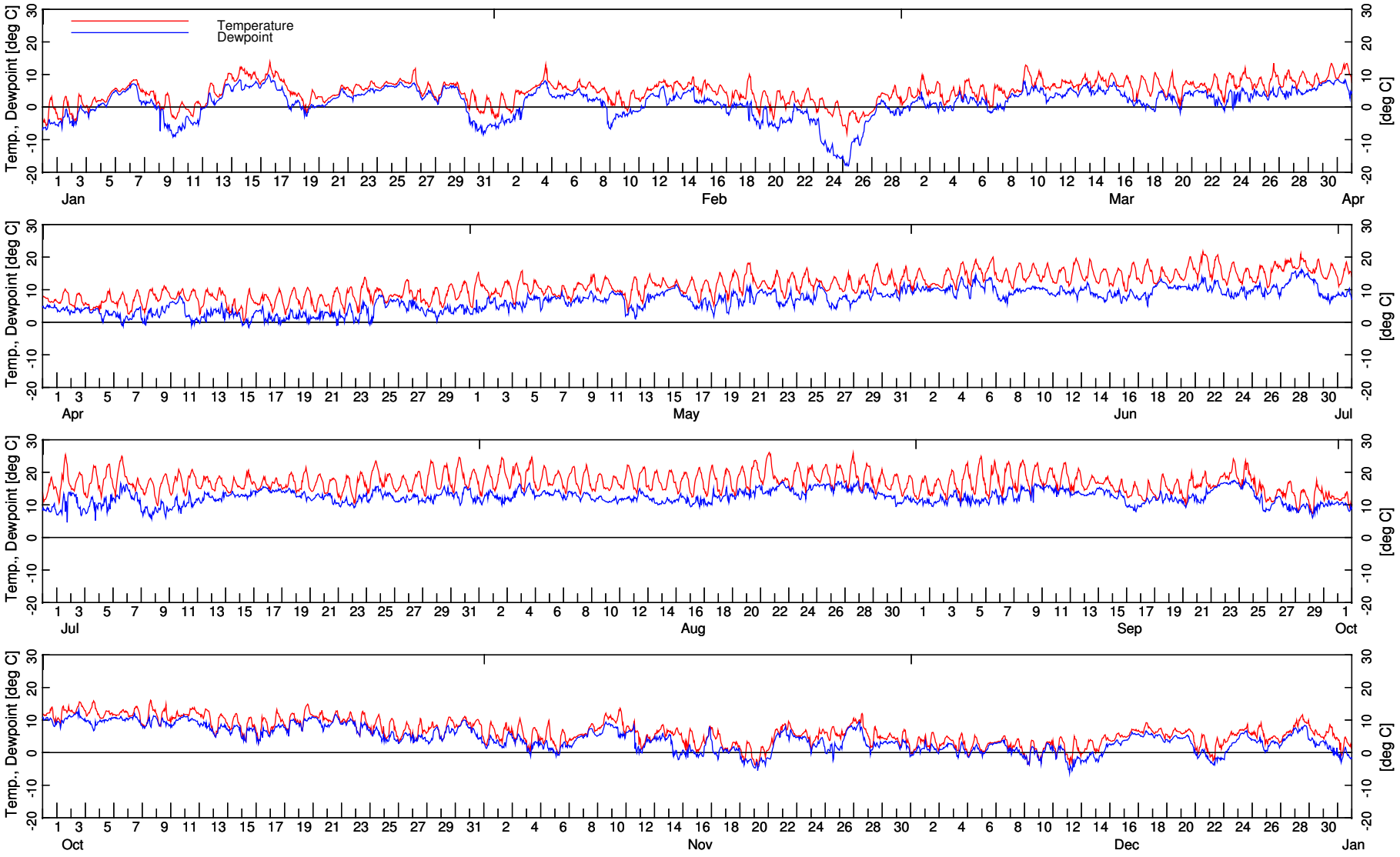
METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Winter Waves: October-March
Halibut Bank, Strait of Georgia

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	AL	JAS	JAS	0

OFFICE: EBA-VANC
DATE: November 14, 2012

Figure 3.6



NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Hourly surface air temperature and dew point
Vancouver Intl Airport: 2011

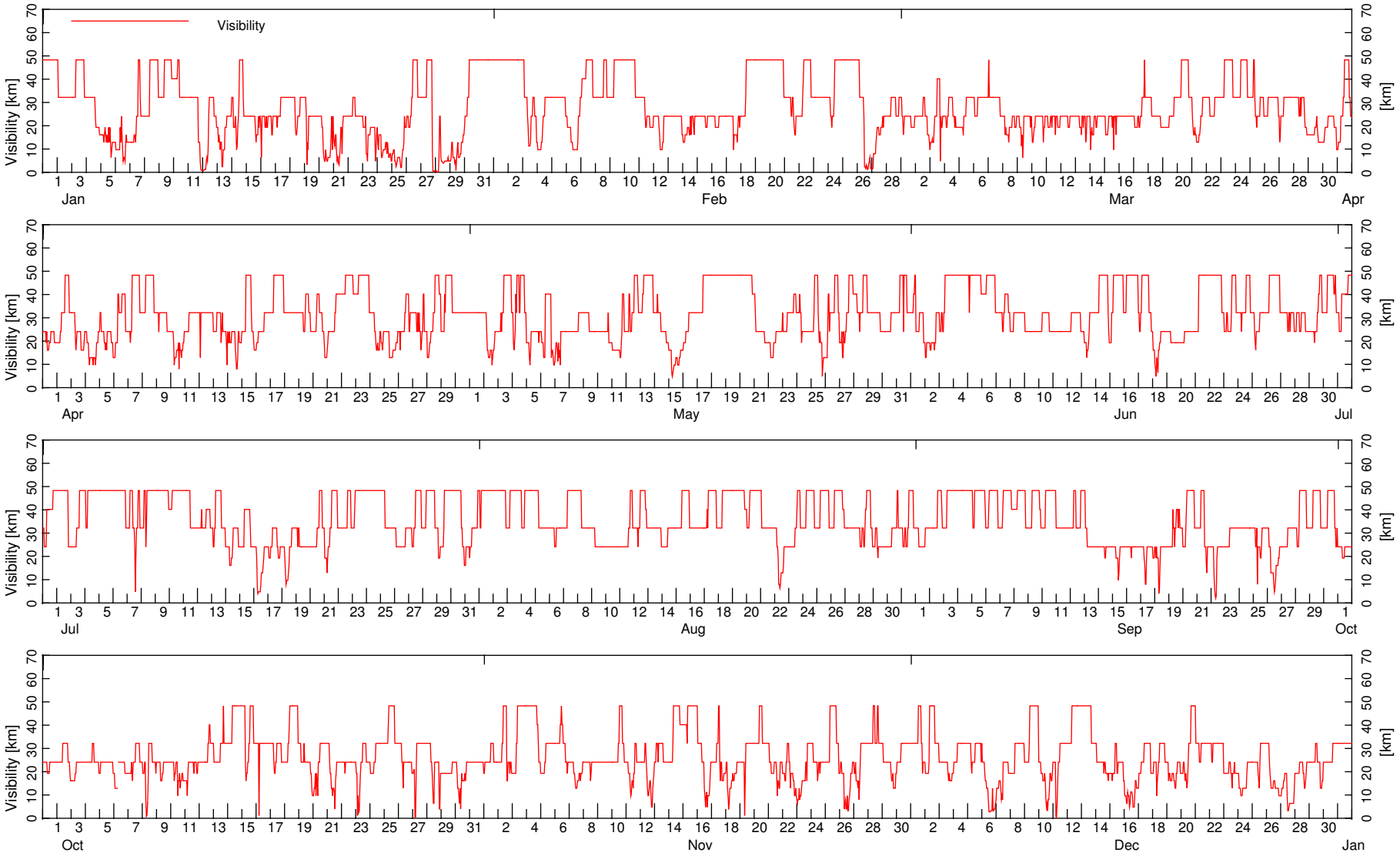
STATUS
ISSUED FOR USE

eba
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 07, 2012

Figure 3.7



NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Hourly visibility
Vancouver Intl Airport: 2011

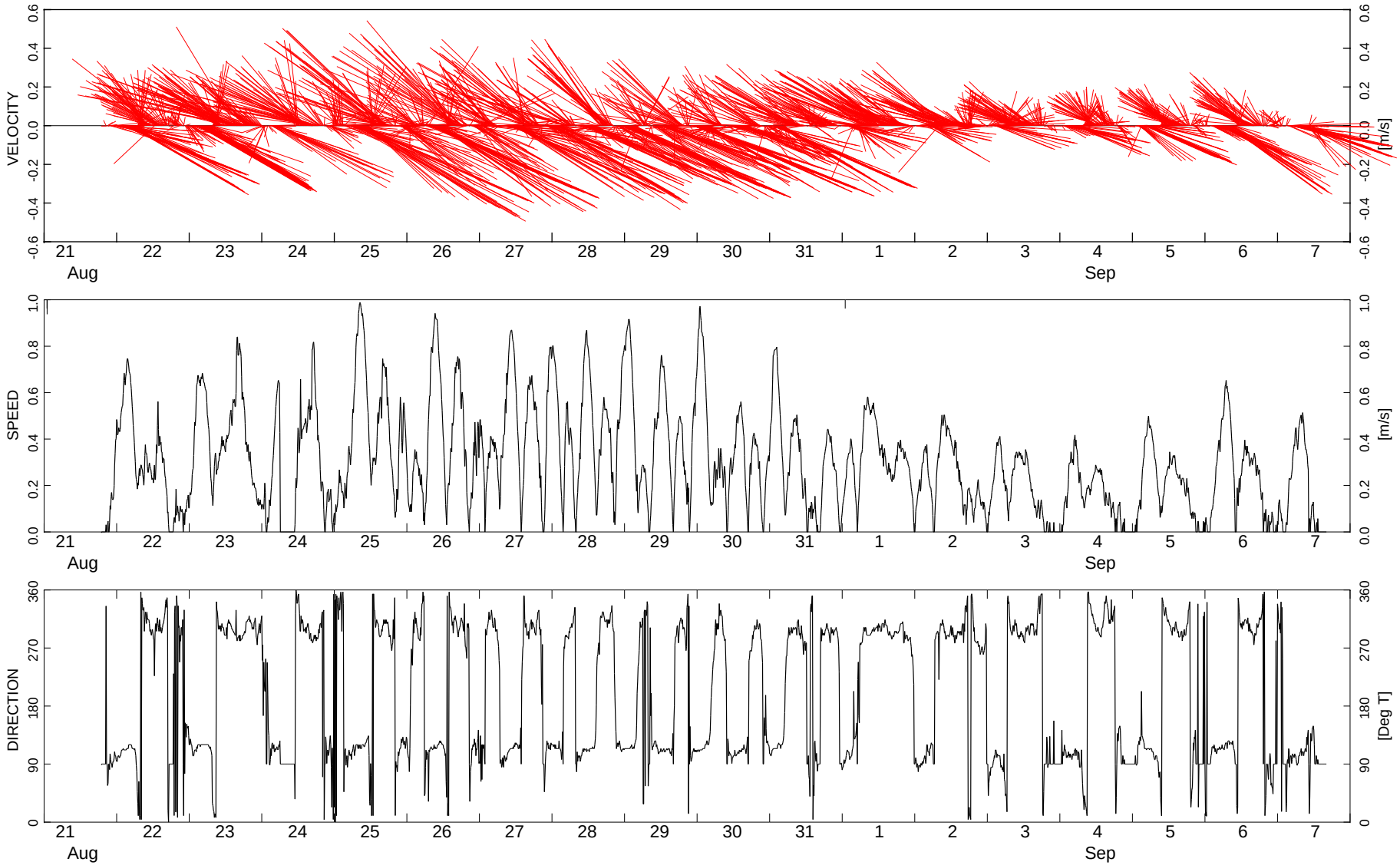
STATUS
ISSUED FOR USE

eba
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 07, 2012

Figure 3.8



NOTES

Time increment: 10 minutes
Instrument depth: 15 m

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Near-Surface Currents in Strait of Georgia near Point Roberts: Aug 21-Sep 7, 1969

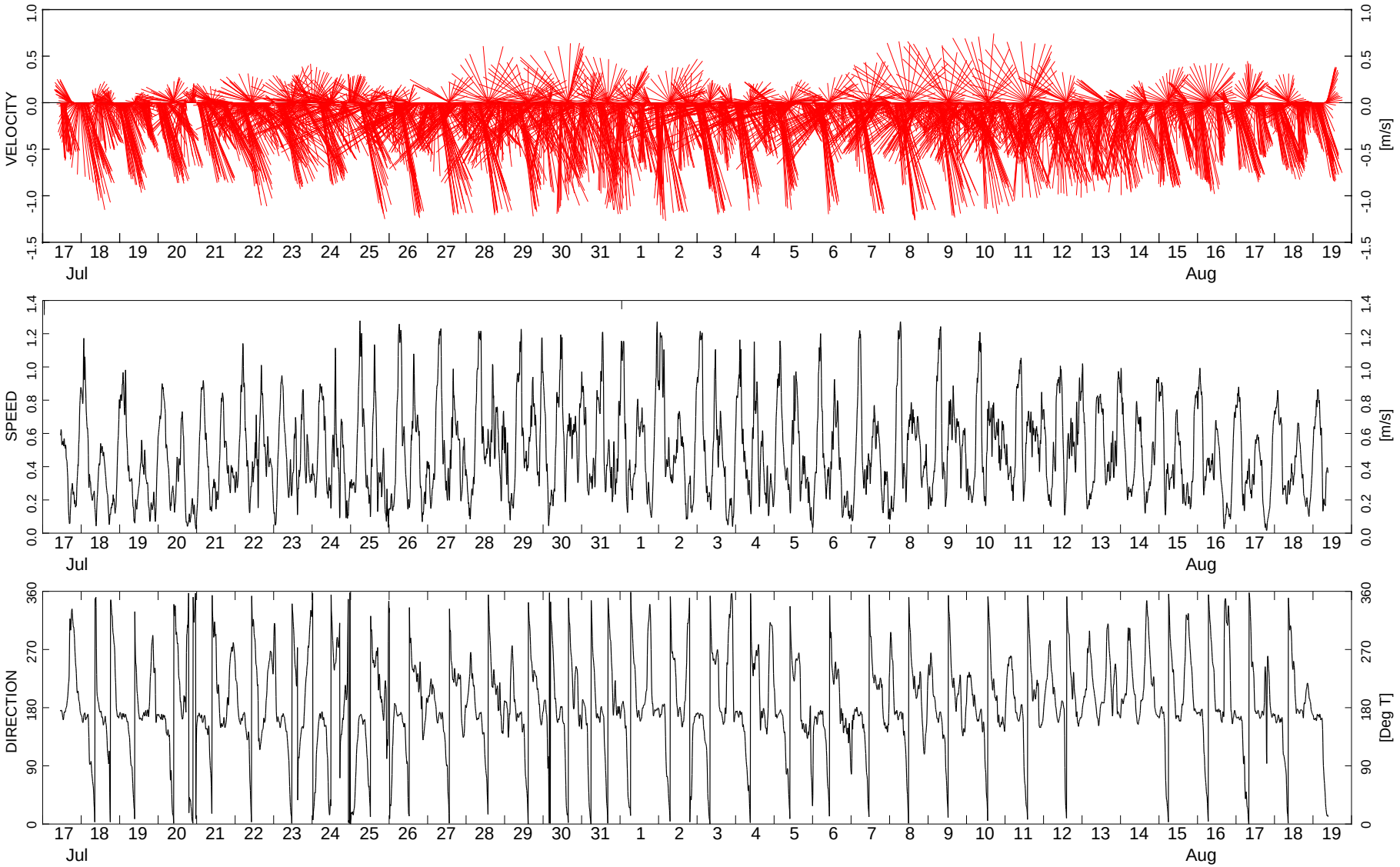
PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 4, 2012

Figure 3.9

STATUS
ISSUED FOR USE

eba
A TETRA TECH COMPANY



NOTES

Time increment: 10 minutes

Instrument depth: 10 m

STATUS
ISSUED FOR USE

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

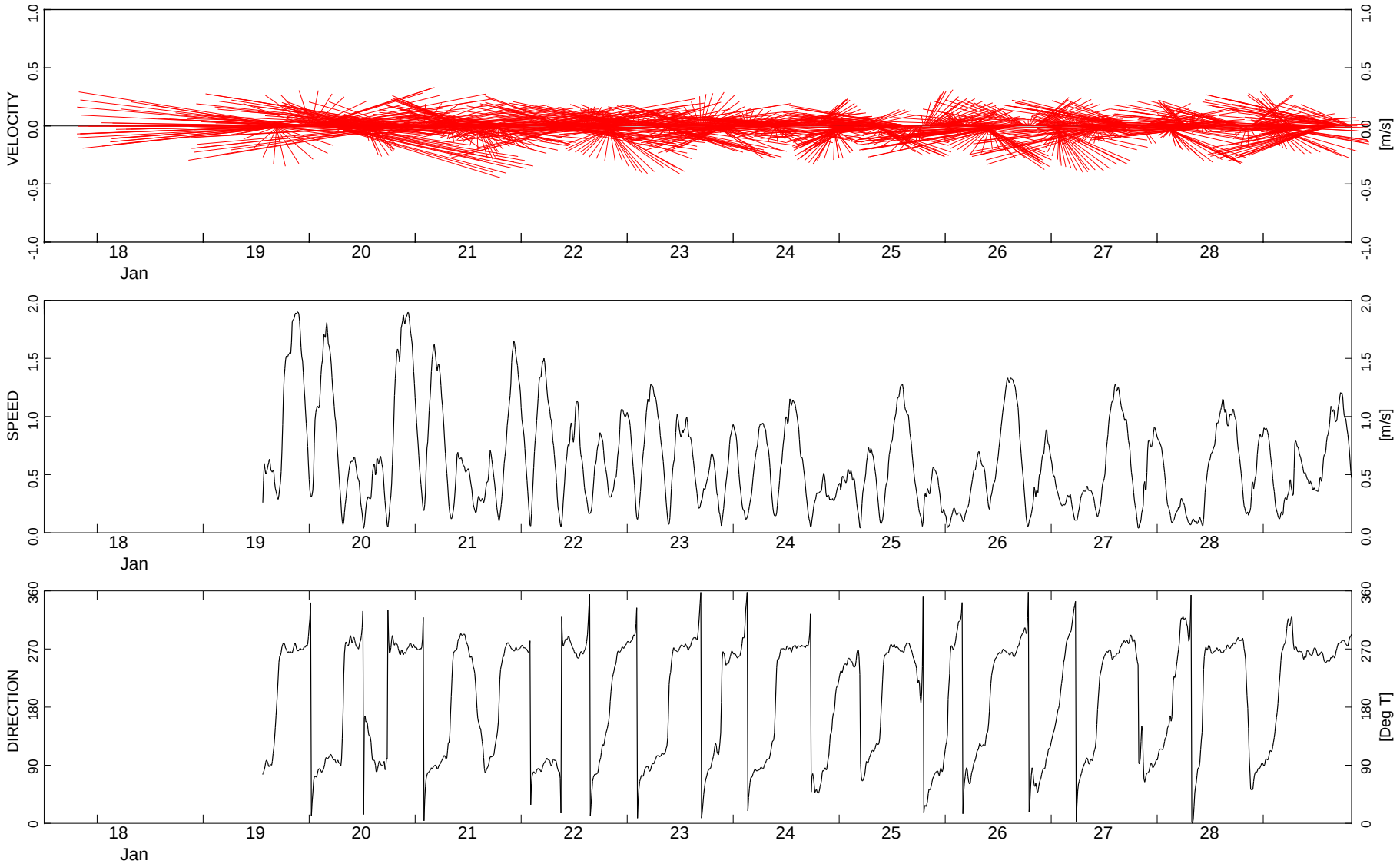
Near-surface currents in Haro Strait near southern exit : Jul 17-Aug 19, 1976

eba
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 4, 2012

Figure 3.10



NOTES

Time increment: 10 minutes
Instrument depth: 18 m

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Near-Surface Currents in Juan de Fuca Strait south of Race Rocks: January 19-28, 1973

STATUS
ISSUED FOR USE

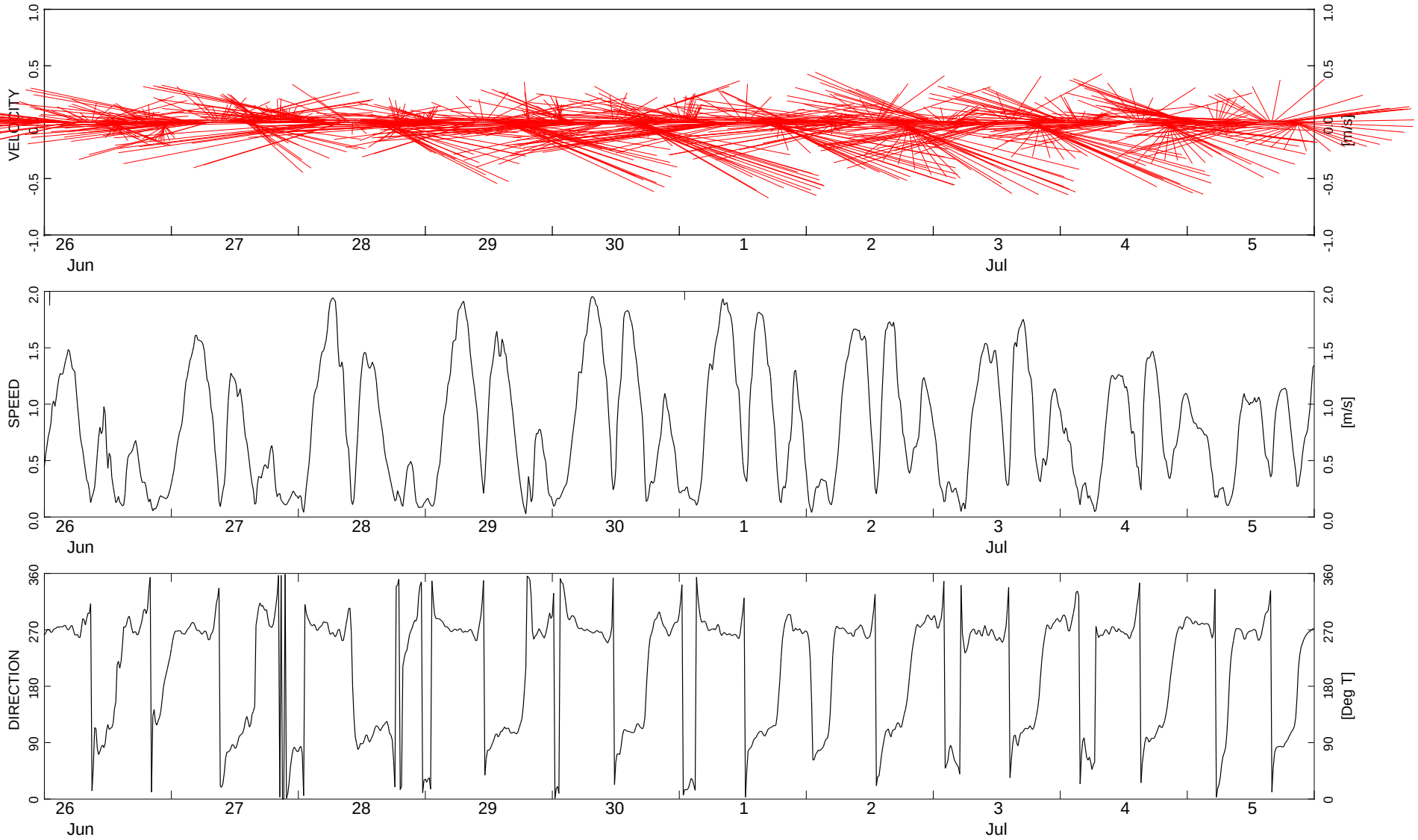
eba
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 4, 2012

Figure 3.11

Tue Dec 04 16:57:13 2012:V:\V13203022 Trans Mountain\working\DD\04_Currents\IOS\Near-surface\JuanDeFuca_Strait



NOTES

Time increment: 15 minutes

Instrument depth: 18 m

STATUS
ISSUED FOR USE

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

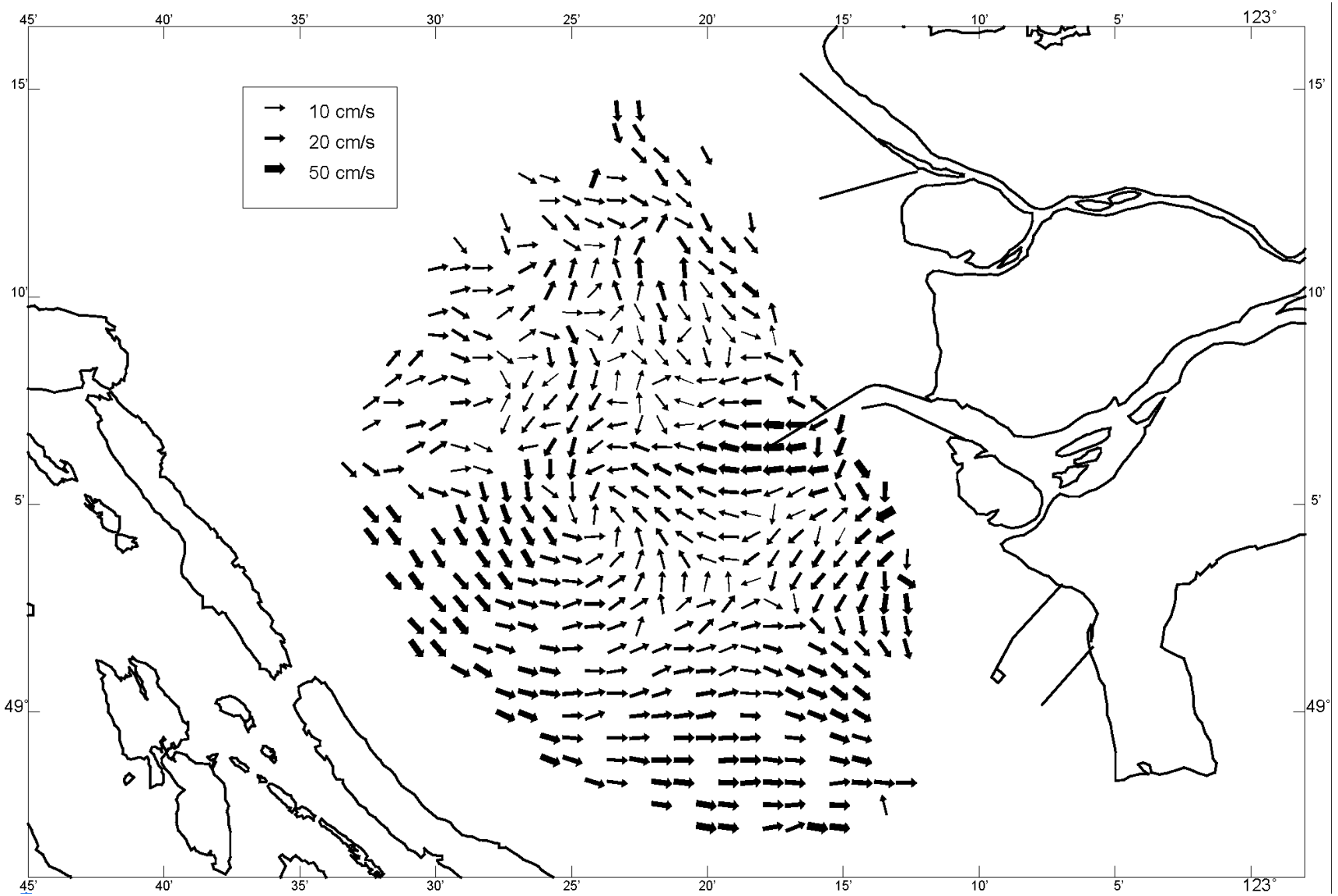
Near-surface currents in Juan de Fuca Strait south of Race Rocks: June 26-July 5, 1973

A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 7, 2012

Figure 3.12



NOTES

STATUS
ISSUED FOR USE

CLIENT
Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

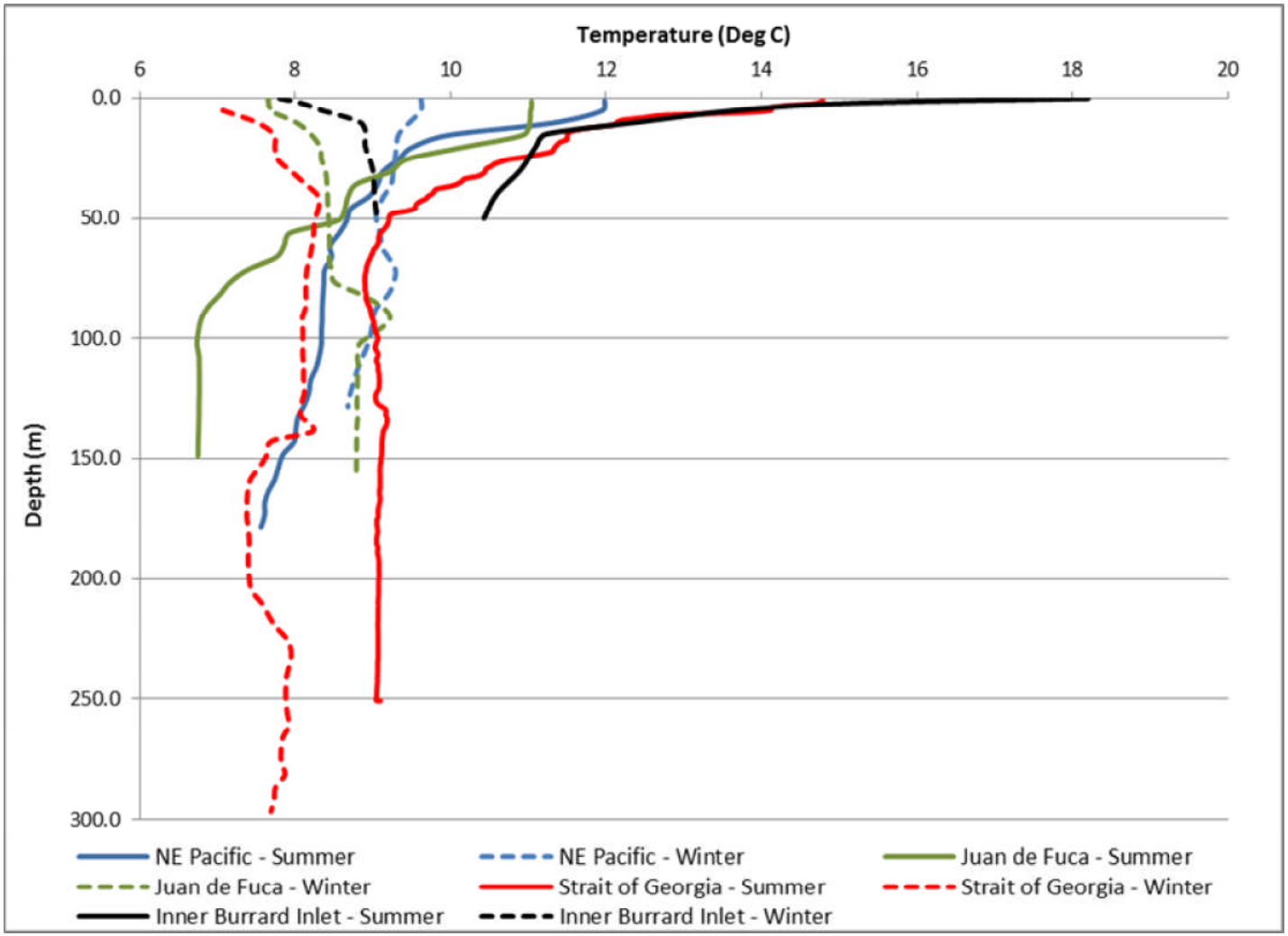
Surface current velocities
from CODAR data: 22:00 UTC 5 Dec 2012

A TETRA TECH COMPANY

PROJECT NO.	DWN	CKD	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC
DATE: January 17, 2013

Figure 3.13



LEGEND

NOTES

STATUS
ISSUED FOR USE

CLIENT
Kinder Morgan

A TETRA TECH COMPANY

METOCEAN DATA
TRANS MOUNTAIN PIPELINE PROJECT

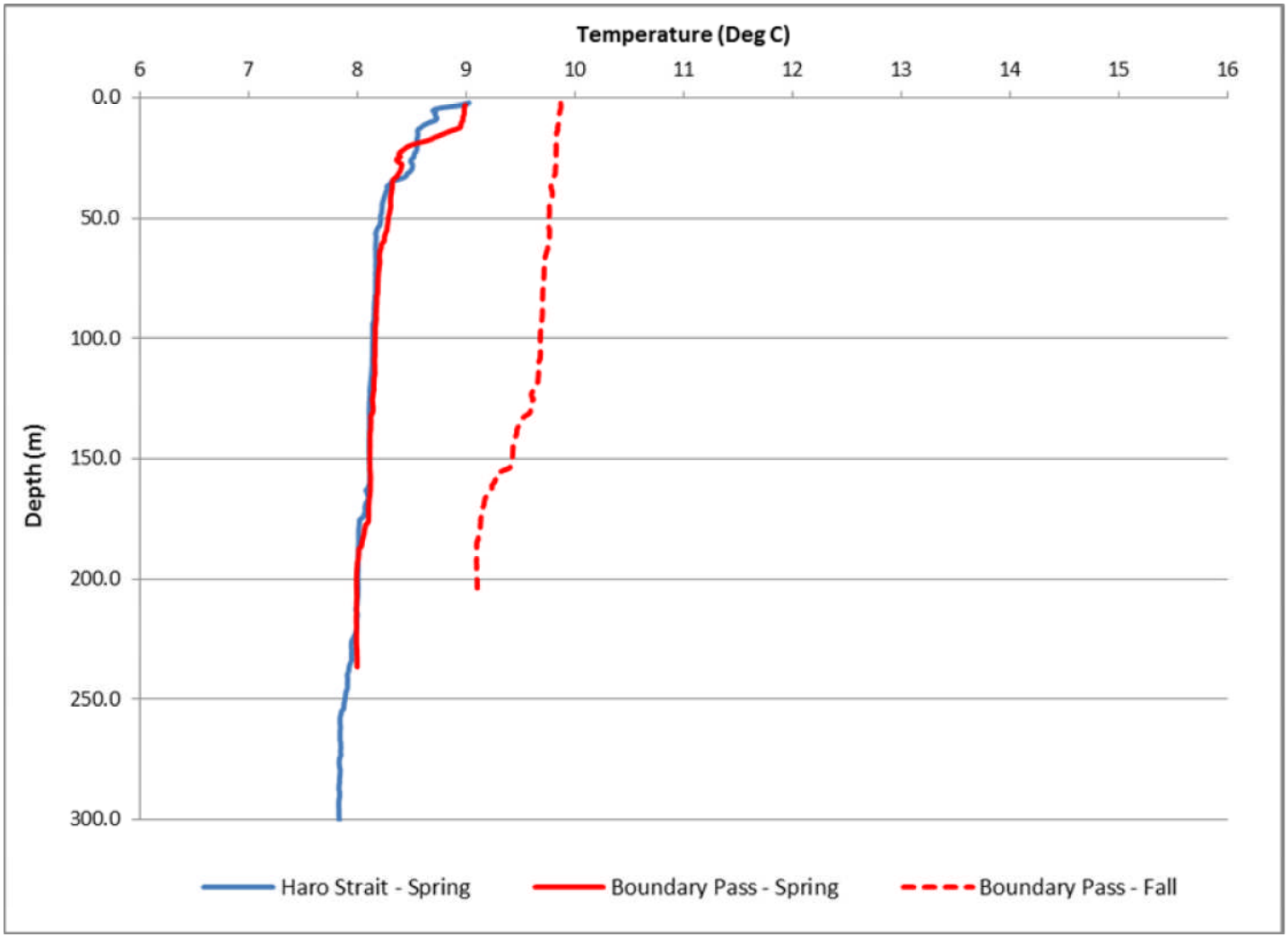
Temperature Profiles
Summer and Winter
Pacific O., Juan de Fuca, Georgia Strait

PROJECT NO.	DWN	CKD	APVD	REV
V13203022	AL	JAS	JAS	1

OFFICE	DATE
EBA-VANC	December 7, 2012

Figure 3.14

C:\Projects\MetOcean\06-CTD\Temp_plot1.doc



LEGEND

NOTES

STATUS
ISSUED FOR USE

CLIENT
Kinder Morgan

A TETRA TECH COMPANY

METOCEAN DATA
TRANS MOUNTAIN PIPELINE PROJECT

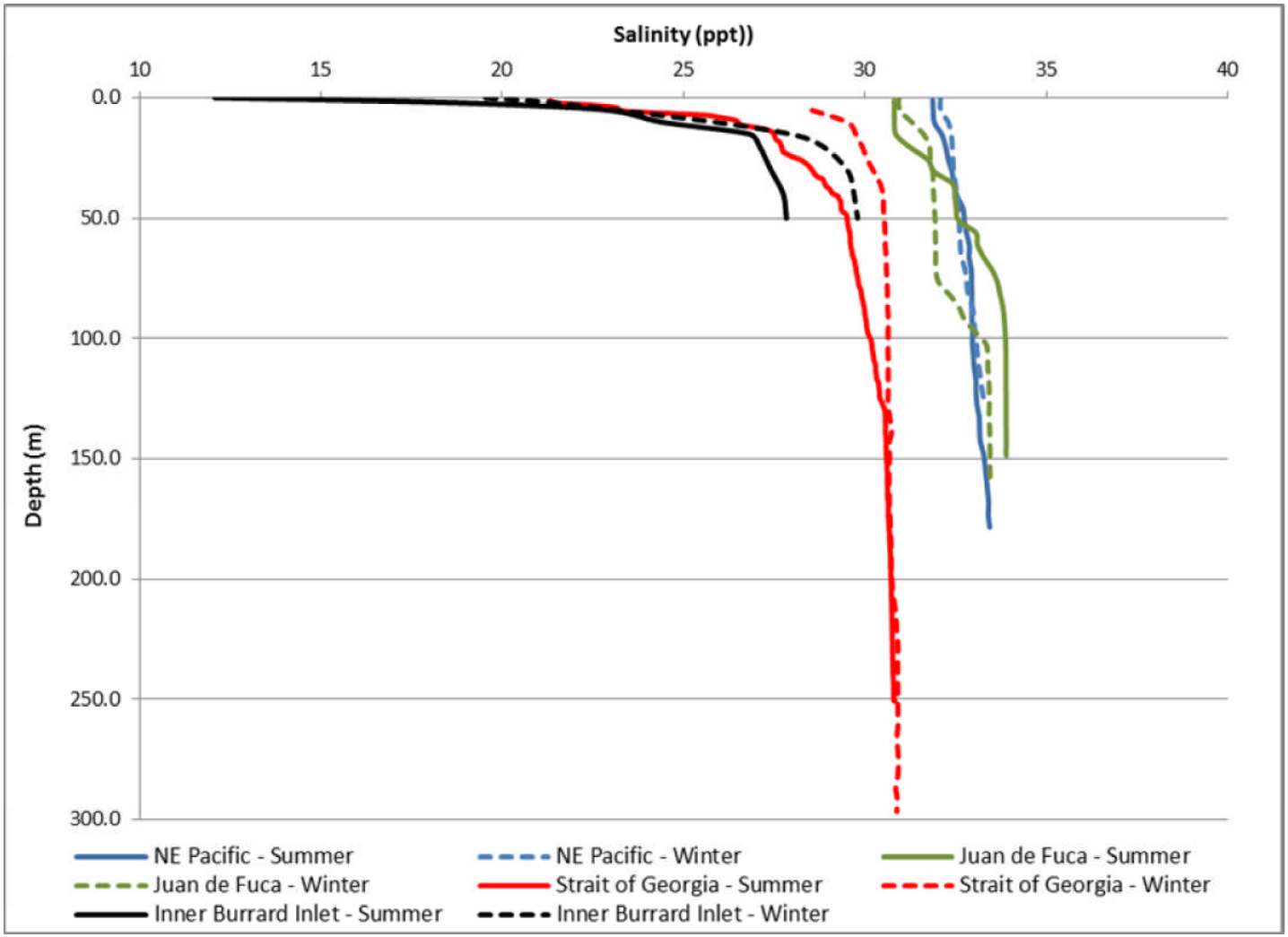
Temperature Profiles
Summer and Winter
Haro Strait and Boundary Pass

PROJECT NO.	DWN	CKD	APVD	REV
V13203022	AL	JAS	JAS	1

OFFICE: EBA-VANC
DATE: December 7, 2012

Figure 3.15

C:\Projects\MetOcean\06-CTD\Temp_plot2.doc



LEGEND

NOTES

STATUS
ISSUED FOR USE

CLIENT
Kinder Morgan

A TETRA TECH COMPANY

METOCEAN DATA
TRANS MOUNTAIN PIPELINE PROJECT

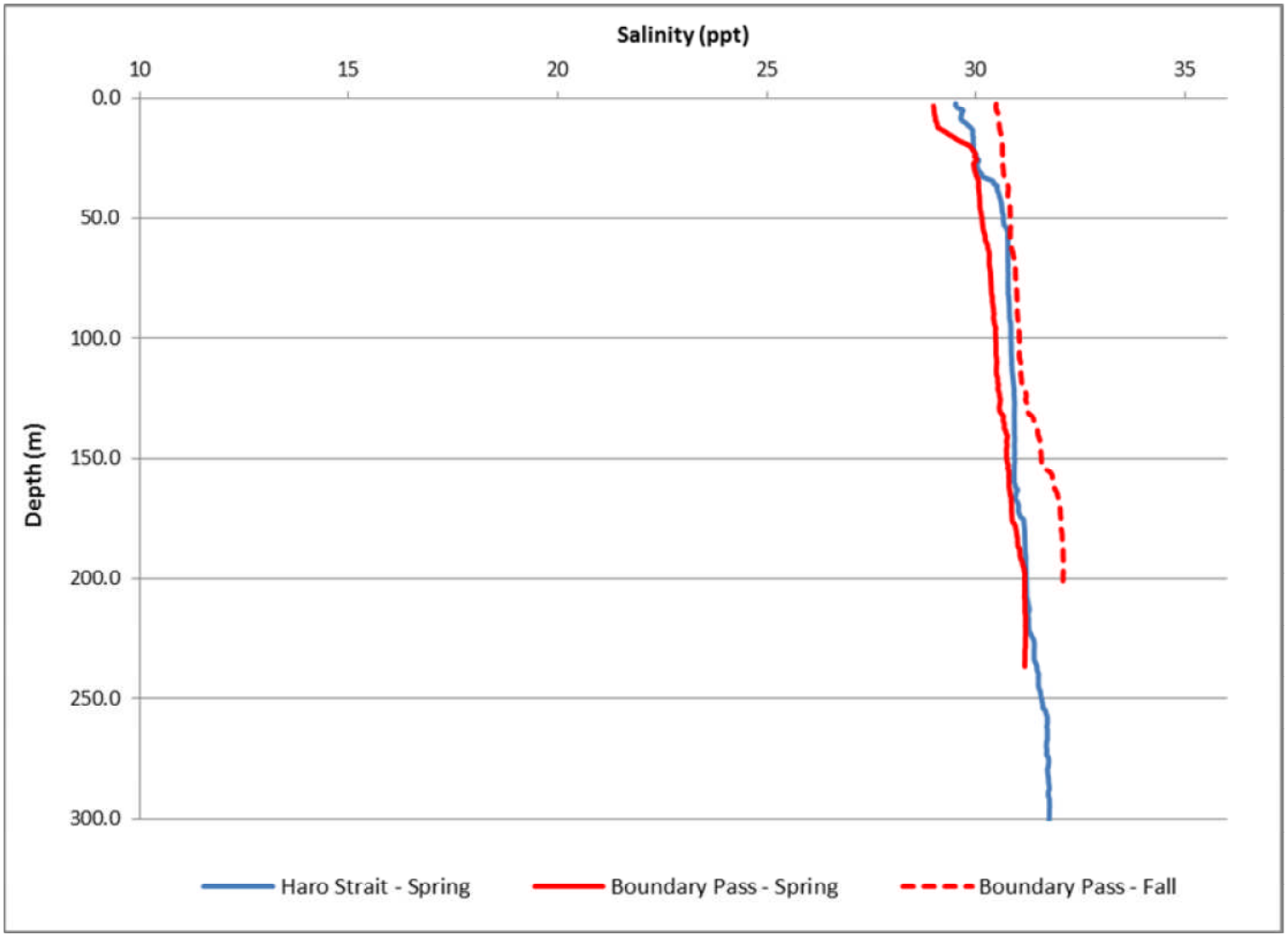
Salinity Profiles
Summer and Winter
Pacific O., Juan de Fuca, Georgia Strait

PROJECT NO.	DWN	CKD	APVD	REV
V13203022	AL	JAS	JAS	1

OFFICE: EBA-VANC
DATE: December 7, 2012

Figure 3.16

C:\Projects\MetOcean\06-CTD\Sal_plot1.doc



LEGEND

NOTES

STATUS
ISSUED FOR USE

CLIENT
Kinder Morgan

A TETRA TECH COMPANY

METOCEAN DATA
TRANS MOUNTAIN PIPELINE PROJECT

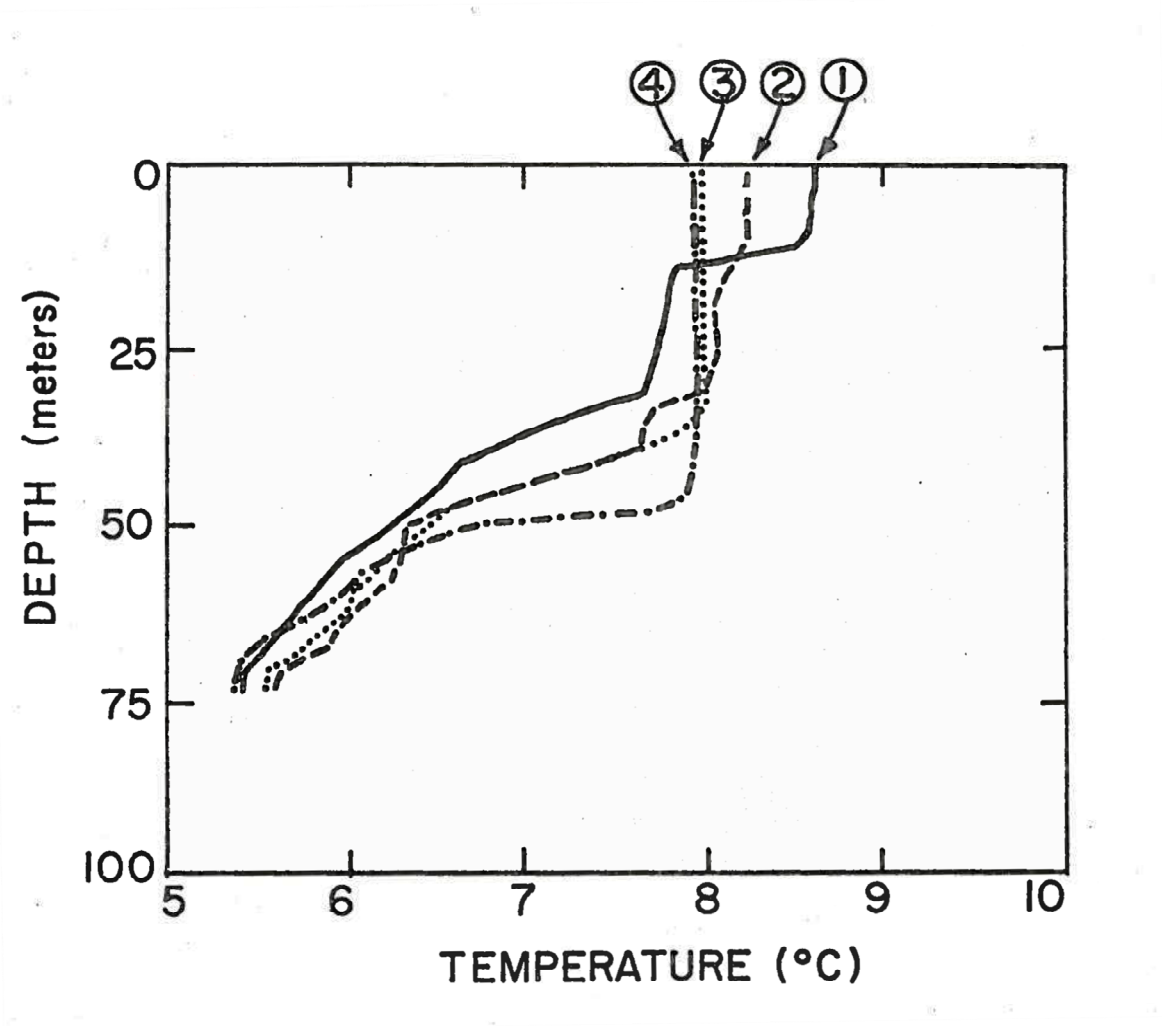
Salinity Profiles
Summer and Winter
Haro Strait and Boundary Pass

PROJECT NO.	DWN	CKD	APVD	REV
V13203022	AL	JAS	JAS	1

OFFICE	DATE
EBA-VANC	December 7, 2012

Figure 3.17

C:\Projects\MetOcean\06-CTD\Sal_plot2.doc



LEGEND

- Source: Denman K.L., 1972. The Response if The Upper Ocean to Meteorologica lForcing
- Location of Ocean Station Papa: 50° N, 145° W, about 1,300 km west of Vancouver Island
- Date of Profiles (all times in GMT): 1: June 21 0430hr; 2: June 22 0045hr; 3: June 22 1500hr; 4: June 23 0900hr.

NOTES

STATUS
ISSUED FOR USE

CLIENT
Kinder Morgan

eba
A TETRA TECH COMPANY

METOCEAN DATA
TRANS MOUNTAIN PIPELINE PROJECT

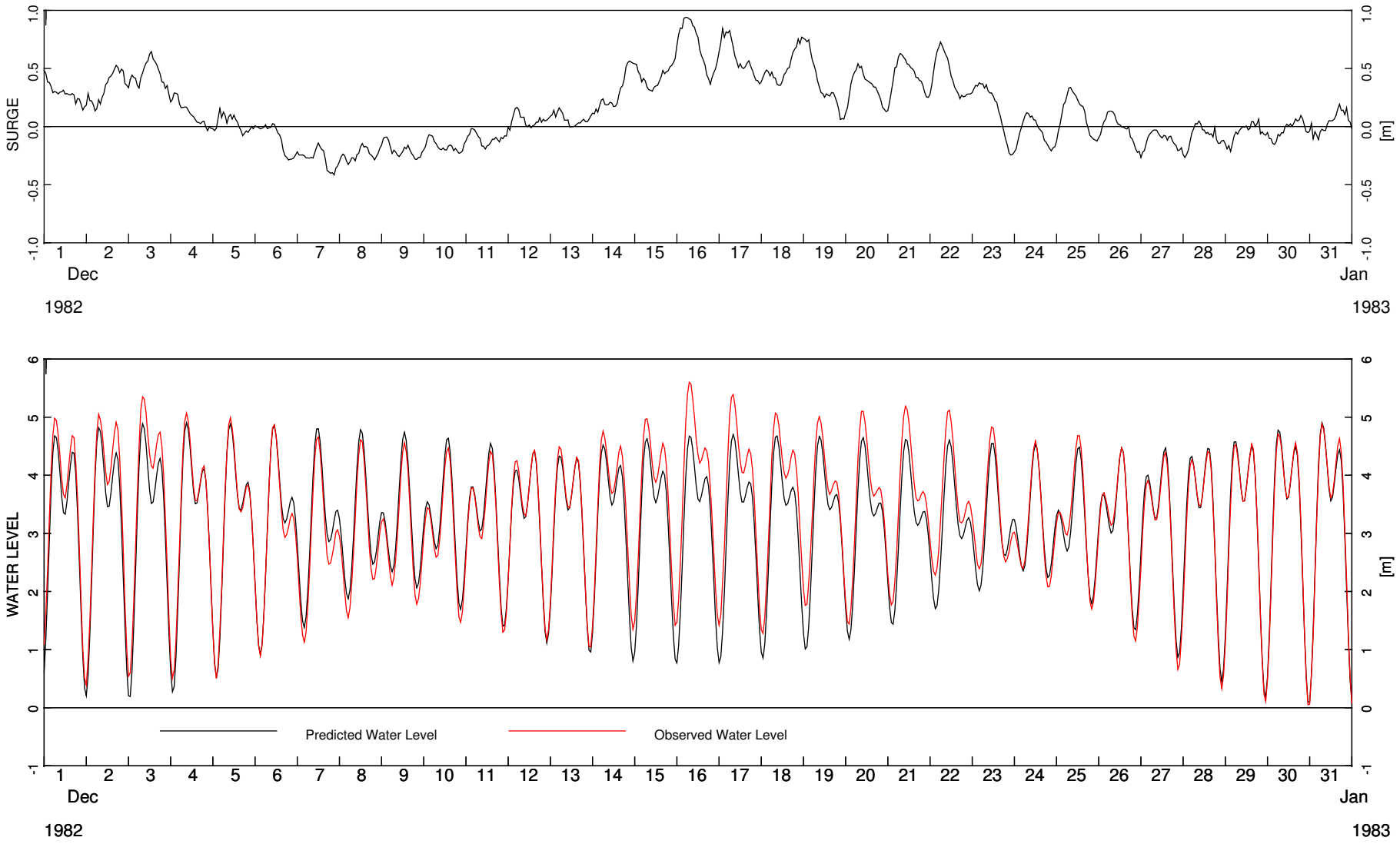
Temperature Profiles during a Wind Storm on June 21-23, 1970 Ocean Station Papa

PROJECT NO.	DWN	CKD	APVD	REV
V13203022	AL	JAS	JAS	1

OFFICE	DATE
EBA-VANC	December 7, 2012

Figure 3.18

C:\Projects\MetOcean\06-CTD\Temp_plot3.doc



NOTES

- Hourly data are presented
- Surge = Observed Water Level - Predicted Water Level

STATUS
ISSUED FOR USE

CLIENT

Kinder Morgan

eba
A TETRA TECH COMPANY

METOCEAN DATA
TRANS MOUNTAIN PIPELINE PROJECT

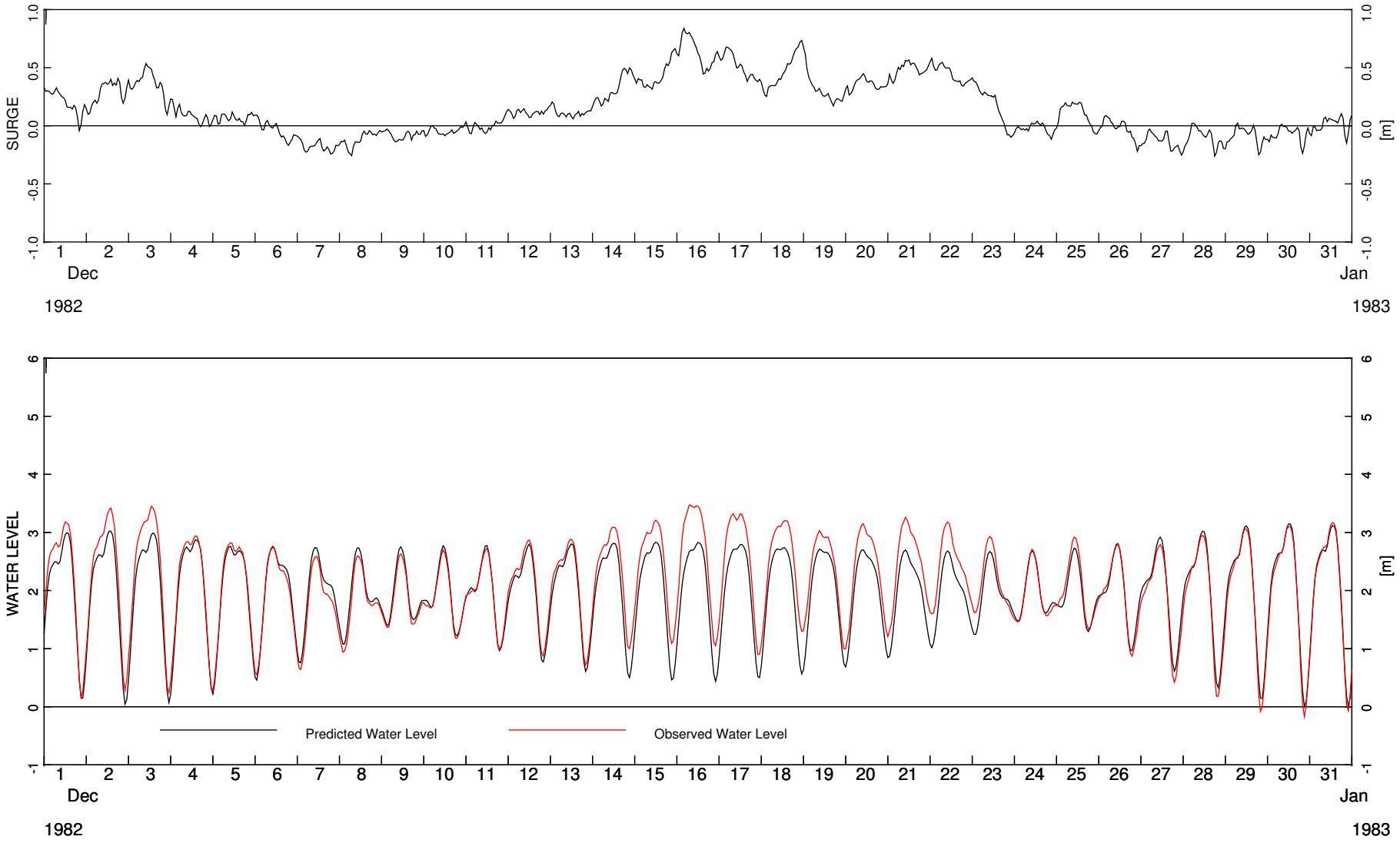
Point Atkinson, Strait of Georgia
Predicted and Observed Water Levels: Dec 1982

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	AL	JAS	JAS	0

OFFICE	DATE
EBA-VANC	November 18, 2012

Figure 3.19

Mon Dec 10 11:02:01 2012:C:\Projects\MetOcean\07-Water_Level\long_time_series



NOTES

- Hourly data are presented
- Surge = Observed Water Level - Predicted Water Level

STATUS
ISSUED FOR USE

CLIENT

Kinder Morgan

A TETRA TECH COMPANY

METOCEAN DATA
TRANS MOUNTAIN PIPELINE PROJECT

Victoria, Juan de Fuca Strait
Predicted and Observed Water Levels: Dec 1982

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	AL	JAS	JAS	0

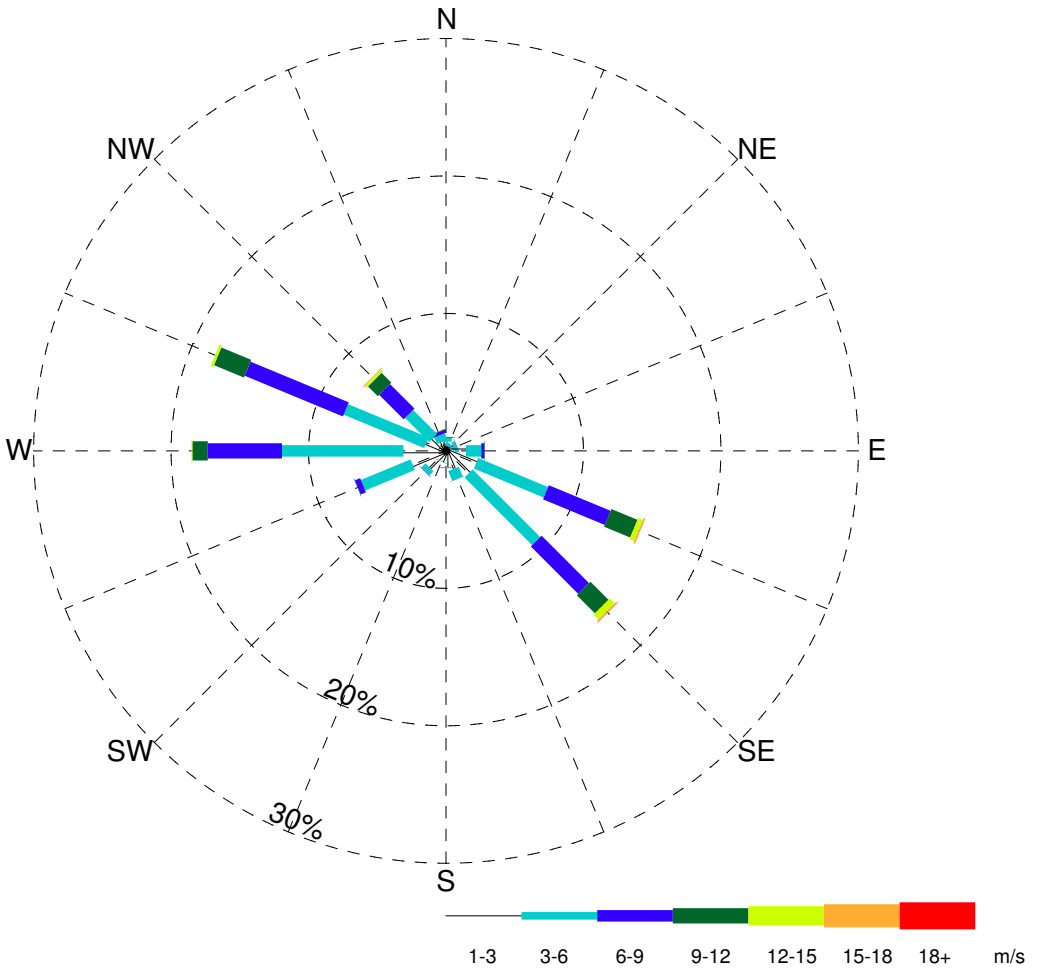
OFFICE	DATE
EBA-VANC	November 18, 2012

Figure 3.20

Mon Dec 10 11:02:39 2012:C:\Projects\MetOcean\07-Water_Level\long_time_series

APPENDIX A

WIND ROSES AND 2011 TIME SERIES PLOTS OF WIND



Ballenas Islands

Location:

N49° 21' 0.0" W124° 9' 36.0"

Elevation: 12.9 m

Sea level: -

Length of Record

Start Date: January 31, 1994

End Date: November 12, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	0.59	0.25	0.02	-	-	-	-	0.87
NE	-	0.39	0.14	0.02	-	-	-	-	0.54
NNE	-	0.36	0.08	-	-	-	-	-	0.45
N	-	0.66	0.28	0.05	0.01	-	-	-	1.00
NNW	-	0.71	0.51	0.25	0.04	0.02	-	-	1.54
NW	-	1.33	2.47	2.52	1.02	0.19	0.07	-	7.60
WNW	-	1.55	6.33	7.74	2.36	0.20	-	-	18.19
W	-	3.10	8.84	5.40	1.12	0.07	-	-	18.52
WSW	-	2.63	3.91	0.41	0.04	-	-	-	6.99
SW	-	1.70	0.43	0.04	-	-	-	-	2.17
SSW	-	0.81	0.05	-	-	-	-	-	0.86
S	-	1.18	0.08	-	-	-	-	-	1.26
SSE	-	1.42	0.76	0.02	-	-	-	-	2.20
SE	-	2.33	6.95	4.89	1.86	0.49	0.12	0.02	16.65
ESE	-	2.36	5.51	4.87	2.05	0.37	0.13	-	15.29
E	-	1.46	1.11	0.23	0.03	-	-	-	2.83
Calm	3.05	-	-	-	-	-	-	-	3.05
Total (%)	3.05	22.57	37.69	26.44	8.54	1.35	0.33	0.03	100.00

NOTES

STATUS
ISSUED FOR USE

CLIENT
Kinder Morgan

A TETRA TECH COMPANY

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

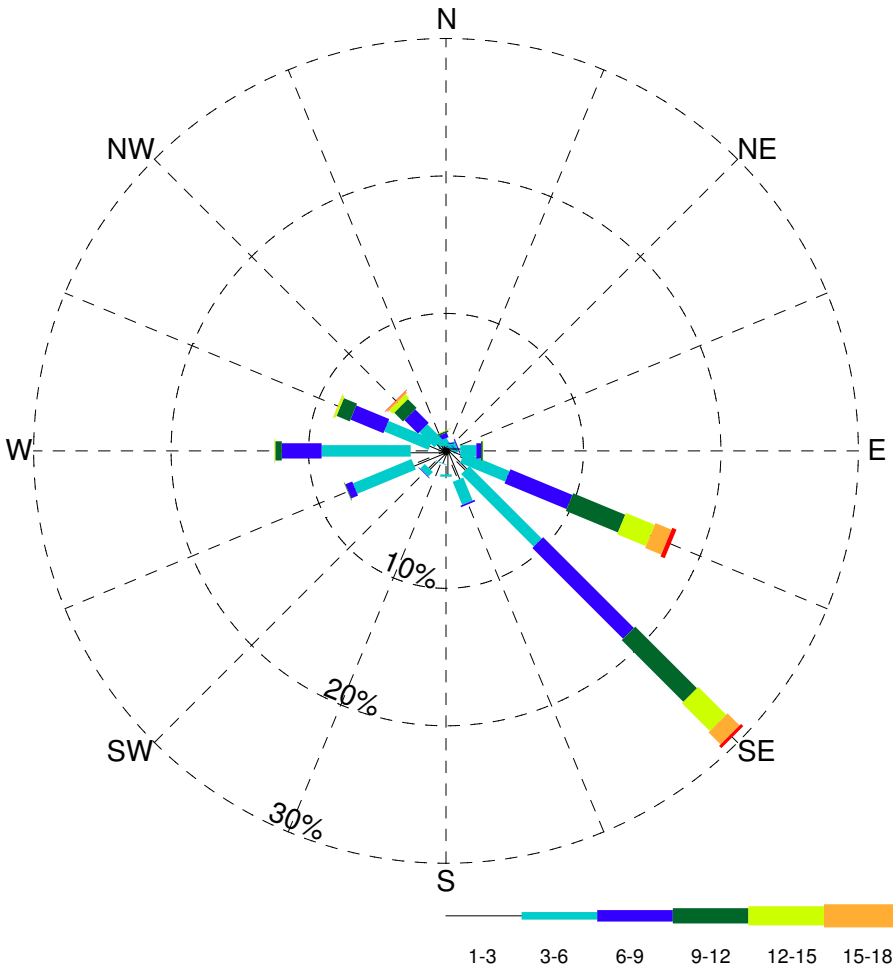
Summer: April-September
Ballenas Islands

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 07, 2012

Figure A.1



Ballenas Islands

Location:

N49° 21' 0.0" W124° 9' 36.0"

Elevation: 12.9 m

Sea level: -

Length of Record

Start Date: January 31, 1994

End Date: November 12, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	0.46	0.38	0.08	0.01	-	-	-	0.93
NE	-	0.31	0.21	0.05	0.01	-	-	-	0.60
NNE	-	0.25	0.08	0.02	-	-	-	-	0.36
N	-	0.37	0.15	0.06	0.01	-	-	-	0.60
NNW	-	0.43	0.43	0.36	0.13	0.04	0.02	-	1.40
NW	-	0.78	1.55	1.39	0.91	0.35	0.16	0.04	5.18
WNW	-	1.21	3.49	2.59	1.04	0.16	0.04	-	8.53
W	-	2.57	6.48	2.89	0.47	0.06	0.01	-	12.50
WSW	-	2.55	4.61	0.54	0.05	0.01	-	-	7.76
SW	-	1.76	0.47	0.05	-	-	-	-	2.29
SSW	-	0.91	0.05	-	-	-	-	-	0.96
S	-	1.71	0.17	-	-	-	-	-	1.88
SSE	-	2.27	1.81	0.12	-	-	-	-	4.21
SE	-	1.98	7.46	9.34	6.35	2.86	1.24	0.23	29.46
ESE	-	1.28	3.56	4.89	4.10	2.27	1.26	0.33	17.69
E	-	1.04	1.16	0.34	0.12	0.03	-	-	2.71
Calm	2.96	-	-	-	-	-	-	-	2.96
Total (%)	2.96	19.86	32.08	22.73	13.23	5.79	2.73	0.61	100.00

NOTES

STATUS
ISSUED FOR USE

CLIENT
Kinder Morgan

A TETRA TECH COMPANY

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

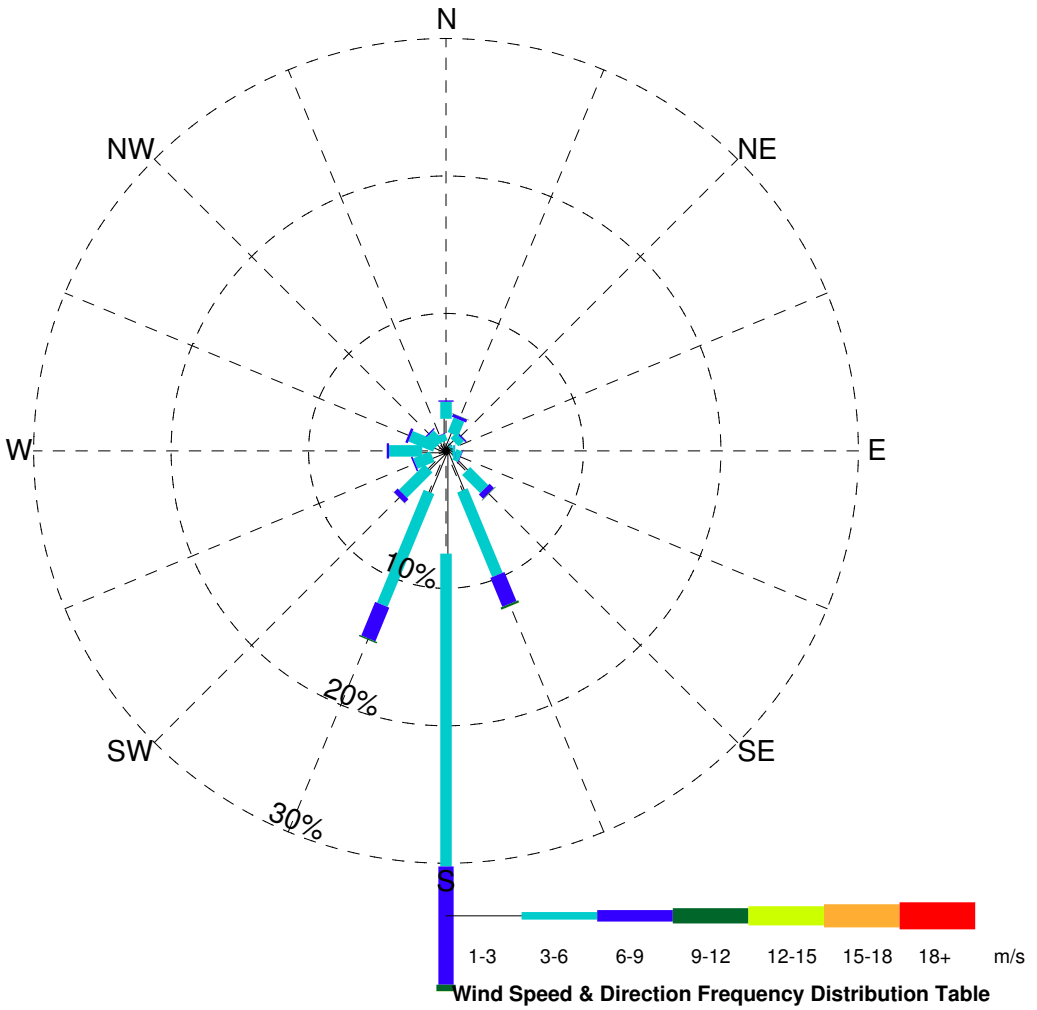
Winter: October-March
Ballenas Islands

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 07, 2012

Figure A.2



Wind Speed & Direction Frequency Distribution Table

Bellingham Intl

Location:

N48° 47' 38.4" W122° 32' 13.2"

Elevation: 46.0 m

Sea level: -

Length of Record

Start Date: January 01, 1948

End Date: November 01, 2012

Comment: -

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	0.33	0.16	0.02	-	-	-	-	0.51
NE	-	0.88	0.56	0.12	0.02	-	-	-	1.58
NNE	-	1.32	1.14	0.23	0.03	-	-	-	2.73
N	-	2.34	1.24	0.10	-	-	-	-	3.68
NNW	-	0.68	0.52	0.04	-	-	-	-	1.24
NW	-	0.71	0.99	0.10	-	-	-	-	1.81
WNW	-	0.85	1.94	0.19	-	-	-	-	2.98
W	-	1.73	2.41	0.17	-	-	-	-	4.32
WSW	-	1.08	1.34	0.12	-	-	-	-	2.54
SW	-	1.80	2.61	0.39	0.02	-	-	-	4.83
SSW	-	3.23	8.89	2.65	0.11	-	-	-	14.88
S	-	7.47	22.76	8.60	0.47	0.01	-	-	39.32
SSE	-	3.11	6.66	2.28	0.17	0.02	-	-	12.23
SE	-	2.07	1.86	0.44	0.05	-	-	-	4.43
ESE	-	0.66	0.46	0.04	-	-	-	-	1.16
E	-	0.48	0.17	0.01	-	-	-	-	0.67
Calm	1.10	-	-	-	-	-	-	-	1.10
Total (%)	1.10	28.74	53.72	15.50	0.89	0.04	-	0.01	100.00

NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Summer: April-September
Bellingham Intl

STATUS
ISSUED FOR USE

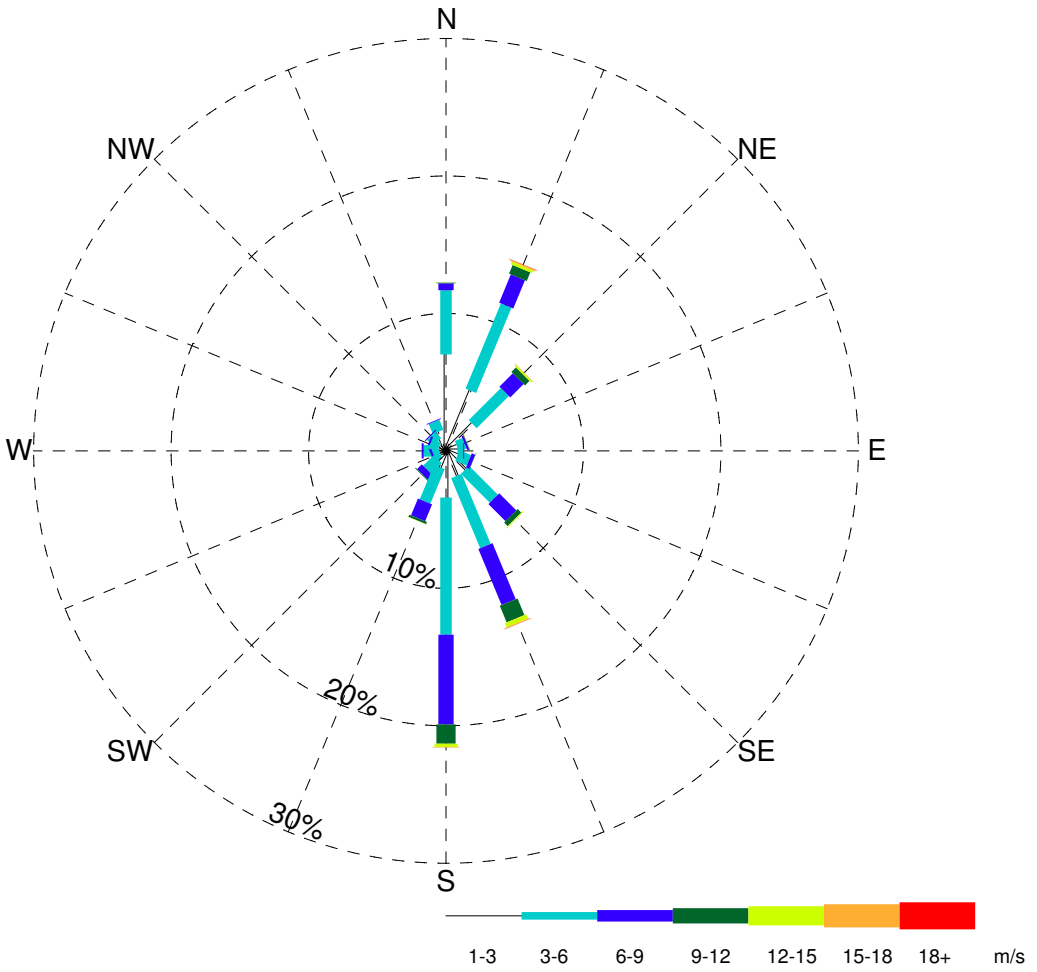
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 07, 2012

Figure A.3



Bellingham Intl

Location:

N48° 47' 38.4" W122° 32' 13.2"

Elevation: 46.0 m

Sea level: -

Length of Record

Start Date: January 01, 1948

End Date: November 01, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	0.87	0.58	0.16	0.04	0.01	0.01	-	1.66
NE	-	2.75	3.31	1.38	0.46	0.13	0.04	-	8.06
NNE	-	4.73	6.71	2.22	0.68	0.21	0.09	0.02	14.68
N	-	7.02	4.67	0.50	0.05	0.01	-	-	12.27
NNW	-	1.50	0.79	0.06	-	-	-	-	2.35
NW	-	0.91	0.64	0.08	-	-	-	-	1.64
WNW	-	0.58	0.67	0.14	-	-	-	-	1.40
W	-	0.84	0.78	0.14	-	-	-	-	1.78
WSW	-	0.46	0.48	0.16	0.02	-	-	-	1.12
SW	-	0.86	1.08	0.49	0.06	-	-	-	2.49
SSW	-	1.26	2.72	1.32	0.17	0.02	-	-	5.50
S	-	3.39	9.98	6.52	1.41	0.23	0.04	-	21.58
SSE	-	1.98	5.52	4.41	1.31	0.33	0.08	0.01	13.64
SE	-	1.95	2.97	1.75	0.37	0.07	0.01	-	7.14
ESE	-	0.90	0.90	0.27	0.03	-	-	-	2.11
E	-	0.84	0.42	0.06	-	-	-	-	1.33
Calm	1.26	-	-	-	-	-	-	-	1.26
Total (%)	1.26	30.84	42.23	19.67	4.63	1.03	0.29	0.06	100.00

NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Winter: October-March
Bellingham Intl

STATUS
ISSUED FOR USE

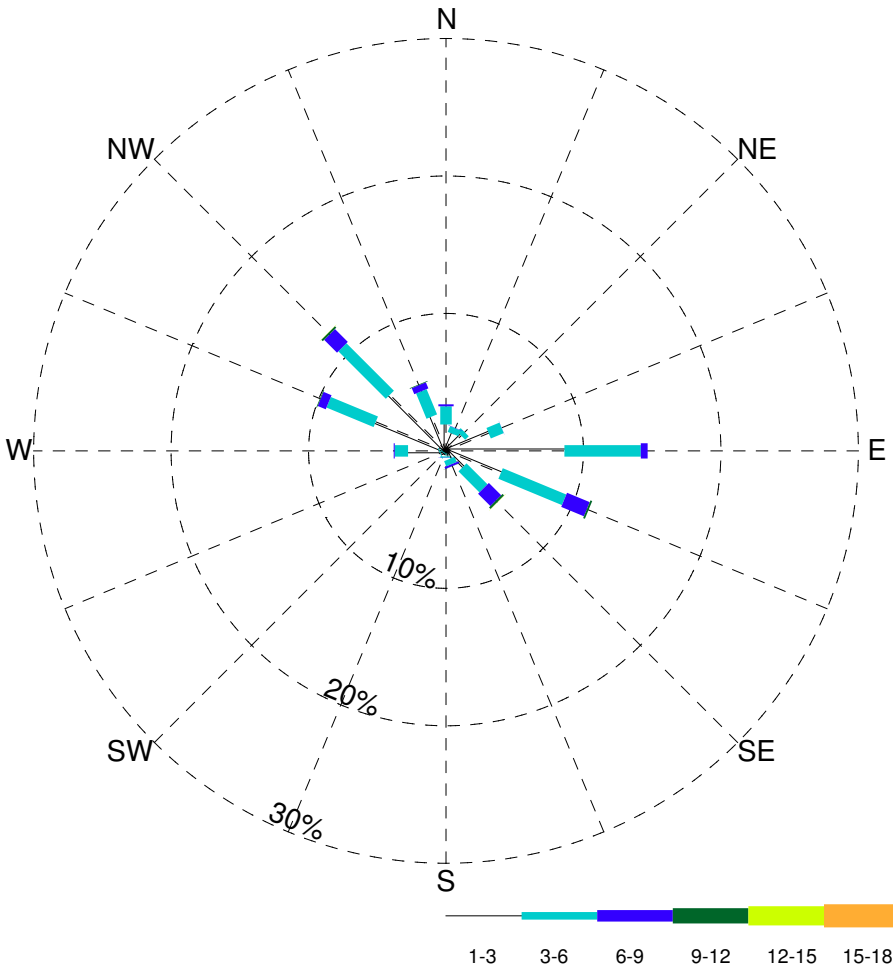
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 07, 2012

Figure A.4



Campbell River Airport

Location:

N49° 57’ 0.0" W125° 16’ 12.0"

Elevation: 108.8 m

Sea level: -

Length of Record

Start Date: March 01, 1979

End Date: November 12, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	3.36	1.02	0.01	-	-	-	-	4.39
NE	-	1.56	0.36	-	-	-	-	-	1.93
NNE	-	1.33	0.46	0.02	-	-	-	-	1.80
N	-	1.92	1.32	0.14	-	-	-	-	3.39
NNW	-	2.70	1.99	0.48	0.05	-	-	-	5.23
NW	-	5.78	4.88	1.32	0.14	0.01	-	-	12.14
WNW	-	5.53	3.71	0.63	0.06	-	-	-	9.94
W	-	2.76	0.97	0.08	-	-	-	-	3.81
WSW	-	0.41	0.06	-	-	-	-	-	0.48
SW	-	0.18	0.03	-	-	-	-	-	0.22
SSW	-	0.15	0.03	-	-	-	-	-	0.19
S	-	0.40	0.09	0.02	-	-	-	-	0.51
SSE	-	0.64	0.41	0.15	0.02	-	-	-	1.21
SE	-	1.70	2.16	1.27	0.16	0.02	-	-	5.30
ESE	-	4.30	5.00	1.79	0.14	-	-	-	11.24
E	-	8.61	5.56	0.50	-	-	-	-	14.67
Calm	23.55	-	-	-	-	-	-	-	23.55
Total (%)	23.55	41.33	28.06	6.42	0.58	0.05	-	-	100.00

NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Summer: April-September
Campbell River Airport

STATUS
ISSUED FOR USE

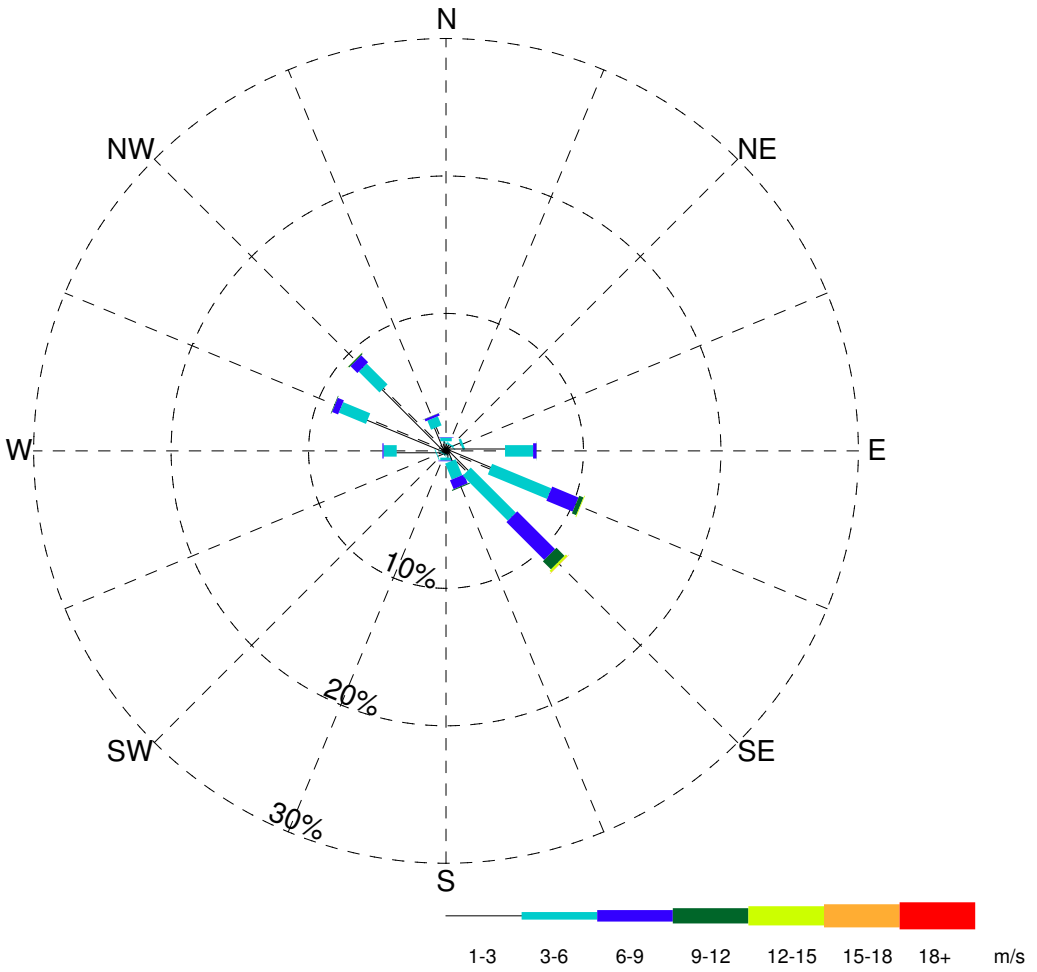
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 07, 2012

Figure A.5



Campbell River Airport

Location:

N49° 57’ 0.0" W125° 16’ 12.0"

Elevation: 108.8 m

Sea level: -

Length of Record

Start Date: March 01, 1979

End Date: November 12, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	1.16	0.18	-	-	-	-	-	1.35
NE	-	0.50	0.06	-	-	-	-	-	0.56
NNE	-	0.48	0.07	-	-	-	-	-	0.57
N	-	0.70	0.27	0.03	-	-	-	-	1.00
NNW	-	1.84	0.71	0.17	0.02	-	-	-	2.75
NW	-	6.43	2.14	0.71	0.09	0.01	-	-	9.38
WNW	-	6.14	2.14	0.48	0.05	-	-	-	8.80
W	-	3.59	0.95	0.08	-	-	-	-	4.63
WSW	-	0.68	0.06	-	-	-	-	-	0.74
SW	-	0.28	0.03	-	-	-	-	-	0.31
SSW	-	0.23	0.03	-	-	-	-	-	0.26
S	-	0.49	0.22	0.05	-	-	-	-	0.76
SSE	-	0.83	1.25	0.70	0.08	-	-	-	2.87
SE	-	2.13	4.64	3.89	0.83	0.16	0.03	-	11.69
ESE	-	3.46	4.67	2.07	0.34	0.05	-	-	10.61
E	-	4.29	2.04	0.25	0.01	-	-	-	6.60
Calm	37.12	-	-	-	-	-	-	-	37.12
Total (%)	37.12	33.23	19.47	8.47	1.43	0.24	0.04	-	100.00

NOTES

STATUS
ISSUED FOR USE

CLIENT
Kinder Morgan

A TETRA TECH COMPANY

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

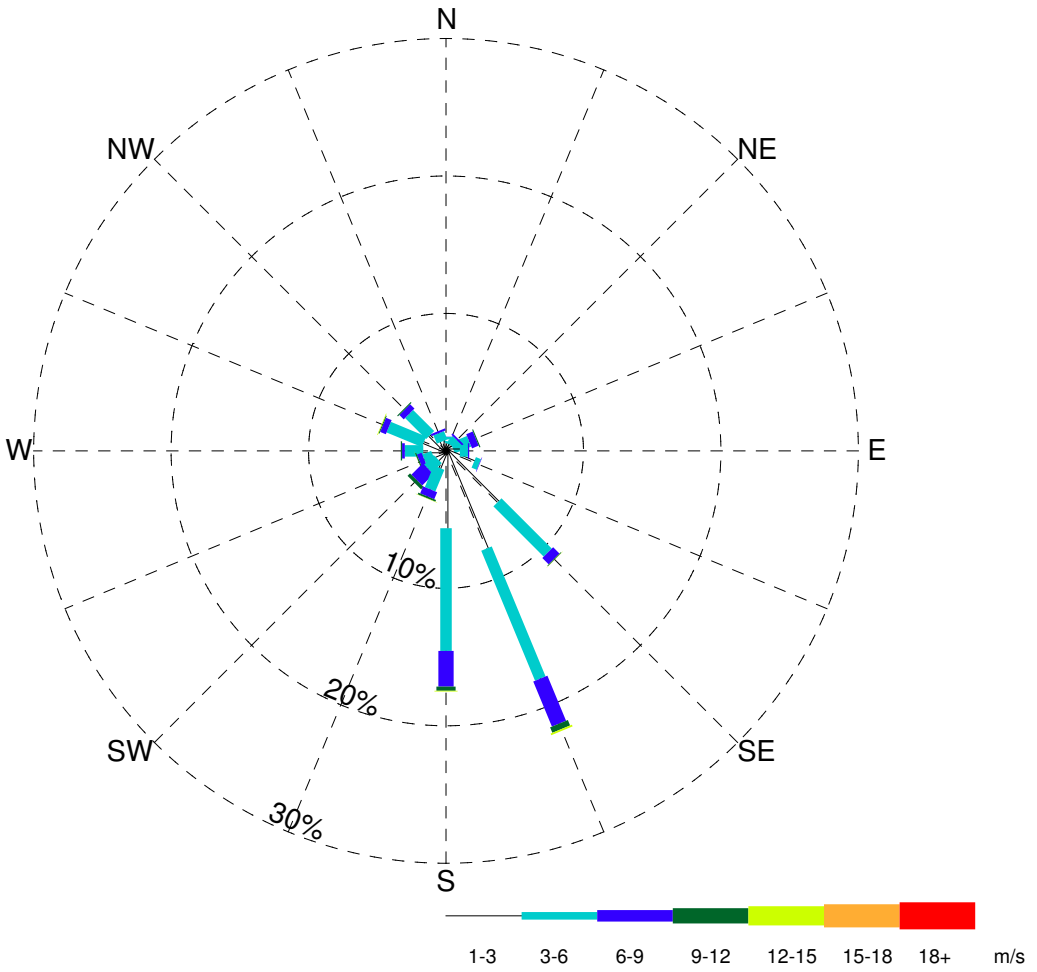
Winter: October-March
Campbell River Airport

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 07, 2012

Figure A.6



Cherry Point

Location:

N48° 52' 1.2" W122° 45' 0.0"

Elevation: 5.0 m

Sea level: -

Length of Record

Start Date: April 19, 2005

End Date: November 01, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	0.53	1.29	0.52	0.08	-	-	-	2.42
NE	-	0.55	0.56	0.13	-	-	-	-	1.25
NNE	-	0.52	0.16	-	-	-	-	-	0.69
N	-	0.84	0.18	0.02	-	-	-	-	1.03
NNW	-	0.74	0.65	0.16	-	-	-	-	1.55
NW	-	1.63	2.17	0.45	0.08	-	-	-	4.33
WNW	-	1.73	2.78	0.44	0.07	0.05	-	-	5.08
W	-	1.65	1.34	0.20	0.10	-	-	-	3.29
WSW	-	1.00	0.70	0.37	0.09	0.01	-	-	2.17
SW	-	0.85	0.99	1.17	0.25	-	-	-	3.27
SSW	-	1.32	1.70	0.55	0.13	0.02	-	-	3.74
S	-	5.62	8.93	2.60	0.30	0.05	-	-	17.51
SSE	-	7.69	10.24	3.55	0.43	0.13	-	-	22.05
SE	-	5.29	5.17	0.65	0.06	0.02	-	-	11.19
ESE	-	2.18	0.40	0.04	-	-	-	-	2.63
E	-	1.00	0.59	0.10	-	-	-	-	1.70
Calm	16.10	-	-	-	-	-	-	-	16.10
Total (%)	16.10	33.16	37.85	10.95	1.62	0.29	0.03	-	100.00

NOTES

STATUS
ISSUED FOR USE

CLIENT
Kinder Morgan

A TETRA TECH COMPANY

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

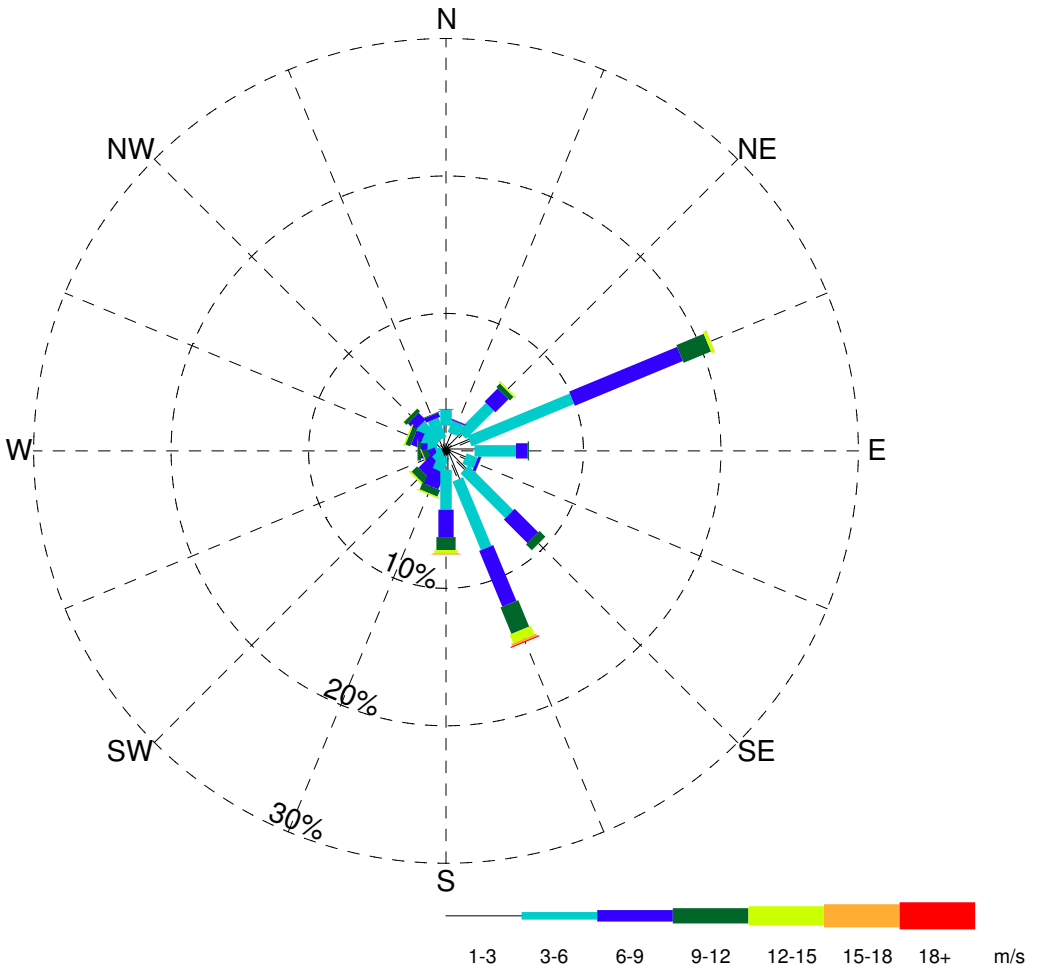
Summer: April-September
Cherry Point

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 07, 2012

Figure A.7



Cherry Point

Location:

N48° 52' 1.2" W122° 45' 0.0"

Elevation: 5.0 m

Sea level: -

Length of Record

Start Date: April 19, 2005

End Date: November 01, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	1.85	8.08	8.50	2.15	0.24	0.03	-	20.85
NE	-	1.64	2.88	1.36	0.36	0.14	-	-	6.39
NNE	-	1.32	0.89	0.09	0.03	-	-	-	2.34
N	-	1.83	1.19	0.03	-	-	-	-	3.05
NNW	-	0.92	1.53	0.34	0.06	-	-	-	2.85
NW	-	0.85	1.80	0.72	0.29	0.03	-	-	3.69
WNW	-	0.77	1.14	0.63	0.38	0.11	-	-	3.03
W	-	0.65	0.70	0.48	0.26	0.03	-	-	2.11
WSW	-	0.25	0.43	0.55	0.39	0.07	0.01	-	1.70
SW	-	0.36	0.68	1.25	0.56	0.14	-	-	2.99
SSW	-	0.41	1.12	1.27	0.52	0.10	0.01	-	3.43
S	-	1.38	2.90	1.99	0.94	0.23	0.08	0.01	7.54
SSE	-	2.24	5.40	4.40	2.09	0.67	0.18	0.09	15.06
SE	-	1.90	4.61	2.42	0.60	0.02	-	-	9.56
ESE	-	1.46	0.87	0.22	0.02	-	-	-	2.57
E	-	2.07	3.02	0.85	0.09	-	-	-	6.03
Calm	6.79	-	-	-	-	-	-	-	6.79
Total (%)	6.79	19.89	37.24	25.10	8.73	1.81	0.32	0.10	100.00

NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Winter: October-March
Cherry Point

STATUS
ISSUED FOR USE

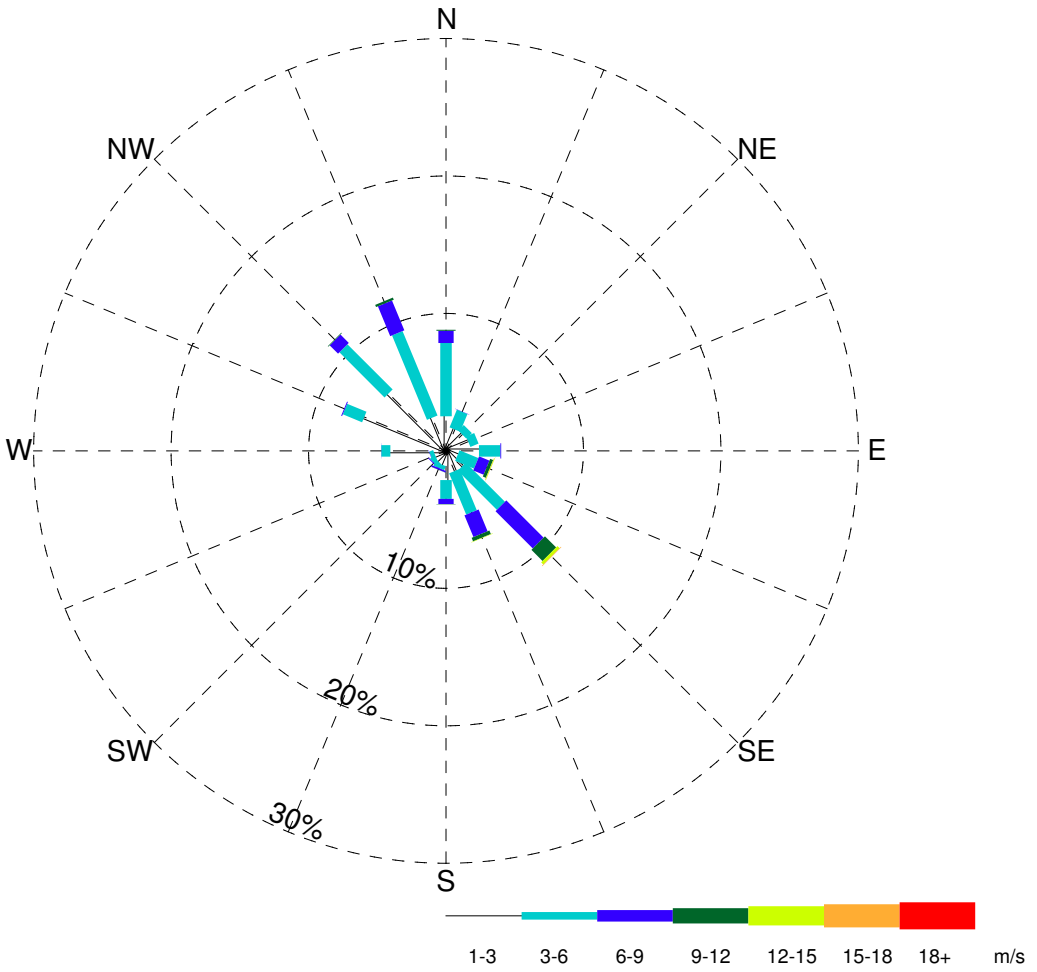
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 07, 2012

Figure A.8



Comox Airport

Location:

N49° 43' 12.0" W124° 54' 0.0"

Elevation: 25.6 m

Sea level: -

Length of Record

Start Date: January 01, 1953

End Date: November 12, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	**0-1 m/s**	**1-3 m/s**	**3-6 m/s**	**6-9 m/s**	**9-12 m/s**	**12-15 m/s**	**15-18 m/s**	**18+ m/s**	**Total (%)**
ENE	-	1.75	0.64	-	-	-	-	-	2.40
NE	-	1.68	0.57	-	-	-	-	-	2.25
NNE	-	1.68	1.40	0.02	-	-	-	-	3.10
N	-	2.52	5.33	0.89	0.07	-	-	-	8.81
NNW	-	2.62	6.65	2.35	0.17	-	-	-	11.79
NW	-	5.91	4.65	0.86	0.05	-	-	-	11.47
WNW	-	6.44	1.52	0.07	-	-	-	-	8.03
W	-	4.05	0.66	0.01	-	-	-	-	4.72
WSW	-	0.85	0.31	0.03	-	-	-	-	1.18
SW	-	0.93	0.31	0.06	-	-	-	-	1.31
SSW	-	1.03	0.32	0.12	0.01	-	-	-	1.49
S	-	2.12	1.37	0.37	0.03	-	-	-	3.89
SSE	-	1.59	3.25	1.71	0.28	0.03	-	-	6.87
SE	-	1.62	4.03	3.84	1.15	0.21	0.04	-	10.89
ESE	-	0.89	1.48	0.81	0.24	0.05	0.01	-	3.50
E	-	2.40	1.56	0.06	-	-	-	-	4.02
Calm	14.29	-	-	-	-	-	-	-	14.29
Total (%)	14.29	38.08	34.03	11.22	2.00	0.31	0.06	-	100.00

NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Summer: April-September
Comox Airport

STATUS
ISSUED FOR USE

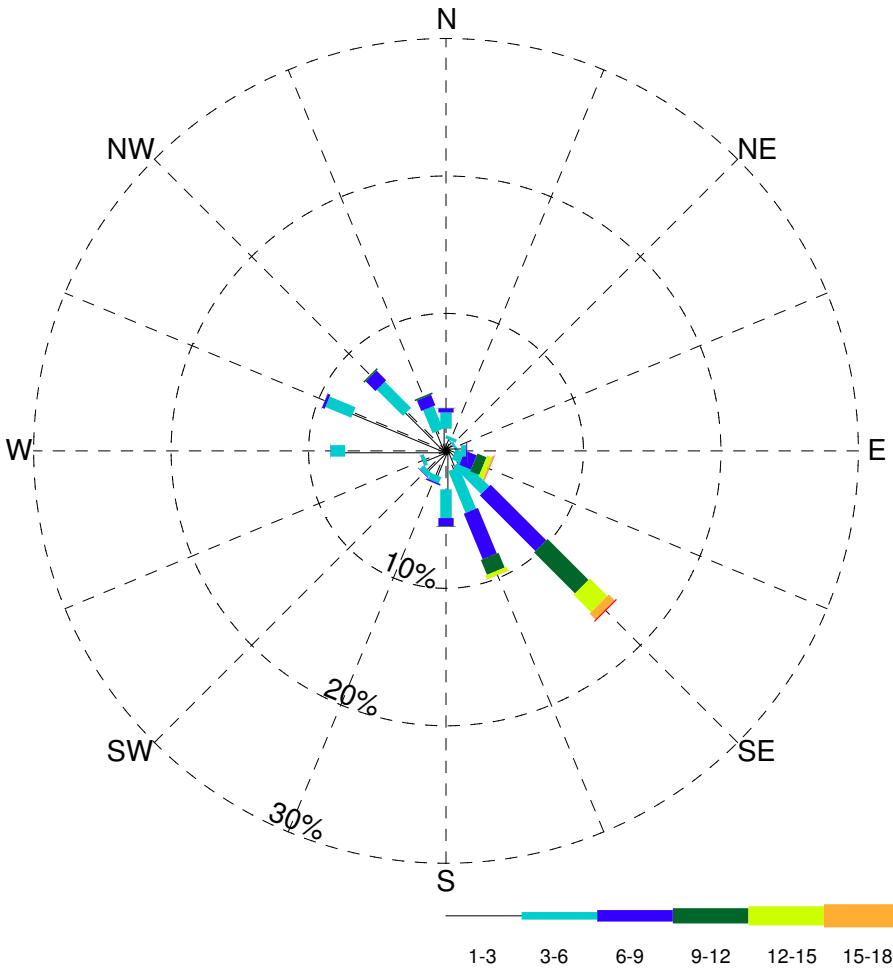
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 07, 2012

Figure A.9



Comox Airport

Location:

N49° 43' 12.0" W124° 54' 0.0"

Elevation: 25.6 m

Sea level: -

Length of Record

Start Date: January 01, 1953

End Date: November 12, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	0.61	0.13	0.01	-	-	-	-	0.76
NE	-	0.64	0.11	-	-	-	-	-	0.75
NNE	-	0.83	0.23	-	-	-	-	-	1.07
N	-	1.62	1.18	0.31	0.03	-	-	-	3.13
NNW	-	1.57	1.80	0.83	0.12	-	-	-	4.32
NW	-	4.01	2.69	1.00	0.12	0.01	-	-	7.84
WNW	-	7.30	2.04	0.21	0.01	-	-	-	9.56
W	-	7.34	1.07	0.02	-	-	-	-	8.43
WSW	-	1.60	0.26	0.02	-	-	-	-	1.87
SW	-	1.90	0.38	0.05	-	-	-	-	2.33
SSW	-	1.90	0.48	0.11	0.01	-	-	-	2.51
S	-	2.80	2.09	0.59	0.05	-	-	-	5.54
SSE	-	1.42	3.30	3.59	1.17	0.28	0.04	-	9.80
SE	-	1.20	2.83	5.72	4.21	1.79	0.60	0.09	16.45
ESE	-	0.62	0.66	0.91	0.71	0.36	0.12	0.02	3.41
E	-	1.10	0.36	0.05	0.03	0.01	-	-	1.55
Calm	20.68	-	-	-	-	-	-	-	20.68
Total (%)	20.68	36.45	19.61	13.44	6.47	2.47	0.76	0.12	100.00

NOTES

STATUS
ISSUED FOR USE

CLIENT
Kinder Morgan

A TETRA TECH COMPANY

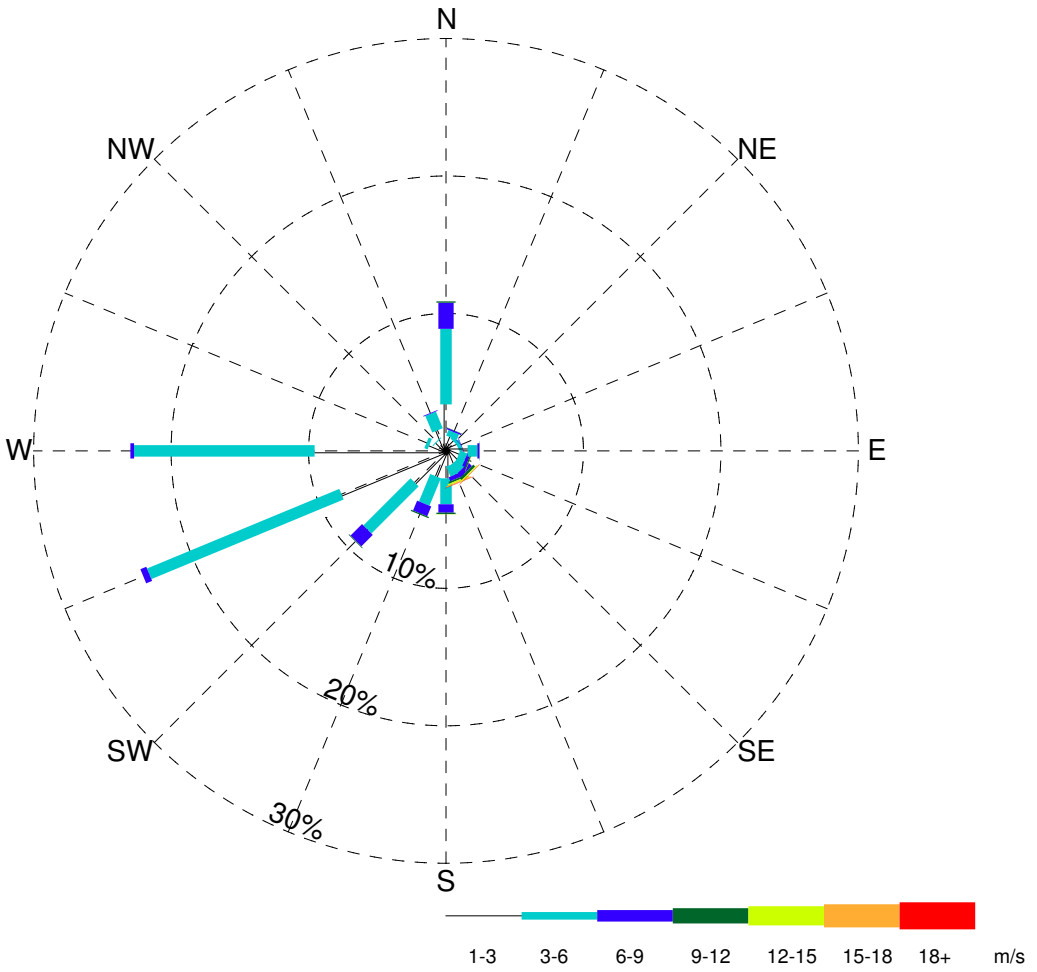
METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Winter: October-March
Comox Airport

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC
DATE: December 07, 2012

Figure A.10



Discovery Island

Location:

N48° 25' 12.0" W123° 13' 48.0"

Elevation: 15.3 m

Sea level: -

Length of Record

Start Date: January 02, 1997

End Date: November 12, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	0.89	0.28	0.03	-	-	-	-	1.20
NE	-	0.87	0.21	0.03	-	-	-	-	1.12
NNE	-	1.03	0.44	0.11	0.02	-	-	-	1.61
N	-	3.38	5.50	1.90	0.10	-	-	-	10.89
NNW	-	1.62	1.31	0.06	-	-	-	-	2.98
NW	-	0.91	0.07	-	-	-	-	-	0.98
WNW	-	1.28	0.25	-	-	-	-	-	1.54
W	-	9.56	13.13	0.27	-	-	-	-	22.96
WSW	-	8.23	15.14	0.47	-	-	-	-	23.84
SW	-	3.23	4.85	1.18	0.06	-	-	-	9.33
SSW	-	1.99	2.16	0.77	0.09	-	-	-	5.02
S	-	2.00	1.89	0.61	0.10	0.02	-	-	4.62
SSE	-	1.07	0.78	0.31	0.14	0.10	0.09	0.02	2.51
SE	-	1.00	0.75	0.37	0.20	0.08	0.05	0.01	2.44
ESE	-	0.95	0.56	0.24	0.09	0.03	-	-	1.88
E	-	1.57	0.71	0.15	0.02	-	-	-	2.45
Calm	4.64	-	-	-	-	-	-	-	4.64
Total (%)	4.64	39.57	48.03	6.50	0.83	0.25	0.14	0.04	100.00

NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Summer: April-September
Discovery Island

STATUS
ISSUED FOR USE

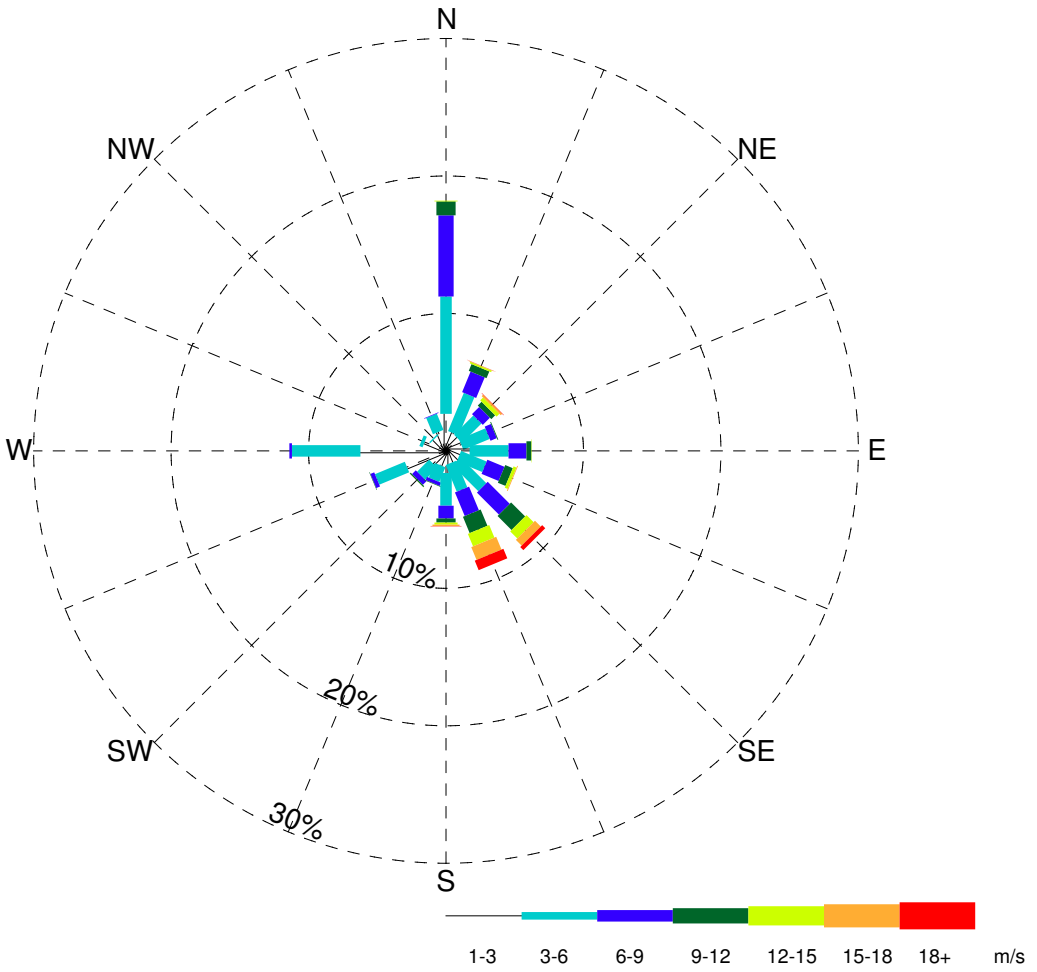
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 07, 2012

Figure A.11



Discovery Island

Location:

N48° 25' 12.0" W123° 13' 48.0"

Elevation: 15.3 m

Sea level: -

Length of Record

Start Date: January 02, 1997

End Date: November 12, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	1.20	2.08	0.50	0.06	-	-	-	3.83
NE	-	1.24	1.99	0.74	0.39	0.29	0.14	0.03	4.82
NNE	-	1.39	3.01	1.62	0.53	0.12	0.03	0.01	6.71
N	-	2.69	8.54	5.91	1.01	0.06	-	-	18.21
NNW	-	1.48	1.28	0.04	-	-	-	-	2.81
NW	-	1.21	0.10	-	-	-	-	-	1.31
WNW	-	1.68	0.25	-	-	-	-	-	1.93
W	-	6.23	4.98	0.19	-	-	-	-	11.40
WSW	-	3.07	2.35	0.30	0.03	-	-	-	5.76
SW	-	1.32	1.24	0.38	0.09	0.01	-	-	3.05
SSW	-	1.12	1.16	0.25	0.05	-	-	-	2.58
S	-	1.60	2.39	0.93	0.30	0.15	0.10	0.03	5.49
SSE	-	0.94	2.10	1.86	1.28	0.99	1.01	0.75	8.93
SE	-	1.10	2.64	2.27	1.44	0.73	0.60	0.32	9.09
ESE	-	1.02	2.01	1.35	0.60	0.23	0.06	-	5.27
E	-	1.71	2.83	1.30	0.36	0.03	-	-	6.24
Calm	2.57	-	-	-	-	-	-	-	2.57
Total (%)	2.57	29.00	38.95	17.63	6.14	2.62	1.94	1.14	100.00

NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Winter: October-March
Discovery Island

STATUS
ISSUED FOR USE

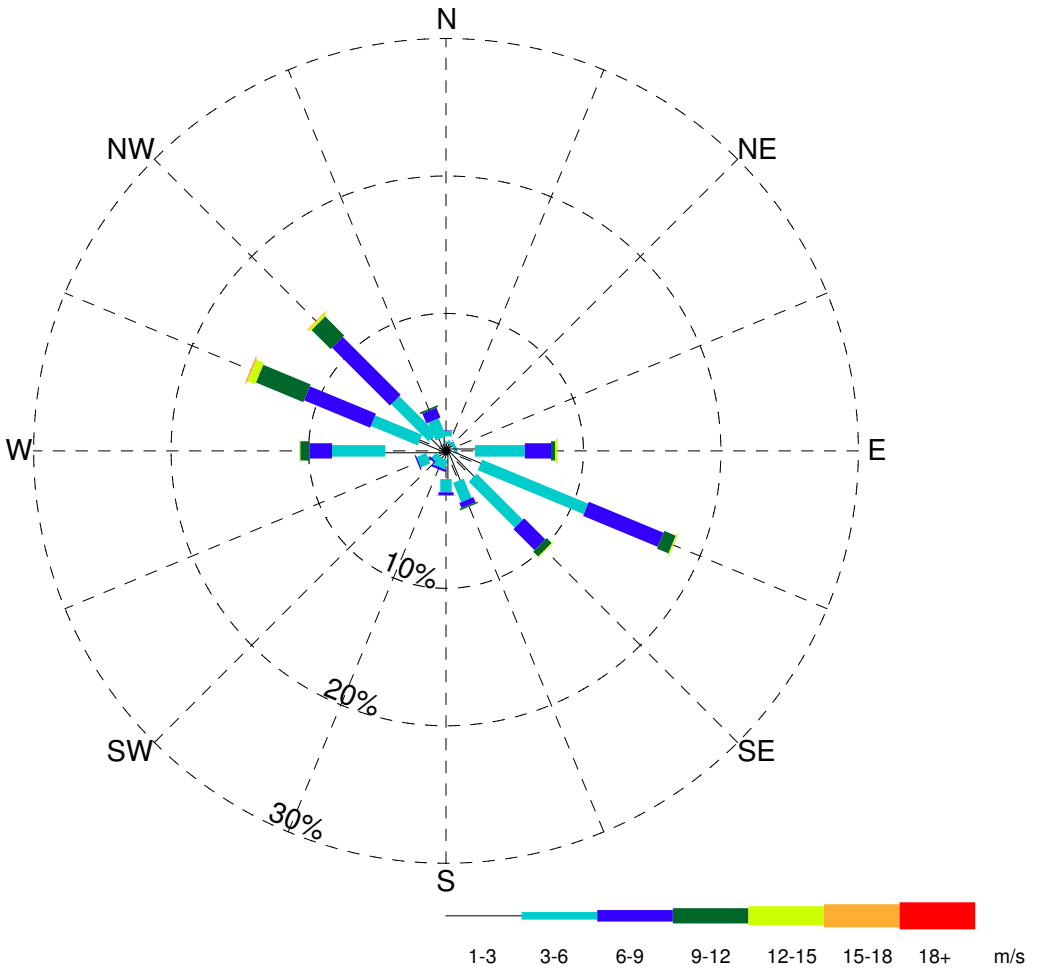
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 07, 2012

Figure A.12



Entrance Island

Location:

N49° 12’ 0.0" W123° 48’ 0.0"

Elevation: 3.3 m

Sea level: -

Length of Record

Start Date: January 31, 1994

End Date: November 12, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	0.54	0.18	0.04	-	-	-	-	0.76
NE	-	0.60	0.11	0.01	-	-	-	-	0.71
NNE	-	0.55	0.12	-	-	-	-	-	0.68
N	-	1.05	0.41	0.04	-	-	-	-	1.51
NNW	-	0.98	1.41	0.78	0.13	-	-	-	3.31
NW	-	1.39	3.83	5.95	1.97	0.19	0.06	-	13.39
WNW	-	2.05	3.70	5.20	3.73	0.61	0.09	0.01	15.40
W	-	4.42	3.87	1.62	0.69	0.08	-	-	10.69
WSW	-	1.40	0.74	0.10	-	-	-	-	2.26
SW	-	0.57	0.51	0.13	0.01	-	-	-	1.23
SSW	-	0.60	0.68	0.16	-	-	-	-	1.45
S	-	2.05	0.96	0.22	0.02	-	-	-	3.26
SSE	-	2.35	1.52	0.41	0.12	0.02	-	-	4.42
SE	-	2.76	4.74	2.17	0.51	0.07	-	-	10.26
ESE	-	2.67	8.35	5.88	0.90	0.09	0.01	-	17.91
E	-	2.10	3.63	1.91	0.31	0.13	0.03	-	8.10
Calm	4.67	-	-	-	-	-	-	-	4.67
Total (%)	4.67	26.11	34.76	24.62	8.41	1.19	0.21	0.03	100.00

NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Summer: April-September
Entrance Island

STATUS
ISSUED FOR USE

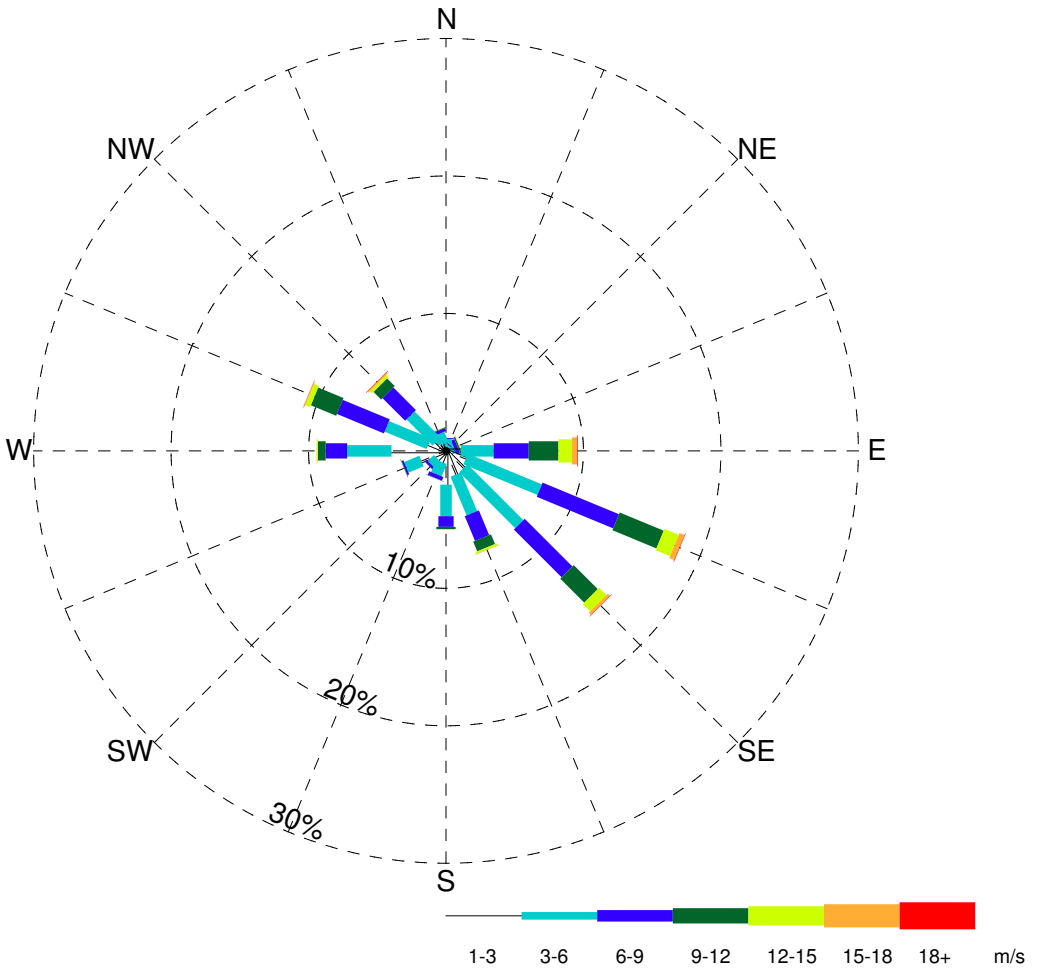
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 07, 2012

Figure A.13



Entrance Island

Location:

N49° 12’ 0.0" W123° 48’ 0.0"

Elevation: 3.3 m

Sea level: -

Length of Record

Start Date: January 31, 1994

End Date: November 12, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	**0-1 m/s**	**1-3 m/s**	**3-6 m/s**	**6-9 m/s**	**9-12 m/s**	**12-15 m/s**	**15-18 m/s**	**18+ m/s**	**Total (%)**
ENE	-	0.34	0.28	0.26	0.12	0.04	0.02	-	1.07
NE	-	0.29	0.14	0.06	0.02	0.01	-	-	0.53
NNE	-	0.28	0.12	-	-	-	-	-	0.41
N	-	0.56	0.30	0.07	0.01	-	-	-	0.94
NNW	-	0.57	0.76	0.24	0.05	0.02	-	-	1.66
NW	-	0.96	2.68	2.33	0.78	0.22	0.11	0.04	7.13
WNW	-	1.37	3.29	3.70	1.99	0.37	0.07	0.02	10.82
W	-	3.96	3.23	1.56	0.57	0.08	0.01	-	9.42
WSW	-	1.93	1.20	0.15	0.04	0.02	-	-	3.33
SW	-	0.85	0.61	0.18	0.03	-	-	-	1.67
SSW	-	0.86	0.97	0.28	0.03	-	-	-	2.15
S	-	2.46	2.30	0.77	0.17	0.01	-	-	5.72
SSE	-	1.86	3.05	1.95	0.76	0.15	0.04	-	7.82
SE	-	1.79	5.76	4.91	2.47	0.75	0.22	0.03	15.92
ESE	-	1.54	5.84	6.01	3.47	1.13	0.39	0.04	18.41
E	-	1.10	2.37	2.55	2.16	0.97	0.39	0.05	9.59
Calm	3.40	-	-	-	-	-	-	-	3.40
Total (%)	3.40	20.72	32.89	25.05	12.69	3.79	1.26	0.20	100.00

NOTES

STATUS
ISSUED FOR USE

CLIENT
Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Winter: October-March
Entrance Island

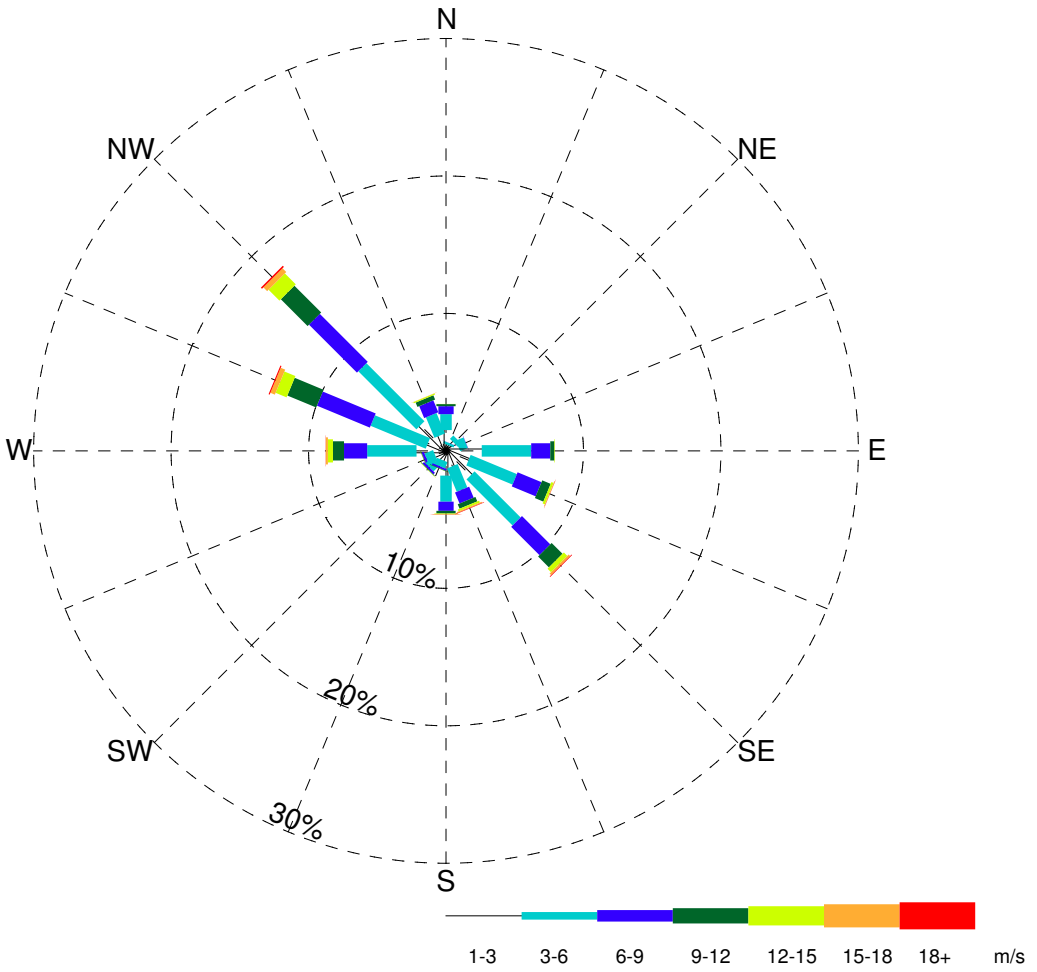
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE EBA-VANC

DATE December 07, 2012

Figure A.14



Estevan Point

Location:

N49° 22' 48.0" W126° 33' 0.0"

Elevation: 7.0 m

Sea level: -

Length of Record

Start Date: January 01, 1953

End Date: November 12, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	0.94	0.61	0.02	-	-	-	-	1.57
NE	-	0.82	0.35	-	-	-	-	-	1.18
NNE	-	0.44	0.17	0.01	-	-	-	-	0.62
N	-	1.51	1.16	0.58	0.15	0.01	-	-	3.42
NNW	-	1.20	1.61	0.94	0.34	0.09	0.02	-	4.20
NW	-	2.63	5.98	4.93	2.76	1.12	0.39	0.11	17.92
WNW	-	1.43	4.34	4.16	2.27	0.86	0.35	0.08	13.50
W	-	2.14	3.59	1.68	0.81	0.37	0.15	0.01	8.76
WSW	-	0.85	0.67	0.17	0.04	0.01	-	-	1.75
SW	-	1.11	0.58	0.16	0.05	0.03	-	-	1.93
SSW	-	0.72	0.49	0.13	0.04	0.01	-	-	1.41
S	-	1.80	1.89	0.67	0.20	0.05	0.03	0.01	4.65
SSE	-	1.21	1.84	0.87	0.35	0.15	0.08	0.03	4.53
SE	-	2.52	4.74	2.91	1.12	0.35	0.15	0.05	11.84
ESE	-	1.77	3.64	1.88	0.66	0.17	0.05	0.01	8.19
E	-	2.60	3.60	1.39	0.30	0.04	-	-	7.93
Calm	6.60	-	-	-	-	-	-	-	6.60
Total (%)	6.60	23.69	35.27	20.52	9.10	3.27	1.23	0.33	100.00

NOTES

STATUS
ISSUED FOR USE

CLIENT
Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Summer: April-September
Estevan Point

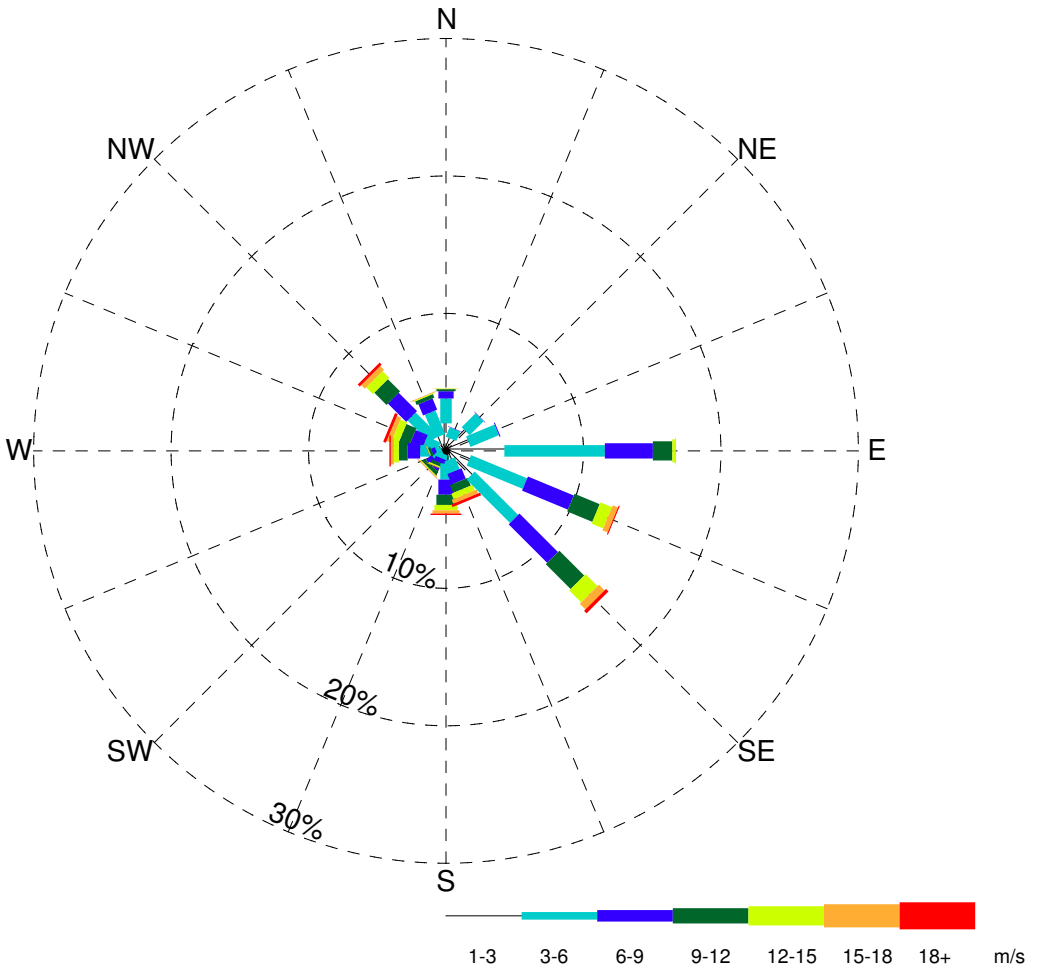
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 07, 2012

Figure A.15



Estevan Point

Location:

N49° 22' 48.0" W126° 33' 0.0"

Elevation: 7.0 m

Sea level: -

Length of Record

Start Date: January 01, 1953

End Date: November 12, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	1.75	2.24	0.07	-	-	-	-	4.08
NE	-	2.02	1.43	0.03	-	-	-	-	3.49
NNE	-	0.95	0.75	0.03	-	-	-	-	1.73
N	-	2.00	1.81	0.53	0.15	0.04	0.01	-	4.55
NNW	-	1.16	1.86	0.88	0.28	0.08	0.03	0.01	4.30
NW	-	1.22	2.31	1.89	1.26	0.69	0.37	0.21	7.96
WNW	-	0.60	1.08	0.95	0.79	0.52	0.33	0.21	4.48
W	-	0.82	1.06	0.91	0.65	0.36	0.22	0.11	4.12
WSW	-	0.26	0.39	0.30	0.19	0.06	0.03	0.01	1.24
SW	-	0.43	0.56	0.50	0.28	0.08	0.04	0.01	1.90
SSW	-	0.26	0.36	0.35	0.23	0.11	0.04	0.01	1.37
S	-	0.92	1.17	1.11	0.75	0.39	0.24	0.10	4.66
SSE	-	0.68	0.92	0.82	0.61	0.42	0.31	0.21	3.96
SE	-	2.54	4.46	3.96	2.56	1.23	0.58	0.26	15.59
ESE	-	1.80	4.42	3.61	1.99	0.91	0.41	0.09	13.22
E	-	4.25	7.31	3.49	1.41	0.24	0.04	-	16.74
Calm	6.59	-	-	-	-	-	-	-	6.59
Total (%)	6.59	21.67	32.12	19.42	11.16	5.11	2.66	1.25	100.00

NOTES

STATUS
ISSUED FOR USE

CLIENT
Kinder Morgan

A TETRA TECH COMPANY

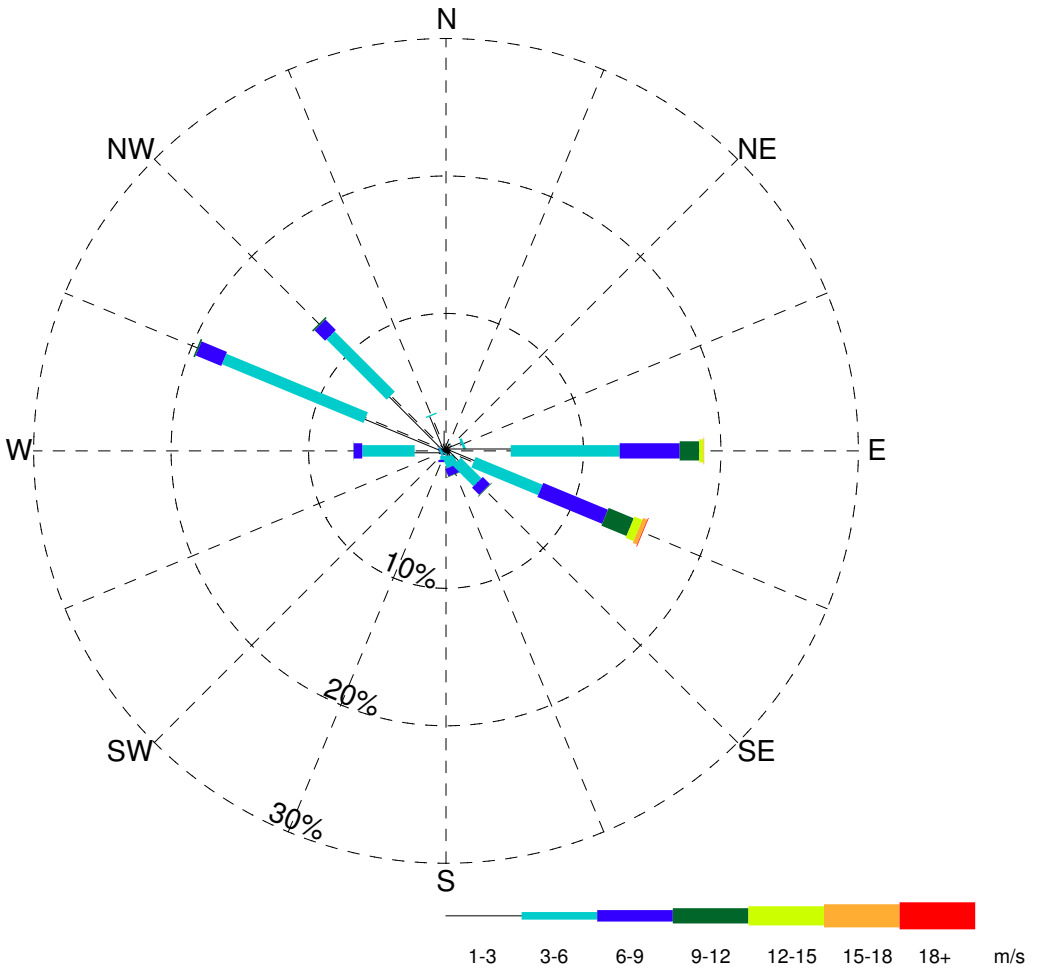
METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Winter: October-March
Estevan Point

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC
DATE: December 07, 2012

Figure A.16



Grief Point

Location:

N49° 48' 0.0" W124° 31' 48.0"

Elevation: 10. m

Sea level: -

Length of Record

Start Date: November 28, 1997

End Date: November 12, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	1.22	0.19	-	-	-	-	-	1.41
NE	-	0.56	0.02	-	-	-	-	-	0.58
NNE	-	0.83	-	-	-	-	-	-	0.84
N	-	1.44	-	-	-	-	-	-	1.44
NNW	-	2.75	0.10	-	-	-	-	-	2.86
NW	-	5.68	6.21	1.08	0.11	-	-	-	13.09
WNW	-	6.32	11.15	2.01	0.12	-	-	-	19.60
W	-	2.28	3.82	0.62	0.01	-	-	-	6.74
WSW	-	0.29	0.14	0.02	-	-	-	-	0.46
SW	-	0.18	0.05	0.02	-	-	-	-	0.25
SSW	-	0.16	0.06	-	-	-	-	-	0.23
S	-	0.37	0.28	0.15	0.01	-	-	-	0.82
SSE	-	0.44	0.76	0.59	0.04	-	-	-	1.83
SE	-	1.12	2.11	0.74	0.06	-	-	-	4.03
ESE	-	2.16	5.26	5.09	1.98	0.62	0.33	0.05	15.50
E	-	4.71	7.93	4.37	1.42	0.30	0.06	-	18.79
Calm	11.55	-	-	-	-	-	-	-	11.55
Total (%)	11.55	30.53	38.09	14.70	3.76	0.92	0.39	0.05	100.00

NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Summer: April-September
Grief Point

STATUS
ISSUED FOR USE

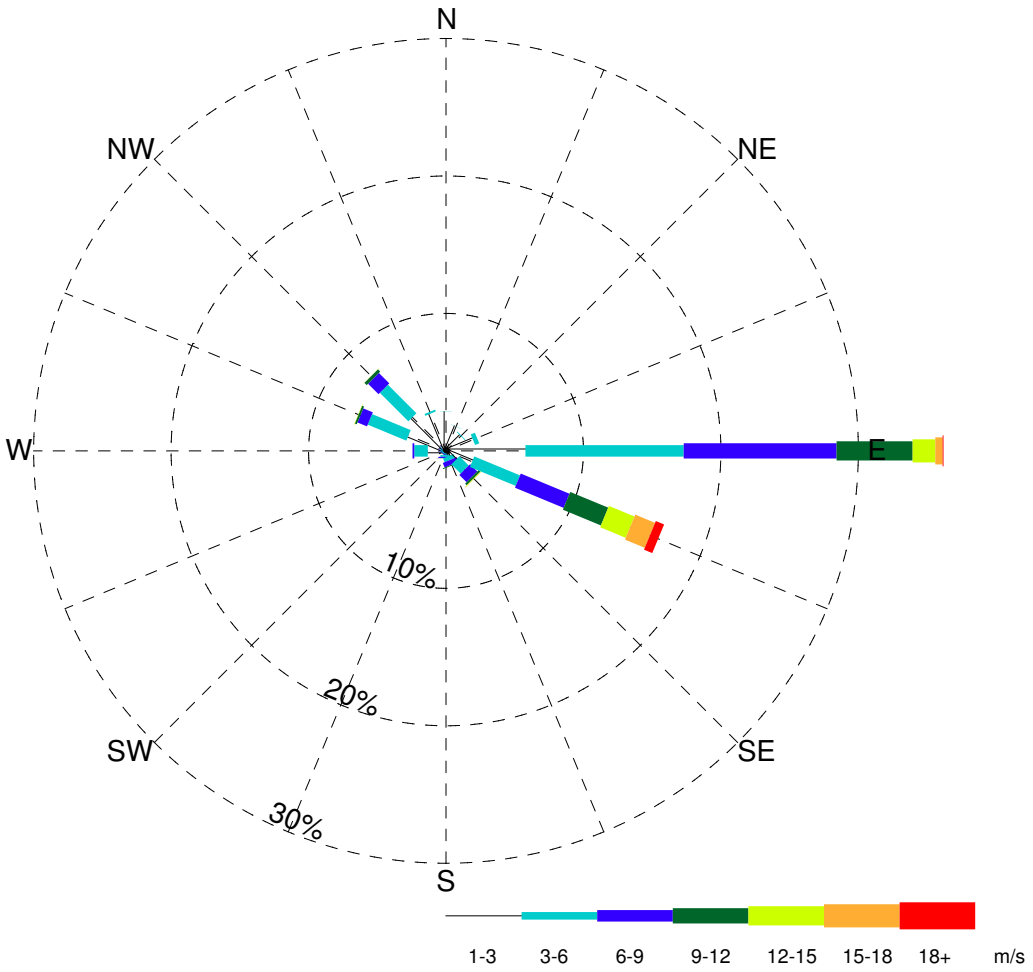
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 07, 2012

Figure A.17



Grief Point

Location:

N49° 48' 0.0" W124° 31' 48.0"

Elevation: 10. m

Sea level: -

Length of Record

Start Date: November 28, 1997

End Date: November 12, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	2.12	0.32	-	-	-	-	-	2.45
NE	-	1.52	0.05	-	-	-	-	-	1.58
NNE	-	1.91	0.01	-	-	-	-	-	1.92
N	-	2.86	0.01	-	-	-	-	-	2.87
NNW	-	2.93	0.14	-	-	-	-	-	3.08
NW	-	3.45	2.94	1.07	0.23	0.01	-	-	7.71
WNW	-	2.95	3.04	0.75	0.15	0.03	-	-	6.92
W	-	1.33	0.98	0.13	-	-	-	-	2.44
WSW	-	0.20	0.05	0.02	-	-	-	-	0.27
SW	-	0.20	0.05	0.02	-	-	-	-	0.27
SSW	-	0.18	0.05	0.02	-	-	-	-	0.25
S	-	0.31	0.12	0.09	0.01	-	-	-	0.53
SSE	-	0.42	0.30	0.35	0.07	-	-	-	1.15
SE	-	0.97	0.95	0.75	0.17	0.04	0.01	-	2.89
ESE	-	2.06	3.60	3.84	2.99	2.01	1.56	0.65	16.71
E	-	5.78	11.51	11.12	5.53	1.65	0.53	0.07	36.19
Calm	12.77	-	-	-	-	-	-	-	12.77
Total (%)	12.77	29.18	24.15	18.16	9.16	3.76	2.10	0.72	100.00

NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Winter: October-March
Grief Point

STATUS
ISSUED FOR USE

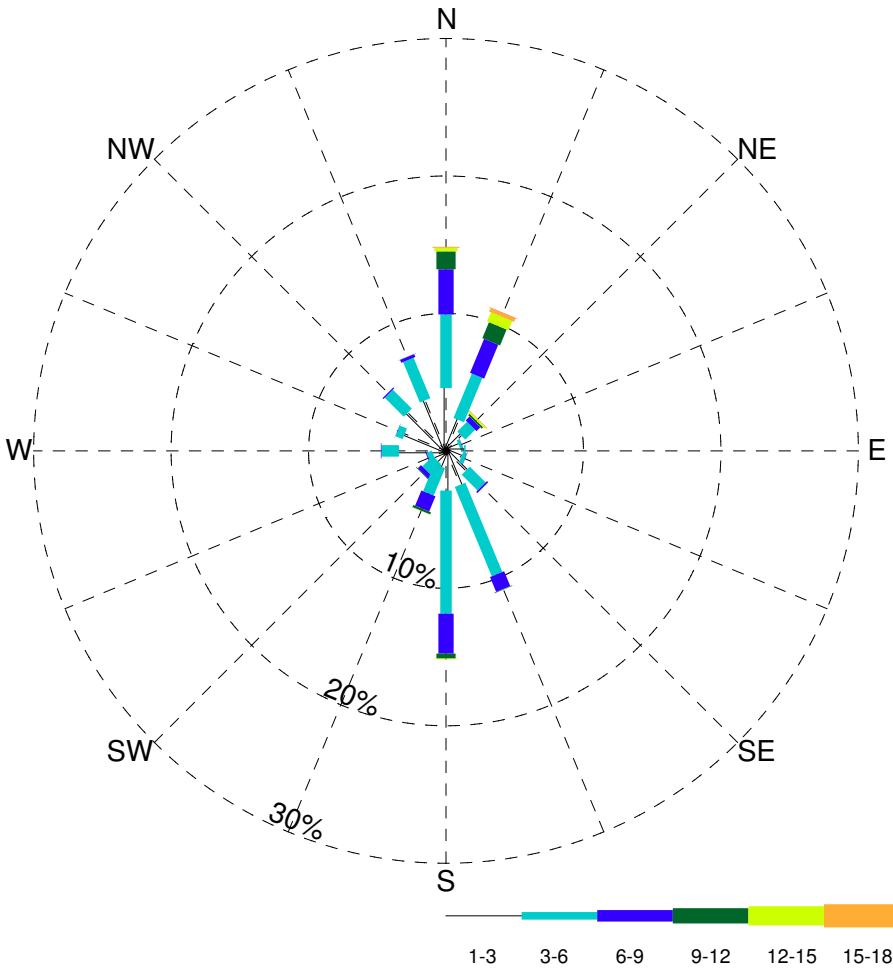
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 07, 2012

Figure A.18



Howe Sound-Pam Rocks

Location:

N49° 29' 24.0" W123° 18' 0.0"

Elevation: 4.9 m

Sea level: -

Length of Record

Start Date: January 31, 1994

End Date: November 12, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	1.02	0.21	0.03	-	-	-	-	1.25
NE	-	1.57	1.01	0.40	0.14	0.12	0.05	-	3.29
NNE	-	2.42	3.49	2.67	1.26	0.71	0.29	0.01	10.87
N	-	4.57	5.35	3.29	1.30	0.26	0.08	-	14.86
NNW	-	3.97	3.19	0.23	0.02	-	-	-	7.41
NW	-	3.93	1.95	0.09	-	-	-	-	5.98
WNW	-	3.24	0.56	0.02	-	-	-	-	3.83
W	-	3.42	1.27	0.05	-	-	-	-	4.75
WSW	-	0.95	0.41	0.06	0.01	-	-	-	1.44
SW	-	0.94	1.08	0.33	0.05	-	-	-	2.40
SSW	-	1.19	2.16	1.20	0.17	0.02	-	-	4.74
S	-	2.89	8.96	2.90	0.36	0.05	-	-	15.17
SSE	-	2.67	7.03	1.17	0.04	0.01	-	-	10.94
SE	-	2.03	1.62	0.13	-	-	-	-	3.79
ESE	-	1.18	0.30	0.02	-	-	-	-	1.51
E	-	1.31	0.10	0.01	-	-	-	-	1.43
Calm	6.35	-	-	-	-	-	-	-	6.35
Total (%)	6.35	37.31	38.71	12.58	3.39	1.19	0.44	0.03	100.00

NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Summer: April-September
Howe Sound-Pam Rocks

STATUS
ISSUED FOR USE

A TETRA TECH COMPANY

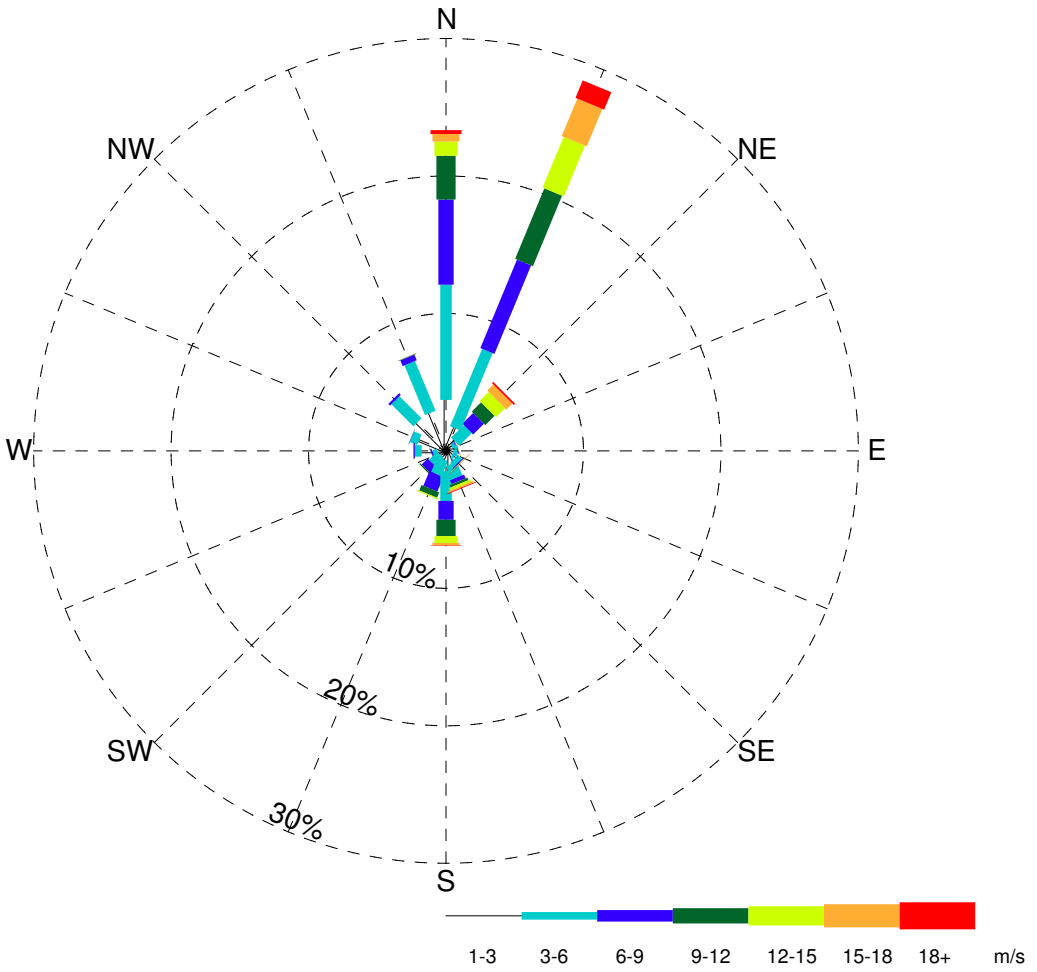
PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 07, 2012

Figure A.19

Fri Dec 07 19:42:21 2012:V:\V13203022 Trans Mountain\working\DD\01_EC\01_MetData_Scripts\Howe_Sound-Pam_Rocks



Howe Sound-Pam Rocks

Location:

N49° 29' 24.0" W123° 18' 0.0"

Elevation: 4.9 m

Sea level: -

Length of Record

Start Date: January 31, 1994

End Date: November 12, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	0.51	0.23	0.08	0.03	0.02	0.01	-	0.88
NE	-	0.94	1.30	1.10	0.95	0.94	0.62	0.13	5.98
NNE	-	1.77	6.09	6.97	5.55	4.00	2.95	1.37	28.71
N	-	3.71	8.38	6.20	3.18	1.04	0.54	0.29	23.34
NNW	-	2.99	3.91	0.44	0.04	0.01	-	-	7.41
NW	-	2.94	2.27	0.17	0.01	-	-	-	5.40
WNW	-	2.10	0.58	0.03	0.01	-	-	-	2.72
W	-	1.77	0.49	0.10	0.01	-	-	-	2.39
WSW	-	0.56	0.36	0.11	0.02	-	-	-	1.06
SW	-	0.50	0.84	0.62	0.10	0.01	-	-	2.07
SSW	-	0.63	1.19	1.15	0.43	0.09	0.01	-	3.51
S	-	1.47	2.17	1.37	1.19	0.50	0.19	0.03	6.92
SSE	-	1.02	1.07	0.31	0.20	0.19	0.12	0.06	2.96
SE	-	0.83	0.40	0.08	0.02	0.02	0.02	0.02	1.39
ESE	-	0.51	0.16	0.03	-	-	-	-	0.71
E	-	0.63	0.17	0.03	-	-	-	-	0.83
Calm	3.72	-	-	-	-	-	-	-	3.72
Total (%)	3.72	22.89	29.61	18.78	11.76	6.83	4.49	1.91	100.00

NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Winter: October-March
Howe Sound-Pam Rocks

STATUS
ISSUED FOR USE

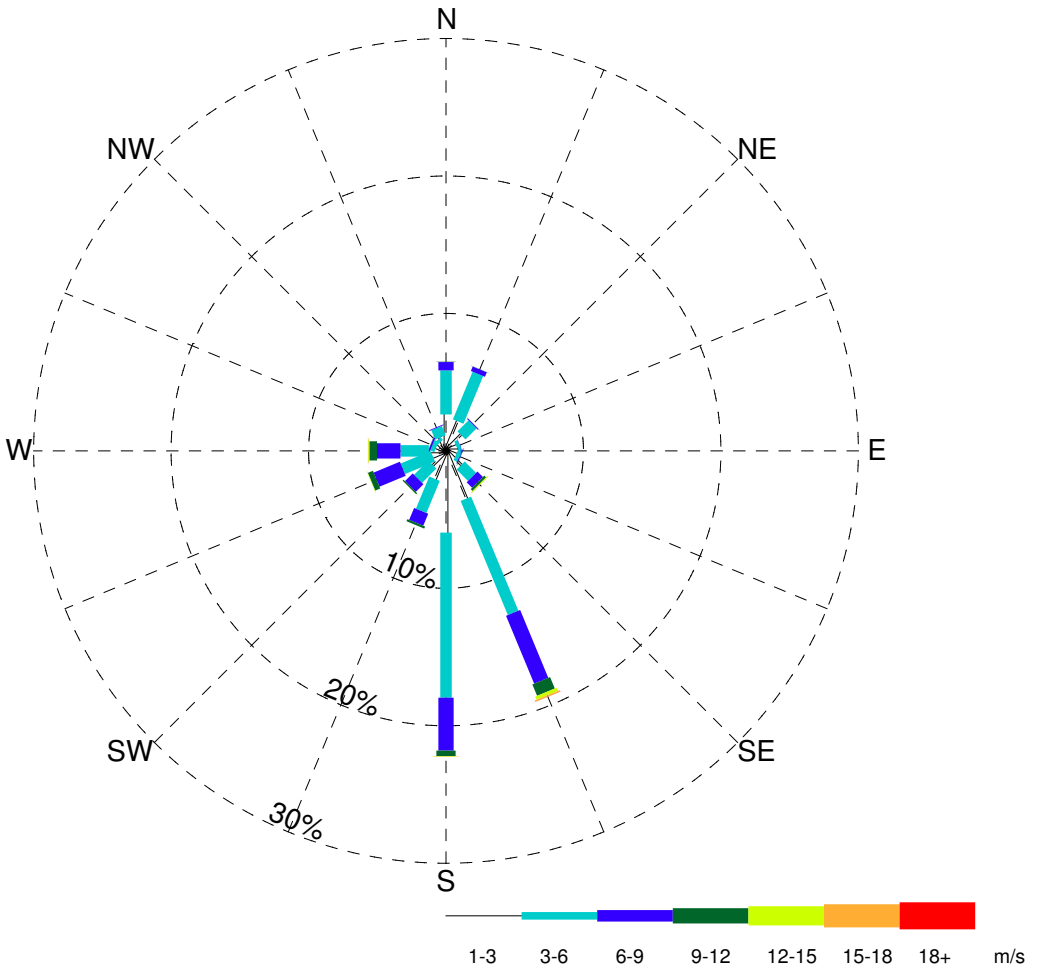
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 07, 2012

Figure A.20



Kelp Reefs

Location:

N48° 33' 0.0" W123° 14' 24.0"

Elevation: Sea Level

Sea level: -

Length of Record

Start Date: March 14, 1997

End Date: November 12, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	0.82	0.25	0.03	-	-	-	-	1.11
NE	-	1.59	1.13	0.08	0.01	-	-	-	2.82
NNE	-	2.31	3.76	0.35	0.02	-	-	-	6.43
N	-	2.65	3.20	0.61	0.03	-	-	-	6.50
NNW	-	1.06	0.74	0.06	-	-	-	-	1.86
NW	-	0.73	0.24	0.02	-	-	-	-	1.00
WNW	-	0.76	0.31	0.13	0.03	-	-	-	1.23
W	-	1.25	2.06	1.71	0.56	0.08	0.02	-	5.68
WSW	-	1.04	2.37	2.07	0.40	0.04	-	-	5.91
SW	-	1.40	1.48	0.79	0.10	0.01	-	-	3.78
SSW	-	2.19	2.54	0.94	0.16	-	-	-	5.83
S	-	5.95	12.01	3.85	0.40	0.04	0.01	-	22.26
SSE	-	3.77	8.99	5.34	0.90	0.25	0.11	0.01	19.36
SE	-	1.51	1.17	0.56	0.18	0.07	0.01	-	3.51
ESE	-	0.77	0.28	0.07	0.03	-	-	-	1.15
E	-	0.88	0.19	0.02	-	-	-	-	1.11
Calm	10.45	-	-	-	-	-	-	-	10.45
Total (%)	10.45	28.67	40.72	16.61	2.84	0.51	0.18	0.03	100.00

NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Summer: April-September
Kelp Reefs

STATUS
ISSUED FOR USE

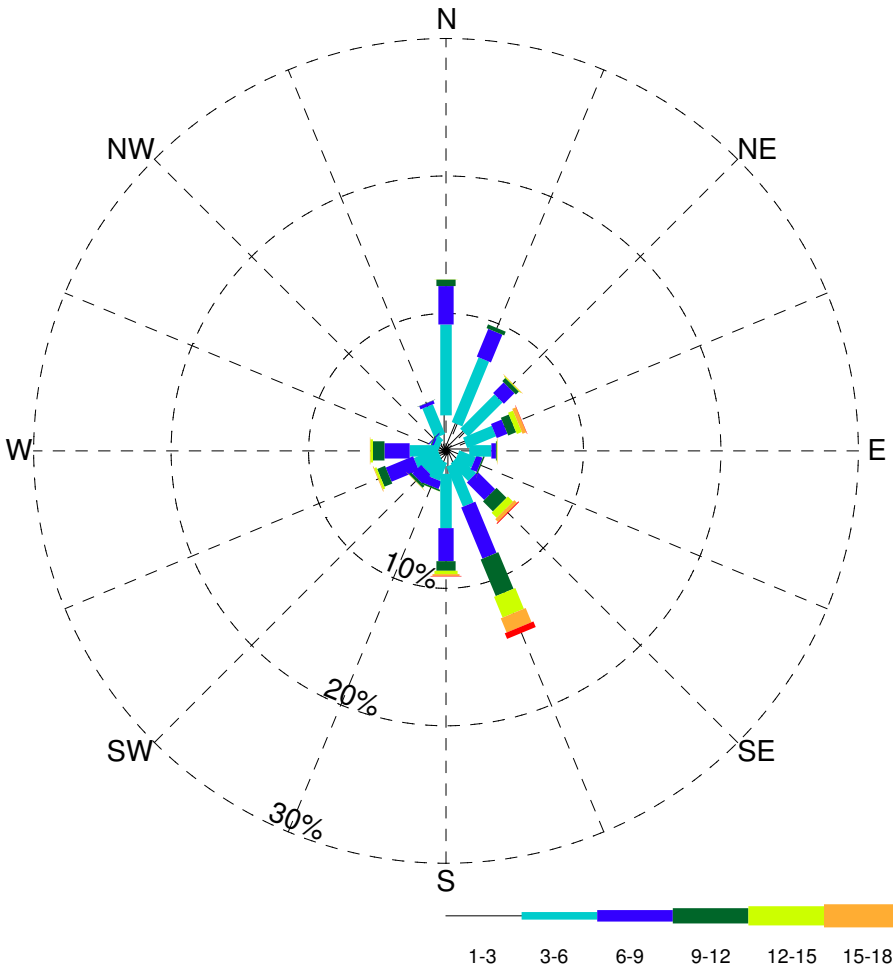
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 07, 2012

Figure A.21



Kelp Reefs

Location:

N48° 33' 0.0" W123° 14' 24.0"

Elevation: Sea Level

Sea level: -

Length of Record

Start Date: March 14, 1997

End Date: November 12, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	1.51	2.26	0.84	0.63	0.39	0.29	0.03	5.95
NE	-	1.87	3.53	1.09	0.31	0.07	0.03	-	6.91
NNE	-	2.10	5.10	2.18	0.30	-	-	-	9.68
N	-	2.58	6.61	2.80	0.47	0.01	-	-	12.48
NNW	-	1.16	2.34	0.25	0.02	-	-	-	3.77
NW	-	0.69	0.51	0.08	0.01	-	-	-	1.30
WNW	-	0.54	0.44	0.14	0.06	0.01	-	-	1.19
W	-	0.83	1.81	1.84	0.83	0.19	0.04	-	5.55
WSW	-	0.53	1.84	2.15	0.62	0.17	0.05	-	5.37
SW	-	0.66	1.34	0.90	0.20	0.03	0.01	-	3.15
SSW	-	0.78	1.40	0.59	0.12	0.01	-	-	2.92
S	-	1.67	3.95	2.40	0.70	0.24	0.13	0.04	9.14
SSE	-	1.07	3.16	4.03	2.88	1.63	1.12	0.44	14.34
SE	-	0.89	1.80	1.80	1.03	0.52	0.27	0.08	6.40
ESE	-	0.88	1.30	0.48	0.10	-	0.01	-	2.79
E	-	1.69	1.61	0.33	0.07	0.04	0.02	-	3.76
Calm	5.31	-	-	-	-	-	-	-	5.31
Total (%)	5.31	19.47	39.00	21.91	8.36	3.34	1.98	0.64	100.00

NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Winter: October-March
Kelp Reefs

STATUS
ISSUED FOR USE

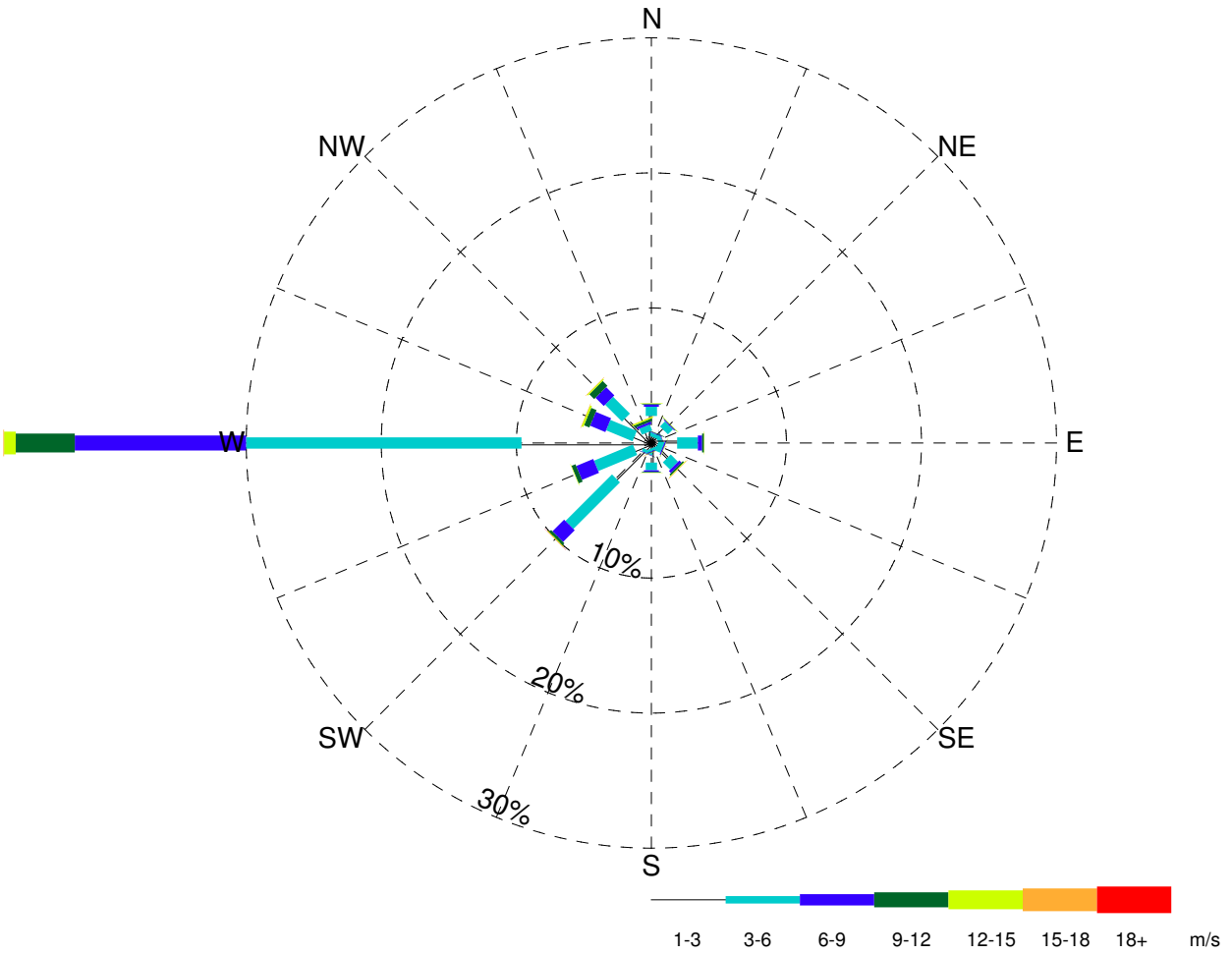
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 07, 2012

Figure A.22



New Dungeness
Location:
N48° 10' 1.2" W123° 6' 0.0"
Elevation: 12.0 m
Sea level: -
Length of Record
Start Date: September 11, 1975
End Date: June 04, 1990
Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	0.49	0.31	0.04	0.02	-	-	-	0.87
NE	-	1.32	0.53	0.07	0.04	0.03	-	-	1.98
NNE	-	0.44	0.28	0.05	0.05	-	-	-	0.82
N	-	2.00	0.68	0.17	0.06	0.04	-	-	2.95
NNW	-	0.83	0.48	0.18	0.18	0.10	0.02	-	1.80
NW	-	2.66	1.76	0.86	0.51	0.09	0.03	-	5.93
WNW	-	1.34	2.12	1.22	0.43	0.14	0.03	-	5.28
W	-	9.62	20.40	12.68	4.37	0.86	0.06	-	48.00
WSW	-	1.31	3.12	1.37	0.32	0.04	-	-	6.16
SW	-	3.71	4.88	1.22	0.20	0.06	-	0.02	10.08
SSW	-	0.59	0.25	0.04	0.02	-	-	-	0.91
S	-	1.45	0.57	0.11	0.06	0.02	-	-	2.21
SSE	-	0.37	0.19	0.06	0.04	-	0.03	-	0.68
SE	-	1.61	0.77	0.22	0.12	0.05	0.03	-	2.80
ESE	-	0.46	0.44	0.09	0.02	0.02	-	-	1.01
E	-	1.91	1.54	0.31	0.14	0.03	-	-	3.94
Calm	4.58	-	-	-	-	-	-	-	4.58
Total (%)	4.58	30.10	38.33	18.68	6.57	1.50	0.21	0.03	100.00

NOTES

CLIENT
Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Summer: April-September
New Dungeness

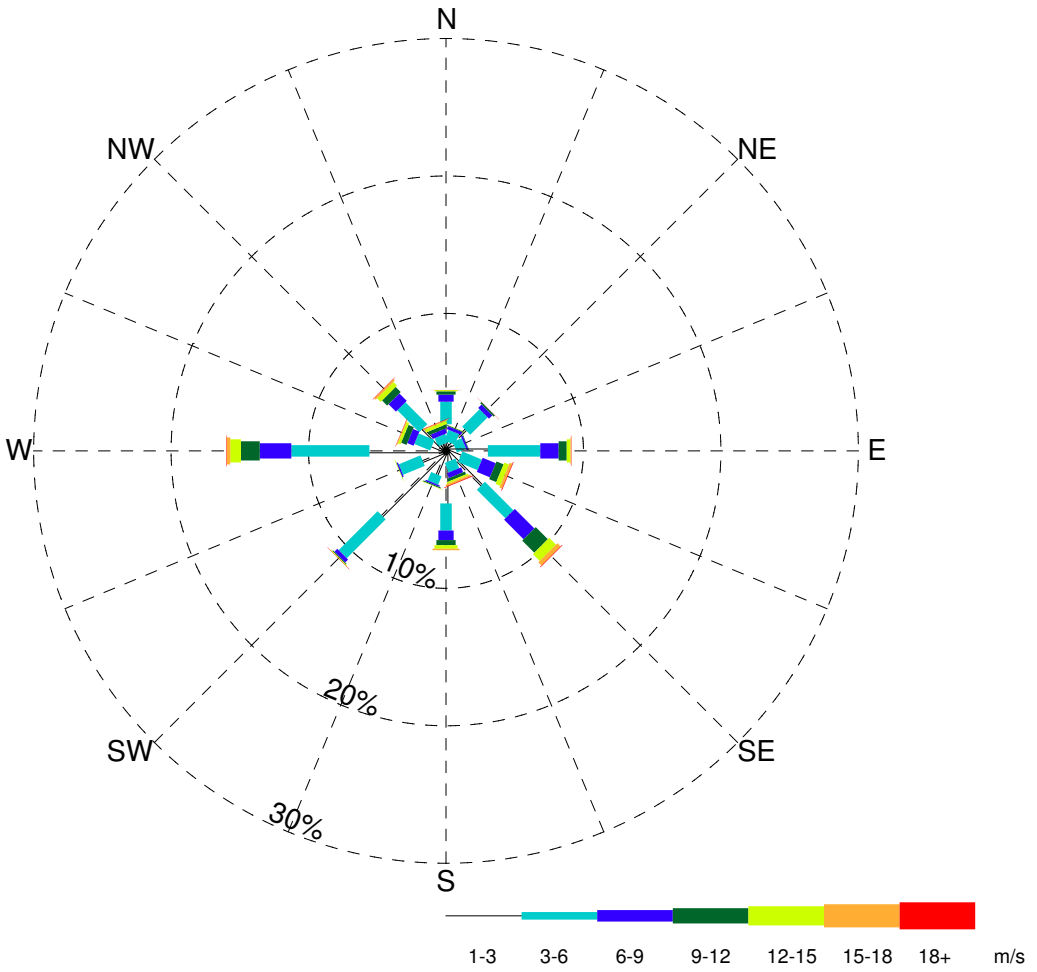
STATUS
ISSUED FOR USE

A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC
DATE: December 07, 2012

Figure A.23



New Dungeness
Location:
N48° 10' 1.2" W123° 6' 0.0"
Elevation: 12.0 m
Sea level: -
Length of Record
Start Date: September 11, 1975
End Date: June 04, 1990
Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	0.69	0.72	0.13	0.04	-	-	-	1.59
NE	-	2.08	1.79	0.34	0.12	-	-	0.01	4.35
NNE	-	0.66	0.83	0.23	0.06	0.02	-	-	1.80
N	-	1.93	1.64	0.51	0.25	0.09	-	0.01	4.44
NNW	-	0.52	0.64	0.36	0.27	0.22	0.08	0.03	2.12
NW	-	2.34	2.26	0.77	0.52	0.37	0.14	0.03	6.43
WNW	-	1.08	1.25	0.50	0.42	0.20	0.07	0.02	3.54
W	-	5.57	5.68	2.30	1.37	0.78	0.26	0.03	15.99
WSW	-	1.85	1.71	0.10	0.02	0.03	-	-	3.71
SW	-	6.63	4.00	0.30	0.07	0.06	-	0.02	11.07
SSW	-	1.83	0.67	0.11	0.08	0.03	-	-	2.72
S	-	3.82	1.97	0.70	0.37	0.26	0.11	-	7.23
SSE	-	0.78	0.76	0.38	0.22	0.13	0.13	0.06	2.46
SE	-	3.59	2.93	2.01	1.25	0.70	0.32	0.04	10.85
ESE	-	1.12	1.53	1.03	0.56	0.37	0.20	0.04	4.86
E	-	3.05	3.81	1.33	0.59	0.27	0.07	0.02	9.14
Calm	7.72	-	-	-	-	-	-	-	7.72
Total (%)	7.72	37.53	32.21	11.12	6.19	3.52	1.38	0.33	100.00

NOTES

CLIENT
Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION
Winter: October-March
New Dungeness

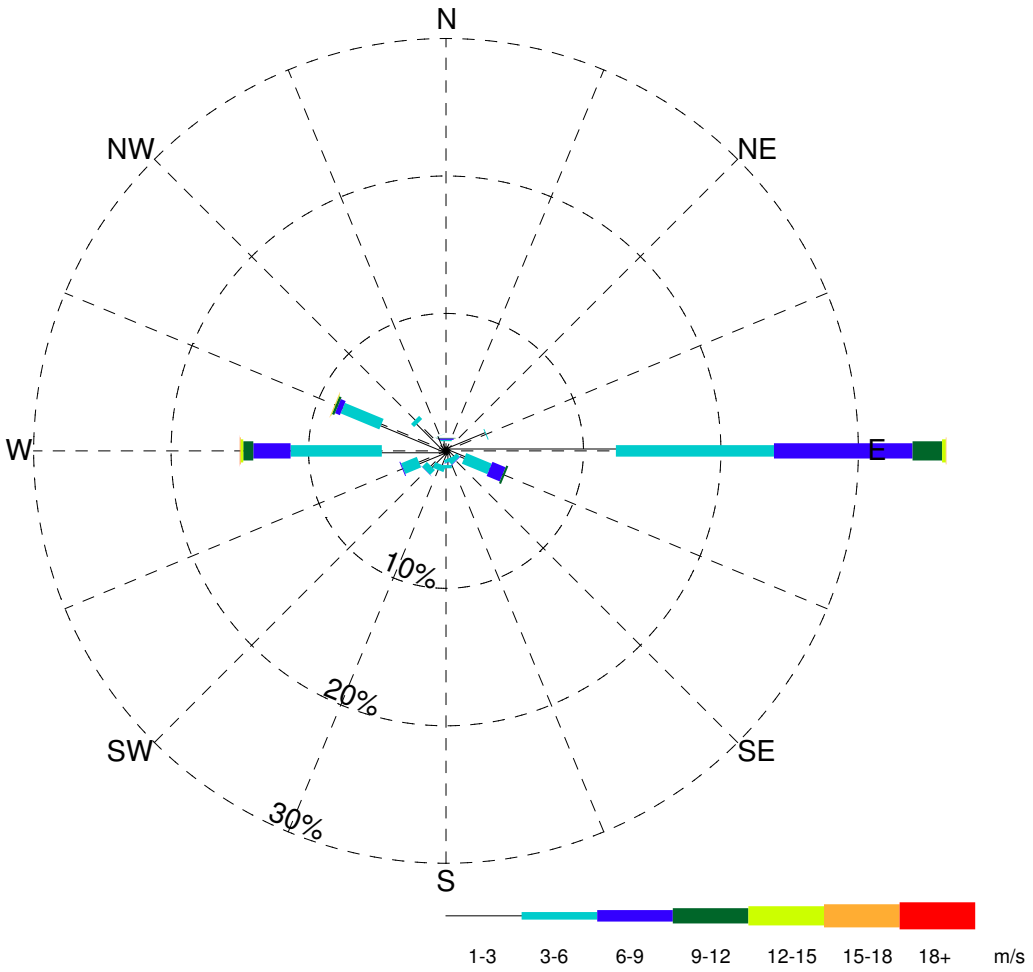
STATUS
ISSUED FOR USE

A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC
DATE: December 07, 2012

Figure A.24



Wind Speed & Direction Frequency Distribution Table

Point Atkinson
Location:
N49° 19' 48.0" W123° 15' 36.0"
Elevation: 35.0 m
Sea level: -
Length of Record
Start Date: May 31, 1996
End Date: November 12, 2012
Comment: -

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	3.12	0.07	-	-	-	-	-	3.19
NE	-	0.30	-	-	-	-	-	-	0.30
NNE	-	0.26	-	-	-	-	-	-	0.26
N	-	0.70	0.10	0.10	0.04	-	-	-	0.95
NNW	-	1.17	0.01	-	-	-	-	-	1.18
NW	-	2.87	0.31	-	-	-	-	-	3.19
WNW	-	5.08	3.05	0.38	0.18	0.04	0.03	-	8.78
W	-	4.67	6.64	2.71	0.73	0.19	0.06	0.01	15.01
WSW	-	2.13	1.25	0.07	-	-	-	-	3.45
SW	-	1.55	0.49	0.01	-	-	-	-	2.06
SSW	-	1.06	0.44	-	-	-	-	-	1.51
S	-	1.03	0.23	-	-	-	-	-	1.27
SSE	-	0.57	0.25	0.02	-	-	-	-	0.84
SE	-	0.66	0.35	0.04	-	-	-	-	1.04
ESE	-	1.42	2.00	1.03	0.16	-	-	-	4.62
E	-	12.36	11.50	10.08	2.15	0.27	0.04	-	36.40
Calm	15.96	-	-	-	-	-	-	-	15.96
Total (%)	15.96	38.96	26.69	14.47	3.26	0.51	0.12	0.02	100.00

NOTES

STATUS
ISSUED FOR USE

CLIENT
Kinder Morgan

A TETRA TECH COMPANY

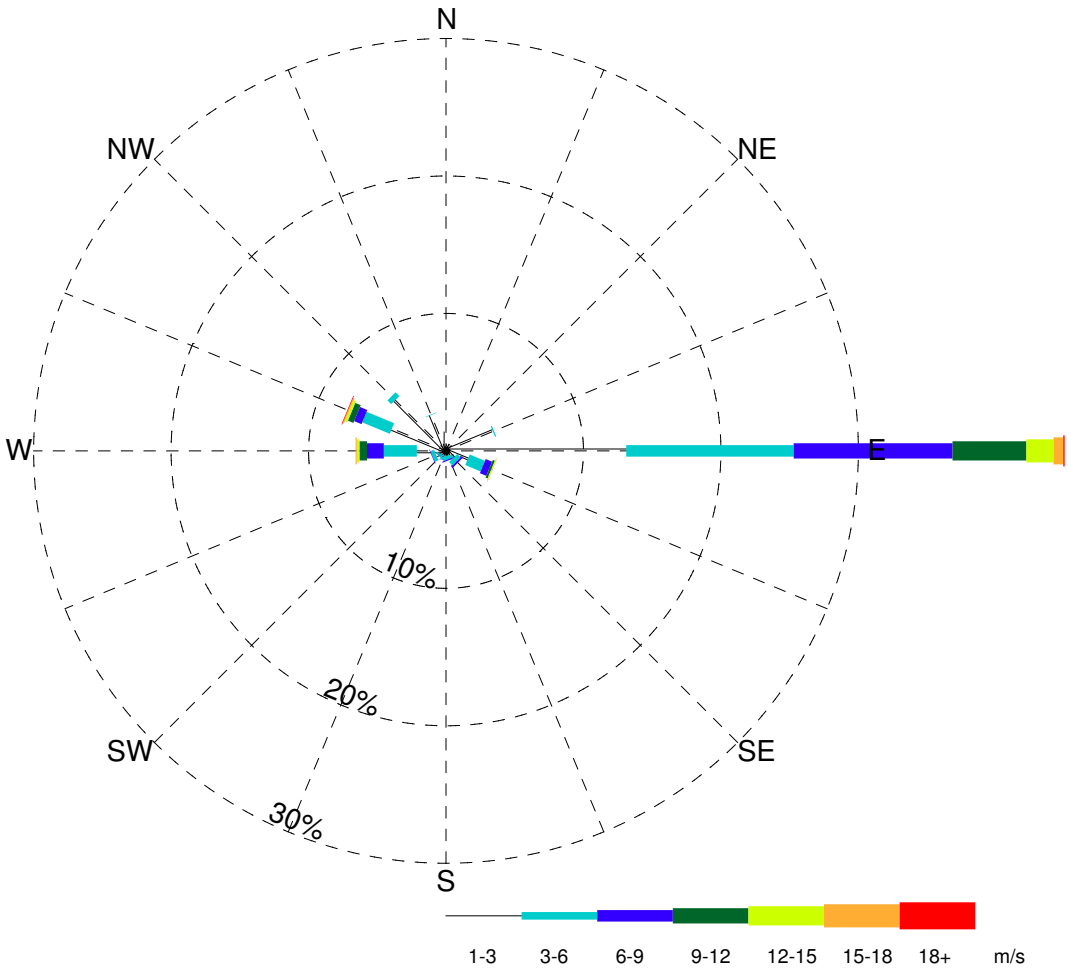
METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Summer: April-September
Point Atkinson

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC
DATE: December 07, 2012

Figure A.25



Point Atkinson

Location:

N49° 19' 48.0" W123° 15' 36.0"

Elevation: 35.0 m

Sea level: -

Length of Record

Start Date: May 31, 1996

End Date: November 12, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	**0-1 m/s**	**1-3 m/s**	**3-6 m/s**	**6-9 m/s**	**9-12 m/s**	**12-15 m/s**	**15-18 m/s**	**18+ m/s**	**Total (%)**
ENE	-	3.69	0.09	-	-	-	-	-	3.78
NE	-	0.50	-	-	-	-	-	-	0.50
NNE	-	0.43	-	-	-	-	-	-	0.43
N	-	1.37	-	-	-	-	-	-	1.37
NNW	-	2.82	0.04	-	-	-	-	-	2.86
NW	-	5.22	0.39	-	-	-	-	-	5.61
WNW	-	4.26	2.17	0.58	0.43	0.19	0.09	0.05	7.77
W	-	2.12	2.40	1.22	0.55	0.20	0.08	-	6.59
WSW	-	0.78	0.28	0.04	-	-	-	-	1.10
SW	-	0.48	0.12	0.01	-	-	-	-	0.62
SSW	-	0.35	0.09	0.01	-	-	-	-	0.46
S	-	0.46	0.16	0.02	-	-	-	-	0.63
SSE	-	0.39	0.24	0.08	-	-	-	-	0.71
SE	-	0.74	0.35	0.14	-	-	-	-	1.22
ESE	-	1.69	1.21	0.50	0.16	0.06	0.03	-	3.65
E	-	13.11	12.18	11.55	5.38	1.98	0.71	0.10	45.01
Calm	17.69	-	-	-	-	-	-	-	17.69
Total (%)	17.69	38.42	19.70	14.17	6.53	2.43	0.90	0.16	100.00

NOTES

STATUS
ISSUED FOR USE

CLIENT
Kinder Morgan

A TETRA TECH COMPANY

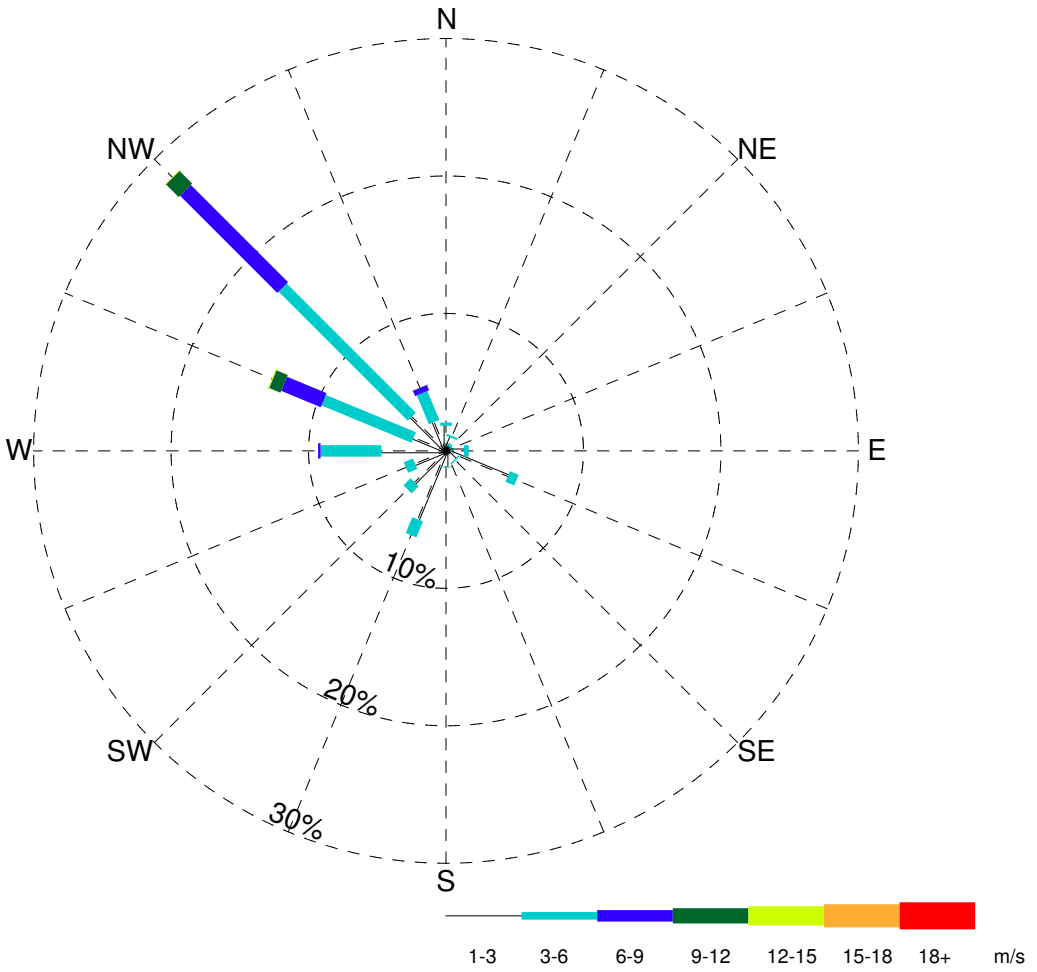
METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Winter: October-March
Point Atkinson

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 07, 2012

Figure A.26



Port Angeles

Location:

N48° 7' 58.8" W123° 25' 58.8"

Elevation: 5.0 m

Sea level: -

Length of Record

Start Date: April 19, 2005

End Date: November 01, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	0.39	0.11	-	-	-	-	-	0.50
NE	-	0.37	0.10	-	-	-	-	-	0.47
NNE	-	1.02	0.15	-	-	-	-	-	1.17
N	-	1.82	0.24	-	-	-	-	-	2.06
NNW	-	2.26	2.28	0.41	0.02	-	-	-	4.98
NW	-	3.52	13.29	10.01	1.30	0.05	-	-	28.16
WNW	-	2.54	7.09	3.12	0.89	0.07	-	-	13.71
W	-	4.70	4.43	0.18	-	-	-	-	9.30
WSW	-	2.43	0.72	-	-	-	-	-	3.15
SW	-	3.23	0.72	-	-	-	-	-	3.96
SSW	-	5.39	1.25	-	-	-	-	-	6.64
S	-	1.14	0.06	-	-	-	-	-	1.20
SSE	-	0.29	0.01	-	-	-	-	-	0.30
SE	-	0.87	0.11	-	-	-	-	-	0.98
ESE	-	4.86	0.69	-	-	-	-	-	5.55
E	-	1.30	0.35	-	-	-	-	-	1.65
Calm	16.20	-	-	-	-	-	-	-	16.20
Total (%)	16.20	36.14	31.61	13.71	2.21	0.12	-	-	100.00

NOTES

STATUS
ISSUED FOR USE

CLIENT
Kinder Morgan

A TETRA TECH COMPANY

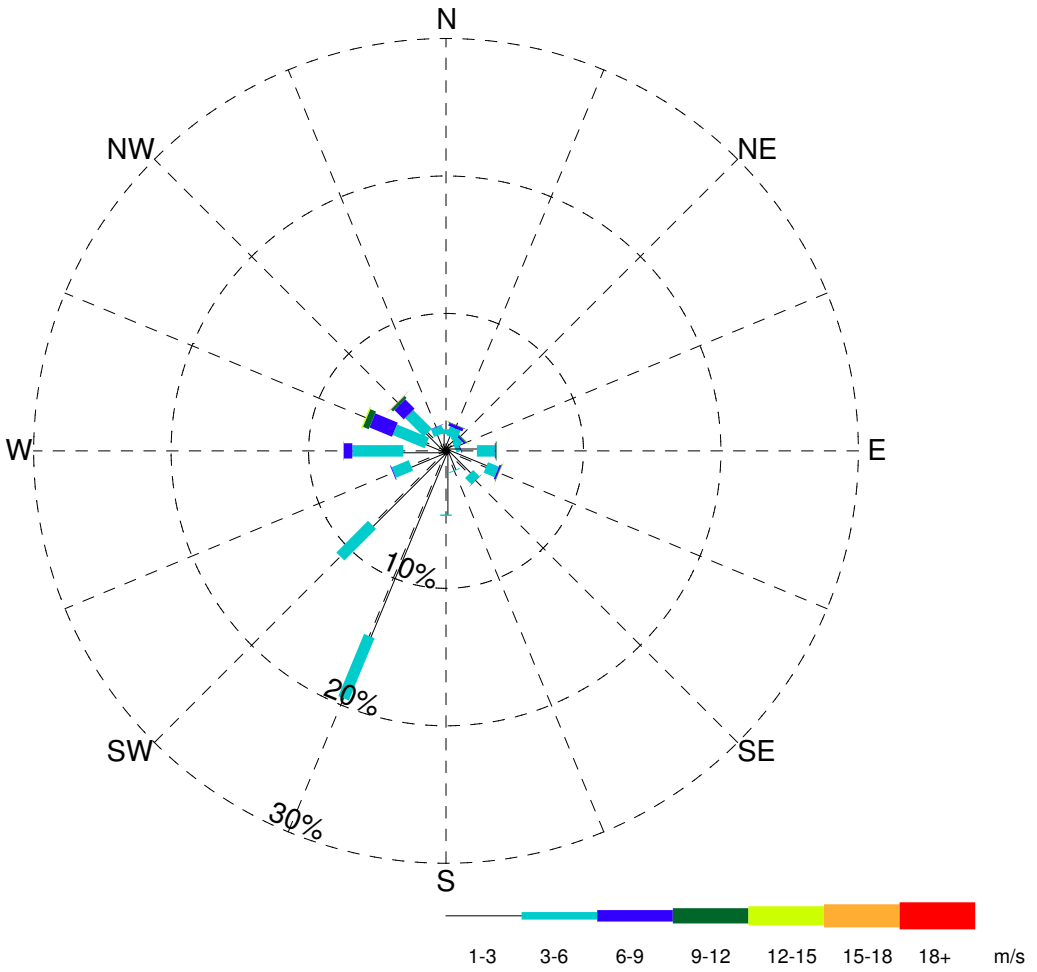
METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Summer: April-September
Port Angeles

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC
DATE: December 07, 2012

Figure A.27



Port Angeles

Location:

N48° 7' 58.8" W123° 25' 58.8"

Elevation: 5.0 m

Sea level: -

Length of Record

Start Date: April 19, 2005

End Date: November 01, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	**0-1 m/s**	**1-3 m/s**	**3-6 m/s**	**6-9 m/s**	**9-12 m/s**	**12-15 m/s**	**15-18 m/s**	**18+ m/s**	**Total (%)**
ENE	-	0.67	0.32	0.07	-	-	-	-	1.06
NE	-	0.89	0.41	0.15	0.06	0.05	-	-	1.56
NNE	-	1.06	0.70	0.22	0.05	-	-	-	2.03
N	-	1.22	0.35	-	-	-	-	-	1.57
NNW	-	1.27	0.59	0.04	-	-	-	-	1.89
NW	-	1.88	1.91	0.96	0.21	0.04	-	0.01	5.01
WNW	-	1.51	2.52	1.78	0.45	0.09	-	-	6.34
W	-	3.10	3.71	0.61	0.02	-	-	-	7.45
WSW	-	2.77	1.35	0.06	-	-	-	-	4.18
SW	-	7.61	3.25	-	-	-	-	-	10.87
SSW	-	14.58	4.90	-	-	-	-	-	19.48
S	-	4.63	0.10	-	-	-	-	-	4.73
SSE	-	1.52	0.07	-	-	-	-	-	1.59
SE	-	2.38	0.65	0.02	0.01	-	-	-	3.06
ESE	-	3.14	0.85	0.13	0.05	0.01	0.01	-	4.19
E	-	2.25	1.30	0.07	0.06	-	-	-	3.68
Calm	21.32	-	-	-	-	-	-	-	21.32
Total (%)	21.32	50.48	23.00	4.09	0.90	0.19	0.01	0.01	100.00

NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Winter: October-March
Port Angeles

STATUS
ISSUED FOR USE

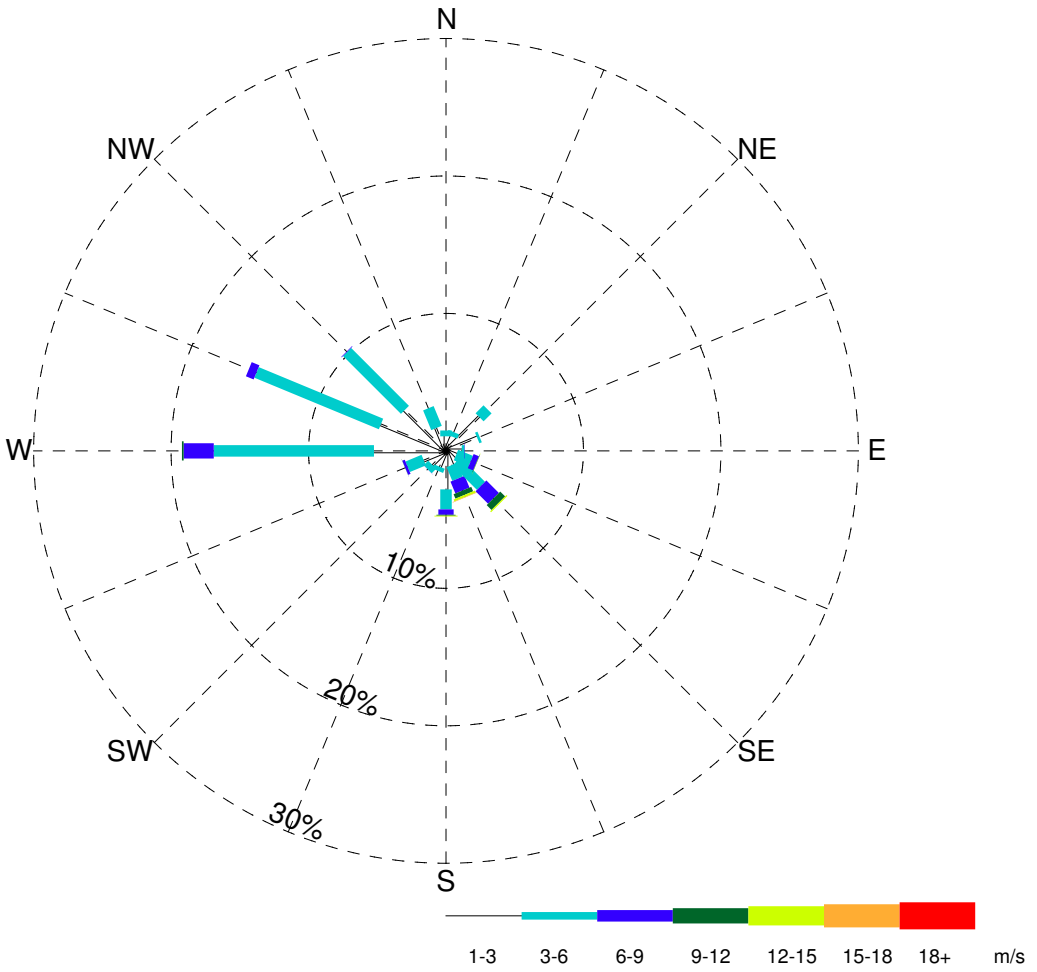
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 07, 2012

Figure A.28



Port Townsend

Location:

N48° 7' 1.2" W122° 45' 0.0"

Elevation: 5.0 m

Sea level: -

Length of Record

Start Date: April 19, 2005

End Date: November 01, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	2.46	0.19	-	-	-	-	-	2.65
NE	-	3.45	0.82	-	-	-	-	-	4.28
NNE	-	1.13	0.34	-	-	-	-	-	1.48
N	-	1.06	0.43	-	-	-	-	-	1.48
NNW	-	1.80	1.55	-	-	-	-	-	3.36
NW	-	4.22	5.95	0.04	-	-	-	-	10.22
WNW	-	5.12	9.80	0.61	-	-	-	-	15.53
W	-	5.24	11.66	2.19	0.12	-	-	-	19.21
WSW	-	1.75	1.27	0.19	0.01	-	-	-	3.23
SW	-	1.42	0.46	0.01	-	-	-	-	1.90
SSW	-	1.24	0.33	-	-	-	-	-	1.57
S	-	2.80	1.45	0.39	0.06	0.06	-	-	4.77
SSE	-	1.12	1.08	0.93	0.35	0.15	0.04	-	3.66
SE	-	1.08	2.51	1.29	0.50	0.09	-	-	5.48
ESE	-	0.79	1.16	0.42	0.03	0.01	-	-	2.41
E	-	1.14	0.20	0.03	-	-	-	-	1.37
Calm	17.40	-	-	-	-	-	-	-	17.40
Total (%)	17.40	35.84	39.21	6.12	1.08	0.32	0.04	-	100.00

NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Summer: April-September
Port Townsend

STATUS
ISSUED FOR USE

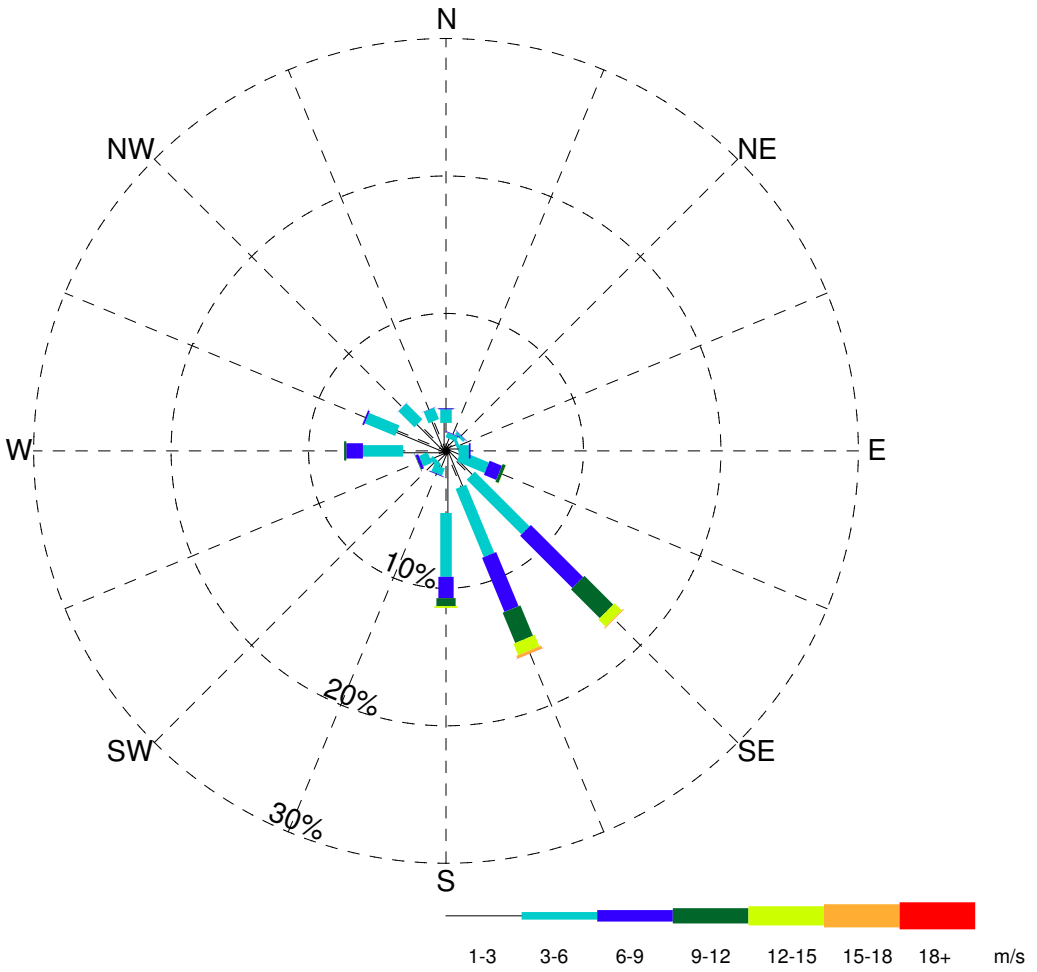
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 07, 2012

Figure A.29



Port Townsend

Location:

N48° 7' 1.2" W122° 45' 0.0"

Elevation: 5.0 m

Sea level: -

Length of Record

Start Date: April 19, 2005

End Date: November 01, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	**0-1 m/s**	**1-3 m/s**	**3-6 m/s**	**6-9 m/s**	**9-12 m/s**	**12-15 m/s**	**15-18 m/s**	**18+ m/s**	**Total (%)**
ENE	-	0.82	0.22	-	-	-	-	-	1.05
NE	-	1.34	0.20	0.04	-	-	-	-	1.58
NNE	-	0.90	0.38	0.05	-	-	-	-	1.33
N	-	2.03	0.99	0.08	0.02	-	-	-	3.12
NNW	-	2.34	0.90	0.02	-	-	-	-	3.26
NW	-	2.84	1.65	0.01	-	-	-	-	4.50
WNW	-	3.83	2.40	0.13	0.01	-	-	-	6.37
W	-	3.12	2.92	1.21	0.16	-	-	-	7.42
WSW	-	1.28	0.69	0.22	0.04	-	-	-	2.23
SW	-	0.94	0.34	0.01	-	-	-	-	1.29
SSW	-	1.22	0.56	0.06	0.01	-	-	-	1.85
S	-	4.51	4.65	1.55	0.58	0.14	-	-	11.43
SSE	-	2.83	5.37	4.26	2.39	0.89	0.21	0.01	15.96
SE	-	2.55	5.63	5.38	2.96	0.73	0.08	-	17.33
ESE	-	1.01	2.20	0.97	0.24	0.03	-	-	4.45
E	-	0.92	0.74	0.12	-	-	-	-	1.79
Calm	15.05	-	-	-	-	-	-	-	15.05
Total (%)	15.05	32.47	29.85	14.10	6.42	1.78	0.30	0.02	100.00

NOTES

STATUS
IISSUED FOR USE

CLIENT
Kinder Morgan

A TETRA TECH COMPANY

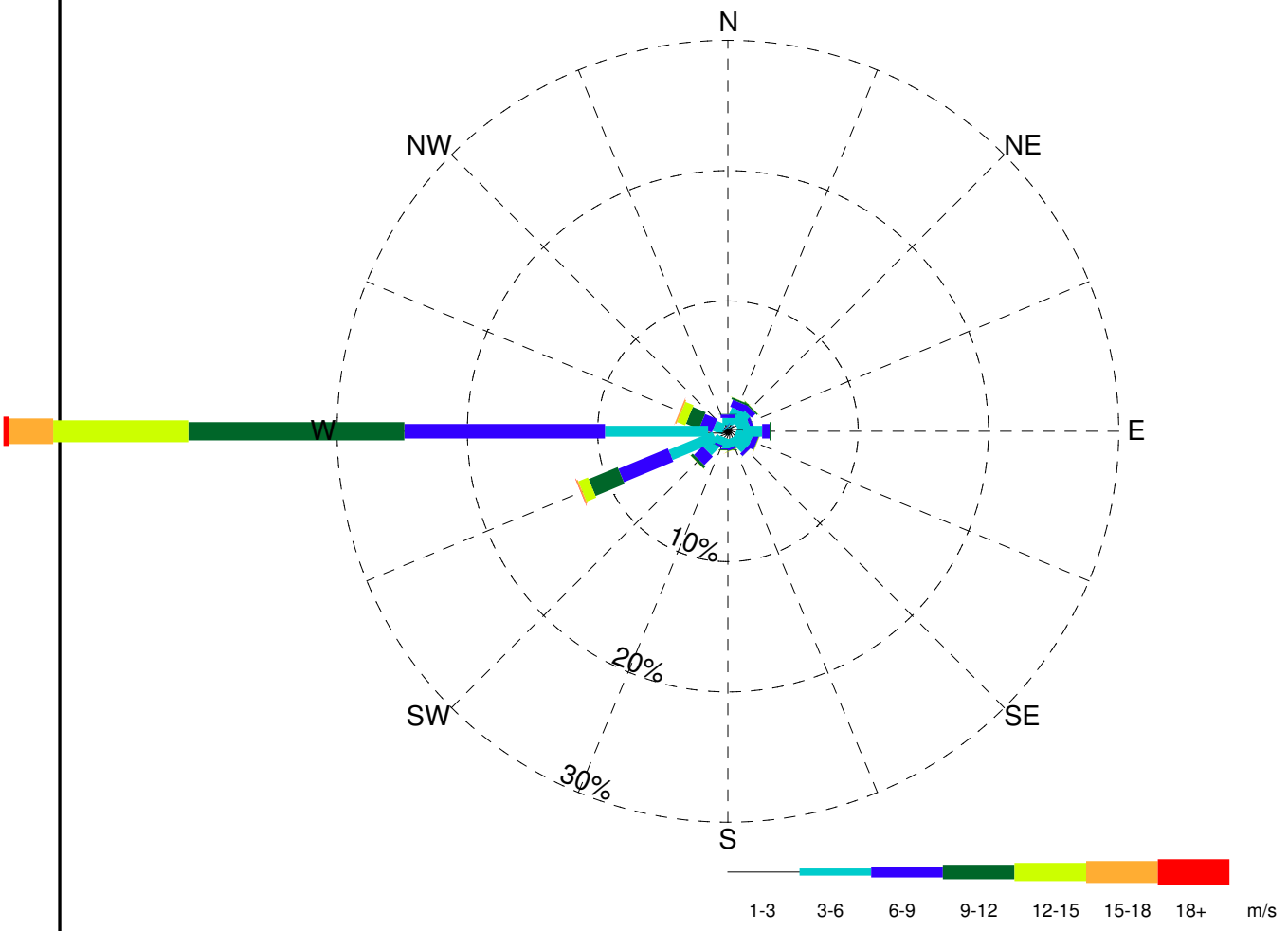
METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Winter: October-March
Port Townsend

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 07, 2012

Figure A.30



Race Rocks

Location:

N48° 18' 0.0" W123° 31' 58.8"

Elevation: 3.0 m

Sea level: -

Length of Record

Start Date: April 23, 1995

End Date: December 01, 2010

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	0.75	0.96	0.25	0.02	-	-	-	1.99
NE	-	0.85	1.17	0.43	0.12	0.02	-	-	2.59
NNE	-	0.67	1.14	0.57	0.15	0.02	-	-	2.55
N	-	0.47	0.56	0.27	0.04	-	-	-	1.33
NNW	-	0.17	0.05	0.01	-	-	-	-	0.23
NW	-	0.22	0.09	0.02	-	-	-	-	0.34
WNW	-	0.38	0.73	1.02	1.08	0.67	0.12	0.01	4.00
W	-	1.52	7.92	15.40	16.59	10.37	3.40	0.41	55.61
WSW	-	1.10	3.66	4.11	2.42	0.79	0.11	0.03	12.22
SW	-	0.71	1.49	0.93	0.21	0.02	-	-	3.36
SSW	-	0.54	0.62	0.15	0.01	-	-	-	1.33
S	-	0.75	0.57	0.08	0.07	0.01	-	-	1.48
SSE	-	0.58	0.68	0.15	0.03	0.03	0.01	-	1.48
SE	-	0.63	1.25	0.27	0.01	-	-	-	2.16
ESE	-	0.58	1.33	0.44	0.04	0.02	0.01	-	2.42
E	-	1.15	1.48	0.57	0.07	0.02	0.01	-	3.31
Calm	3.61	-	-	-	-	-	-	-	3.61
Total (%)	3.61	11.06	23.68	24.67	20.85	11.98	3.68	0.46	100.00

NOTES

STATUS
ISSUED FOR USE

CLIENT
Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

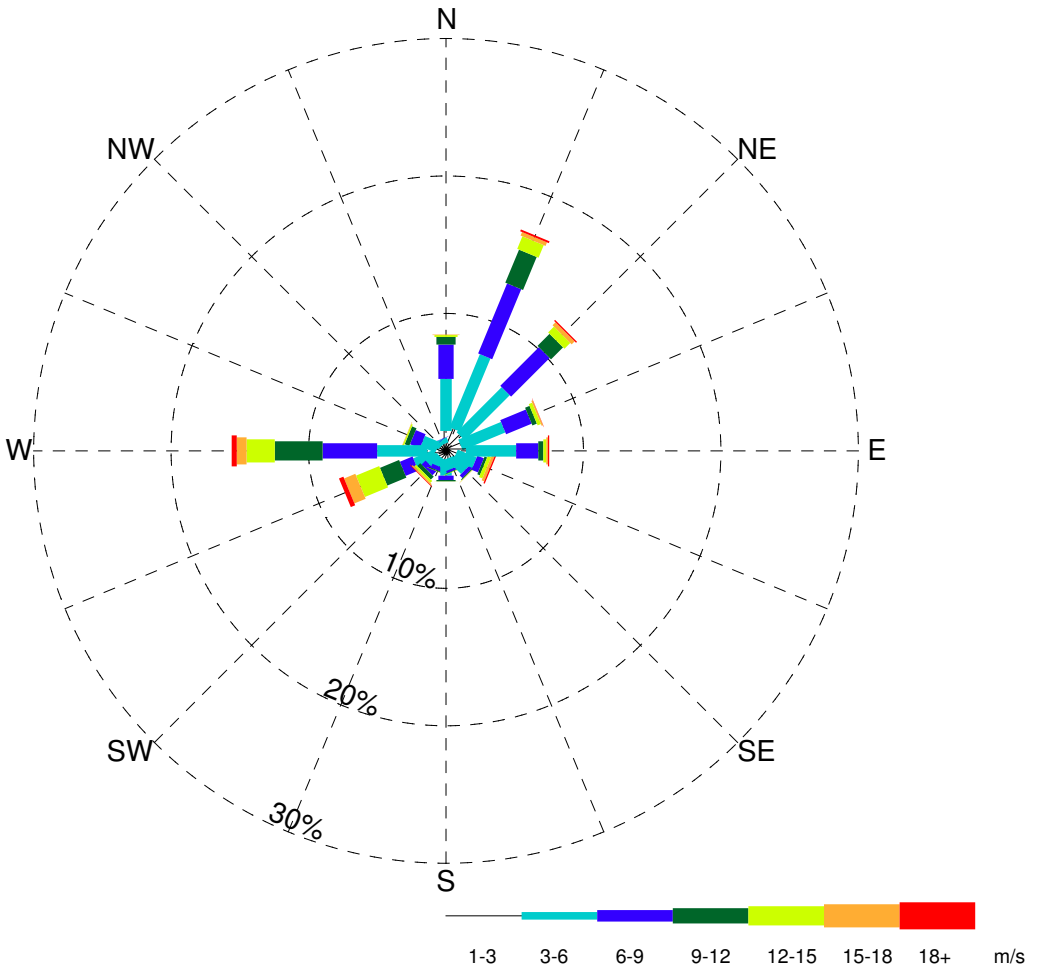
Summer: April-September
Race Rocks

A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC
DATE: December 07, 2012

Figure A.31



Race Rocks

Location:

N48° 18' 0.0" W123° 31' 58.8"

Elevation: 3.0 m

Sea level: -

Length of Record

Start Date: April 23, 1995

End Date: December 01, 2010

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	1.14	3.37	2.02	0.35	0.26	0.11	0.02	7.25
NE	-	1.50	4.64	3.97	1.24	0.60	0.30	0.10	12.35
NNE	-	1.68	5.76	5.51	2.60	0.99	0.28	0.14	16.97
N	-	1.45	3.79	2.50	0.55	0.14	0.04	-	8.47
NNW	-	0.51	0.39	0.02	-	-	-	-	0.93
NW	-	0.48	0.29	0.03	-	-	-	-	0.80
WNW	-	0.67	1.17	0.77	0.36	0.11	0.03	-	3.10
W	-	1.35	3.66	3.96	3.48	2.05	0.71	0.37	15.59
WSW	-	0.79	1.62	1.00	1.50	1.82	0.89	0.34	7.96
SW	-	0.59	0.96	0.41	0.30	0.19	0.10	0.05	2.60
SSW	-	0.60	0.64	0.30	0.07	0.02	-	-	1.64
S	-	0.75	1.06	0.31	0.10	0.01	-	-	2.24
SSE	-	0.55	0.81	0.17	0.04	0.04	-	-	1.62
SE	-	0.70	1.26	0.28	0.08	0.03	0.02	-	2.36
ESE	-	0.75	1.49	0.51	0.20	0.26	0.20	0.10	3.52
E	-	1.46	3.65	1.61	0.37	0.21	0.12	0.09	7.51
Calm	5.09	-	-	-	-	-	-	-	5.09
Total (%)	5.09	14.97	34.54	23.38	11.25	6.73	2.81	1.24	100.00

NOTES

STATUS
ISSUED FOR USE

CLIENT
Kinder Morgan

A TETRA TECH COMPANY

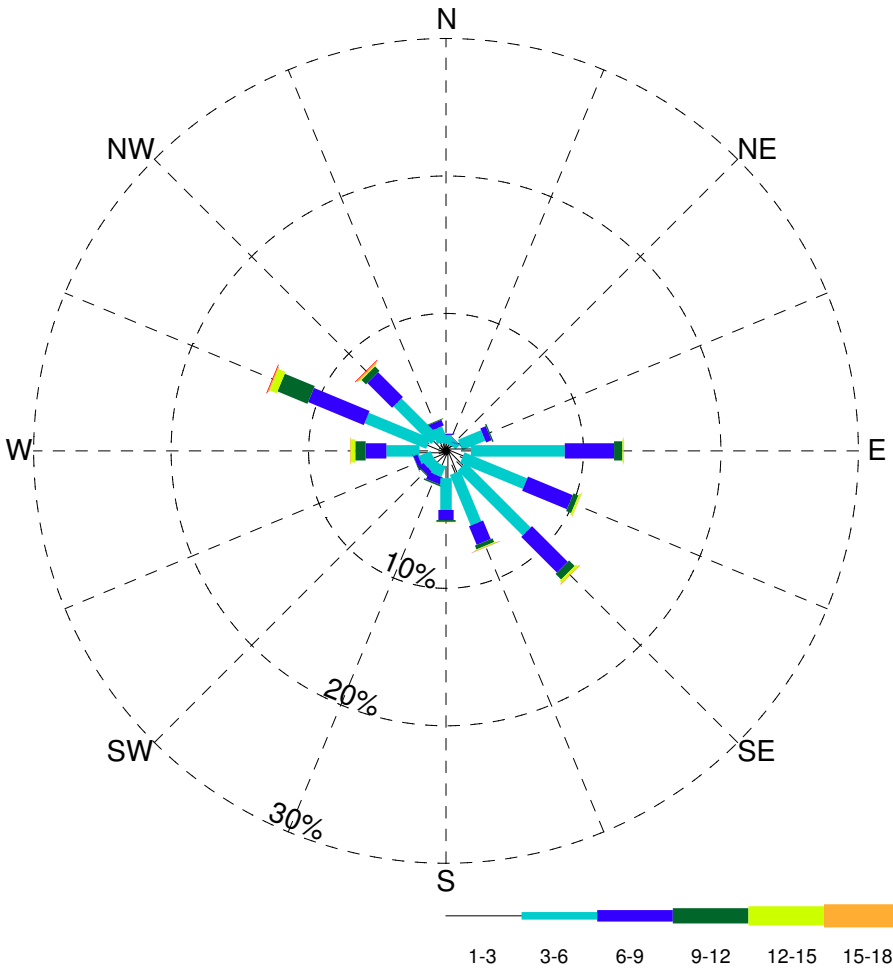
METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Winter: October-March
Race Rocks

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC
DATE: December 07, 2012

Figure A.32



Sand Heads

Location:

N49° 6' 0.0" W123° 18' 0.0"

Elevation: Sea Level

Sea level: -

Length of Record

Start Date: July 05, 2001

End Date: November 01, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	1.10	1.83	0.43	0.10	-	-	-	3.47
NE	-	0.56	0.43	0.04	-	-	-	-	1.03
NNE	-	0.48	0.27	0.03	0.02	-	-	-	0.79
N	-	0.58	0.58	0.08	0.01	-	-	-	1.26
NNW	-	0.70	1.07	0.45	0.06	0.01	-	-	2.30
NW	-	1.12	3.88	2.54	0.47	0.09	0.09	0.06	8.24
WNW	-	1.40	4.85	4.38	2.36	0.56	0.09	0.06	13.69
W	-	1.93	2.41	1.51	0.75	0.34	0.05	-	6.99
WSW	-	1.03	0.99	0.33	0.03	-	-	-	2.38
SW	-	1.00	0.80	0.41	0.08	-	-	-	2.29
SSW	-	1.05	0.84	0.55	0.12	-	-	-	2.56
S	-	1.98	2.31	0.74	0.13	0.02	-	-	5.20
SSE	-	1.73	3.98	1.46	0.30	0.08	0.01	0.02	7.58
SE	-	1.61	6.68	3.67	0.57	0.17	0.08	-	12.80
ESE	-	1.28	4.95	3.52	0.40	0.14	0.03	-	10.31
E	-	1.81	6.83	3.59	0.61	0.09	0.03	-	12.95
Calm	6.15	-	-	-	-	-	-	-	6.15
Total (%)	6.15	19.35	42.70	23.72	6.01	1.53	0.39	0.16	100.00

NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Summer: April-September
Sand Heads

STATUS
ISSUED FOR USE

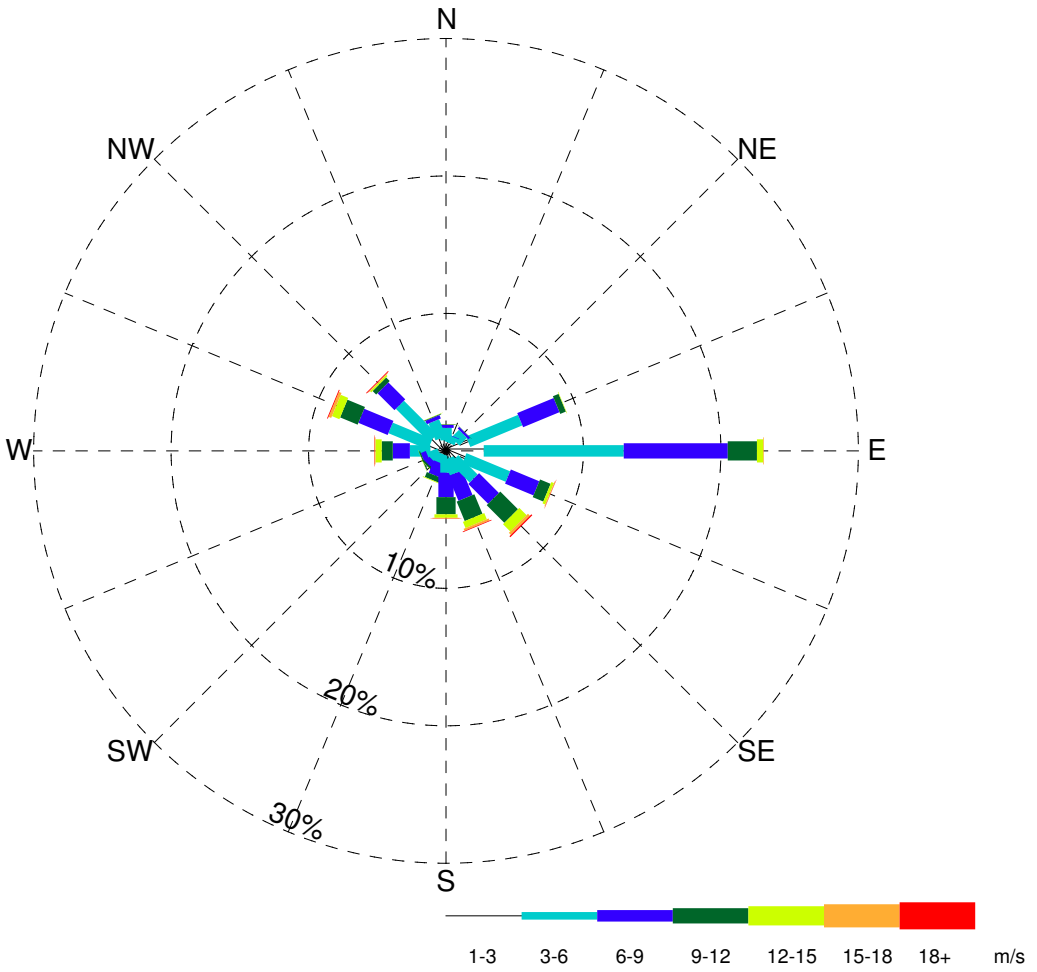
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 07, 2012

Figure A.33



Sand Heads

Location:

N49° 6' 0.0" W123° 18' 0.0"

Elevation: Sea Level

Sea level: -

Length of Record

Start Date: July 05, 2001

End Date: November 01, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	1.75	4.09	2.87	0.45	0.04	-	-	9.20
NE	-	0.96	0.80	0.17	0.02	-	-	-	1.94
NNE	-	0.61	0.53	0.04	-	-	-	-	1.19
N	-	0.76	0.91	0.22	0.04	0.02	-	-	1.95
NNW	-	1.00	1.33	0.27	0.05	0.02	-	-	2.68
NW	-	1.31	3.43	1.75	0.37	0.12	0.05	0.06	7.09
WNW	-	1.24	3.12	2.30	1.38	0.59	0.20	0.06	8.90
W	-	1.13	1.50	1.24	0.81	0.46	0.07	0.03	5.23
WSW	-	0.51	0.85	0.39	0.09	0.02	-	-	1.88
SW	-	0.43	0.72	0.44	0.14	0.03	-	-	1.78
SSW	-	0.31	0.66	0.99	0.39	0.05	-	-	2.41
S	-	0.58	1.02	1.77	1.25	0.25	0.05	0.02	4.94
SSE	-	0.57	1.20	1.94	1.54	0.49	0.16	0.05	5.94
SE	-	0.85	2.00	2.04	1.82	0.75	0.20	0.10	7.75
ESE	-	1.44	3.44	2.24	0.83	0.20	0.05	0.02	8.23
E	-	2.75	10.19	7.56	2.12	0.46	0.05	-	23.14
Calm	5.75	-	-	-	-	-	-	-	5.75
Total (%)	5.75	16.19	35.79	26.23	11.30	3.50	0.88	0.35	100.00

NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Winter: October-March
Sand Heads

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

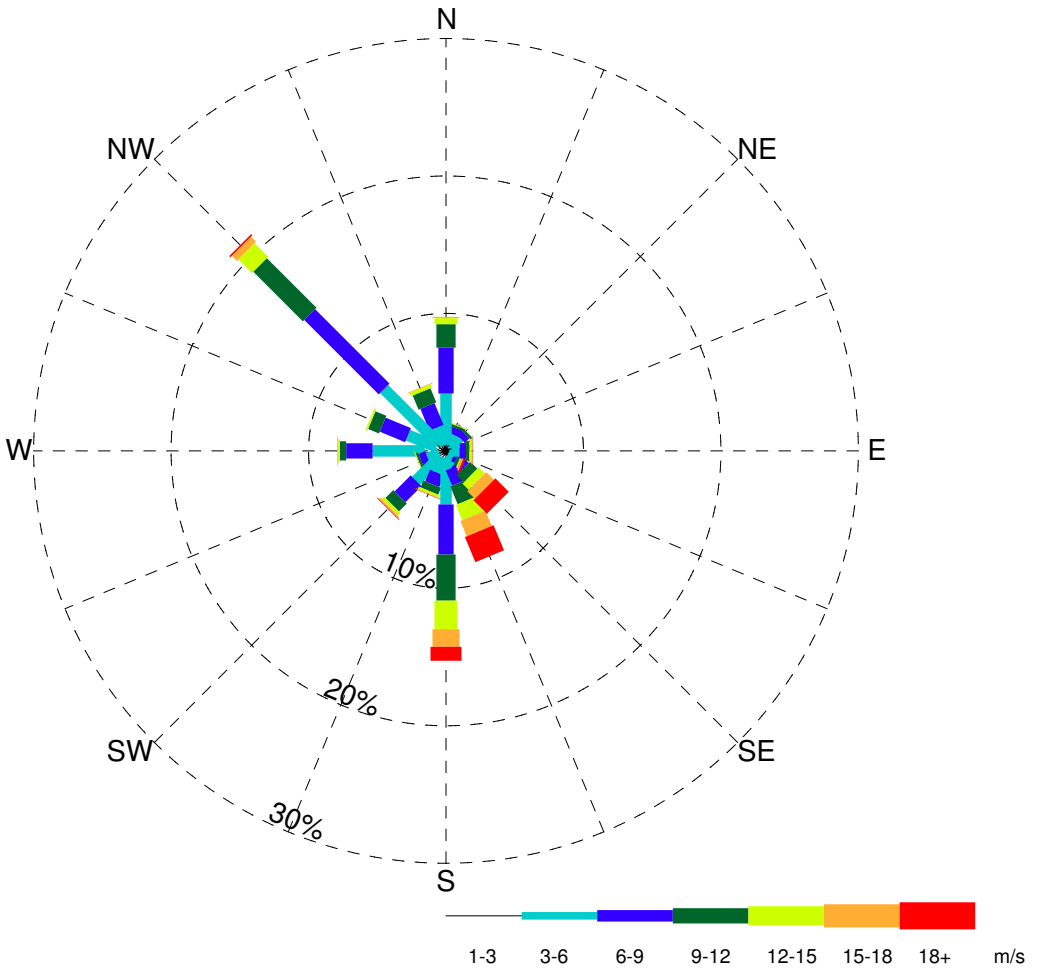
OFFICE: EBA-VANC

DATE: December 07, 2012

STATUS: ISSUED FOR USE

A TETRA TECH COMPANY

Figure A.34



Sartine Island

Location:

N50° 49’ 12.0" W128° 54’ 36.0"

Elevation: 111.5 m

Sea level: -

Length of Record

Start Date: January 31, 1994

End Date: November 12, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	0.19	0.28	0.13	0.08	0.04	0.01	0.01	0.73
NE	-	0.51	0.87	0.48	0.19	0.02	-	-	2.07
NNE	-	0.44	0.84	0.51	0.18	0.06	0.03	-	2.07
N	-	1.00	3.17	3.34	1.71	0.44	0.10	-	9.76
NNW	-	0.42	1.40	1.71	1.12	0.26	0.06	-	4.97
NW	-	1.10	5.27	7.66	5.11	1.40	0.52	0.12	21.18
WNW	-	0.74	2.25	2.00	0.86	0.13	0.02	-	6.00
W	-	1.54	3.80	1.92	0.47	0.11	0.04	0.01	7.89
WSW	-	0.51	0.91	0.52	0.18	0.06	0.02	-	2.20
SW	-	0.77	2.31	1.65	0.81	0.27	0.13	0.05	5.98
SSW	-	0.54	1.17	0.91	0.54	0.18	0.05	0.03	3.43
S	-	0.96	2.93	3.64	3.36	2.08	1.28	1.01	15.27
SSE	-	0.38	0.93	1.20	1.41	1.20	1.20	1.98	8.30
SE	-	0.38	0.75	0.68	0.73	0.64	0.78	1.38	5.33
ESE	-	0.22	0.41	0.29	0.21	0.13	0.14	0.13	1.53
E	-	0.40	0.59	0.47	0.24	0.15	0.08	0.02	1.95
Calm	1.33	-	-	-	-	-	-	-	1.33
Total (%)	1.33	10.11	27.87	27.10	17.19	7.17	4.46	4.78	100.00

NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Summer: April-September
Sartine Island

STATUS
ISSUED FOR USE

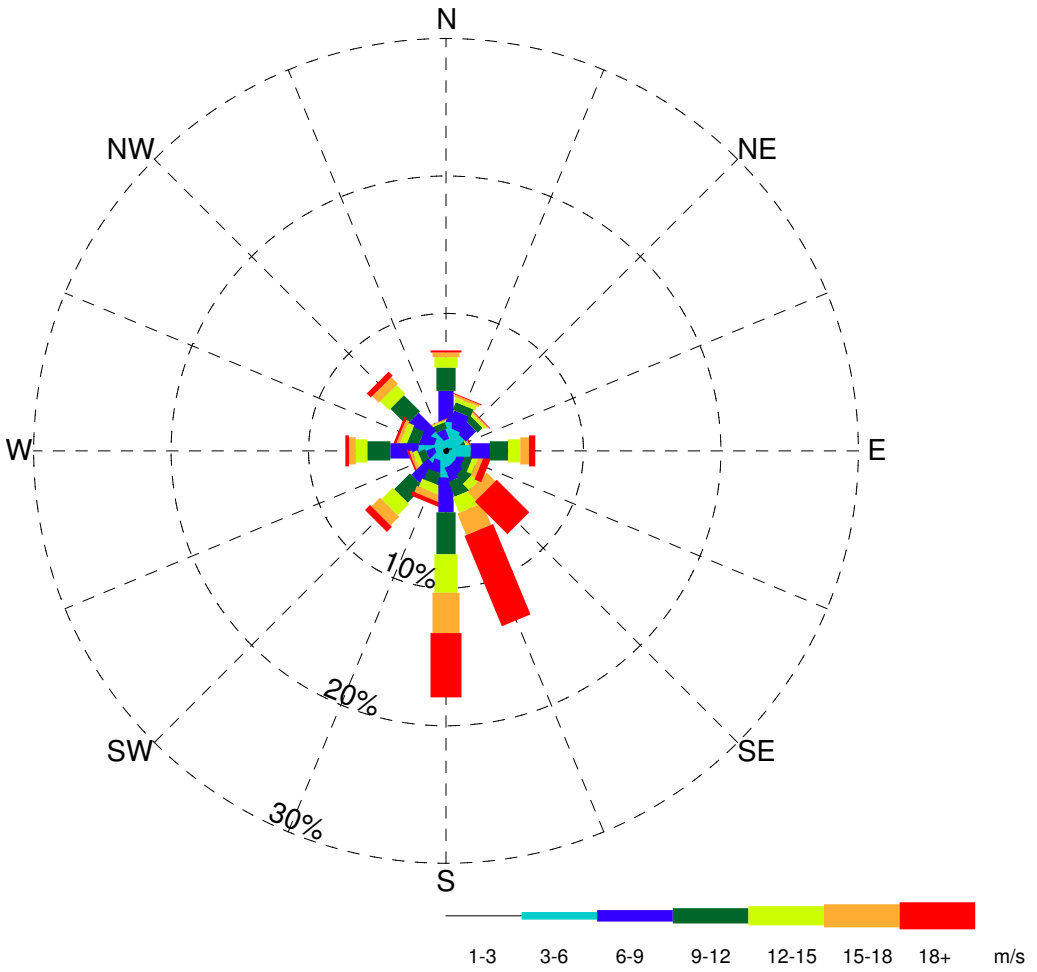
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 07, 2012

Figure A.35



Sartine Island

Location:

N50° 49' 12.0" W128° 54' 36.0"

Elevation: 111.5 m

Sea level: -

Length of Record

Start Date: January 31, 1994

End Date: November 12, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	0.20	0.48	0.48	0.31	0.16	0.11	0.10	1.84
NE	-	0.35	1.15	1.06	0.50	0.21	0.11	0.06	3.45
NNE	-	0.32	1.32	1.31	0.60	0.32	0.17	0.07	4.11
N	-	0.46	1.63	2.28	1.70	0.75	0.35	0.15	7.31
NNW	-	0.18	0.56	0.75	0.48	0.14	0.06	0.01	2.17
NW	-	0.34	1.20	1.83	1.67	0.91	0.67	0.42	7.03
WNW	-	0.22	0.74	1.07	0.83	0.45	0.26	0.19	3.74
W	-	0.40	1.61	2.05	1.67	0.84	0.49	0.26	7.32
WSW	-	0.19	0.49	0.66	0.57	0.36	0.22	0.13	2.63
SW	-	0.26	1.06	1.70	1.63	1.16	0.89	0.52	7.21
SSW	-	0.23	0.58	0.88	0.85	0.63	0.48	0.33	3.98
S	-	0.41	1.52	2.53	3.06	2.80	2.93	4.68	17.94
SSE	-	0.24	0.85	1.07	1.17	1.21	1.70	7.12	13.34
SE	-	0.27	0.67	0.83	0.79	0.66	0.88	3.35	7.44
ESE	-	0.22	0.63	0.56	0.56	0.38	0.36	0.53	3.24
E	-	0.44	1.37	1.40	1.32	0.88	0.63	0.46	6.49
Calm	0.76	-	-	-	-	-	-	-	0.76
Total (%)	0.76	4.73	15.84	20.43	17.68	11.86	10.32	18.38	100.00

NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Winter: October-March
Sartine Island

STATUS
ISSUED FOR USE

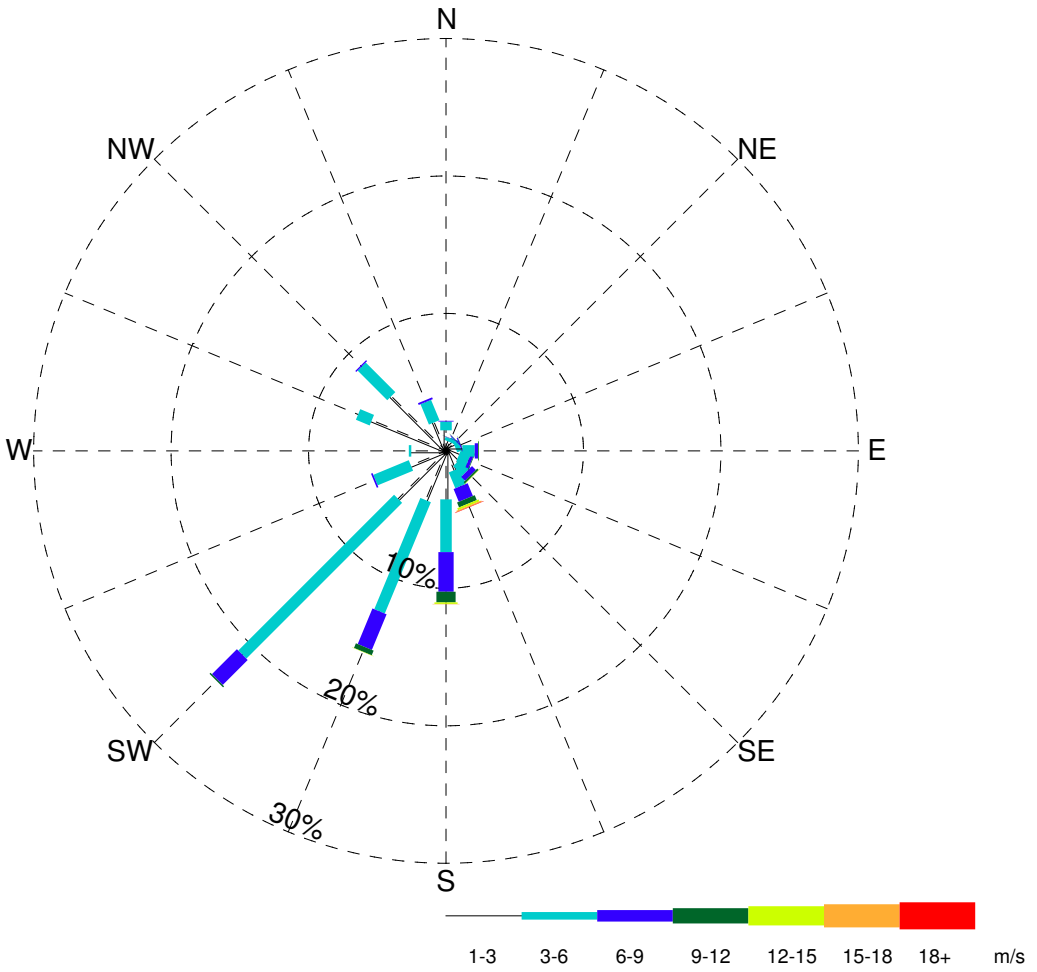
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 07, 2012

Figure A.36



Saturna Island

Location:

N48° 46' 48.0" W123° 1' 47.0"

Elevation: 4.3 m

Sea level: -

Length of Record

Start Date: February 28, 1994

End Date: November 12, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	0.71	0.36	0.09	0.01	-	-	-	1.18
NE	-	0.74	0.25	0.06	0.02	-	-	-	1.08
NNE	-	0.70	0.24	0.03	0.01	-	-	-	0.98
N	-	1.50	0.64	0.05	-	-	-	-	2.20
NNW	-	2.24	1.60	0.14	-	-	-	-	3.99
NW	-	5.63	3.05	0.10	-	-	-	-	8.77
WNW	-	5.84	1.09	-	-	-	-	-	6.93
W	-	2.53	0.18	-	-	-	-	-	2.71
WSW	-	2.76	2.79	0.12	-	-	-	-	5.68
SW	-	4.93	16.03	2.57	0.10	-	-	-	23.64
SSW	-	3.87	8.77	2.80	0.36	0.03	-	-	15.84
S	-	3.53	3.84	2.88	0.77	0.11	0.03	-	11.16
SSE	-	1.52	1.25	1.00	0.39	0.15	0.09	0.03	4.44
SE	-	1.15	0.97	0.40	0.14	0.03	-	-	2.69
ESE	-	0.98	0.78	0.23	0.05	-	-	-	2.05
E	-	1.19	0.90	0.24	0.06	0.01	-	-	2.40
Calm	4.26	-	-	-	-	-	-	-	4.26
Total (%)	4.26	39.83	42.72	10.72	1.93	0.36	0.14	0.04	100.00

NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Summer: April-September
Saturna Island

STATUS
ISSUED FOR USE

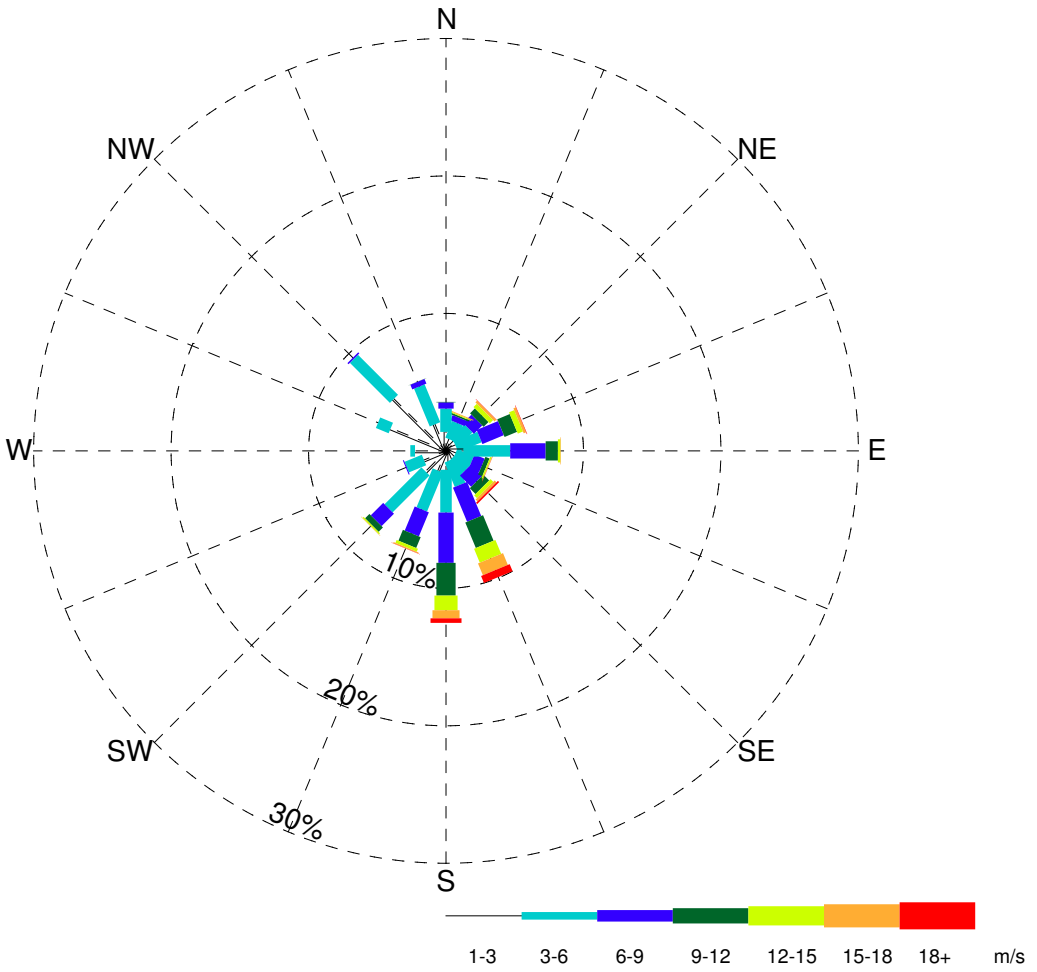
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 07, 2012

Figure A.37



Saturna Island

Location:

N48° 46' 48.0" W123° 1' 47.0"

Elevation: 4.3 m

Sea level: -

Length of Record

Start Date: February 28, 1994

End Date: November 12, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	**0-1 m/s**	**1-3 m/s**	**3-6 m/s**	**6-9 m/s**	**9-12 m/s**	**12-15 m/s**	**15-18 m/s**	**18+ m/s**	**Total (%)**
ENE	-	0.79	1.86	1.69	0.98	0.41	0.18	0.04	5.93
NE	-	0.85	1.47	0.86	0.50	0.34	0.17	0.03	4.21
NNE	-	0.87	1.31	0.41	0.12	0.07	0.06	-	2.86
N	-	1.38	1.69	0.46	0.04	-	-	-	3.57
NNW	-	2.09	2.98	0.37	0.01	-	-	-	5.45
NW	-	5.36	4.12	0.12	-	-	-	-	9.59
WNW	-	4.35	1.00	-	-	-	-	-	5.36
W	-	2.26	0.34	-	-	-	-	-	2.61
WSW	-	1.73	1.36	0.07	-	-	-	-	3.17
SW	-	2.11	3.80	1.27	0.45	0.10	0.03	-	7.77
SSW	-	1.55	3.06	1.90	0.86	0.23	0.08	0.02	7.69
S	-	1.37	3.12	3.66	2.38	1.07	0.59	0.33	12.51
SSE	-	0.74	1.93	2.68	2.01	1.10	0.93	0.55	9.94
SE	-	0.68	1.31	1.15	0.60	0.28	0.19	0.13	4.34
ESE	-	0.70	1.32	0.80	0.32	0.11	0.04	0.01	3.30
E	-	1.26	3.41	2.58	0.89	0.19	0.04	-	8.37
Calm	3.33	-	-	-	-	-	-	-	3.33
Total (%)	3.33	28.09	34.07	18.02	9.16	3.90	2.31	1.13	100.00

NOTES

STATUS
ISSUED FOR USE

CLIENT
Kinder Morgan

A TETRA TECH COMPANY

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

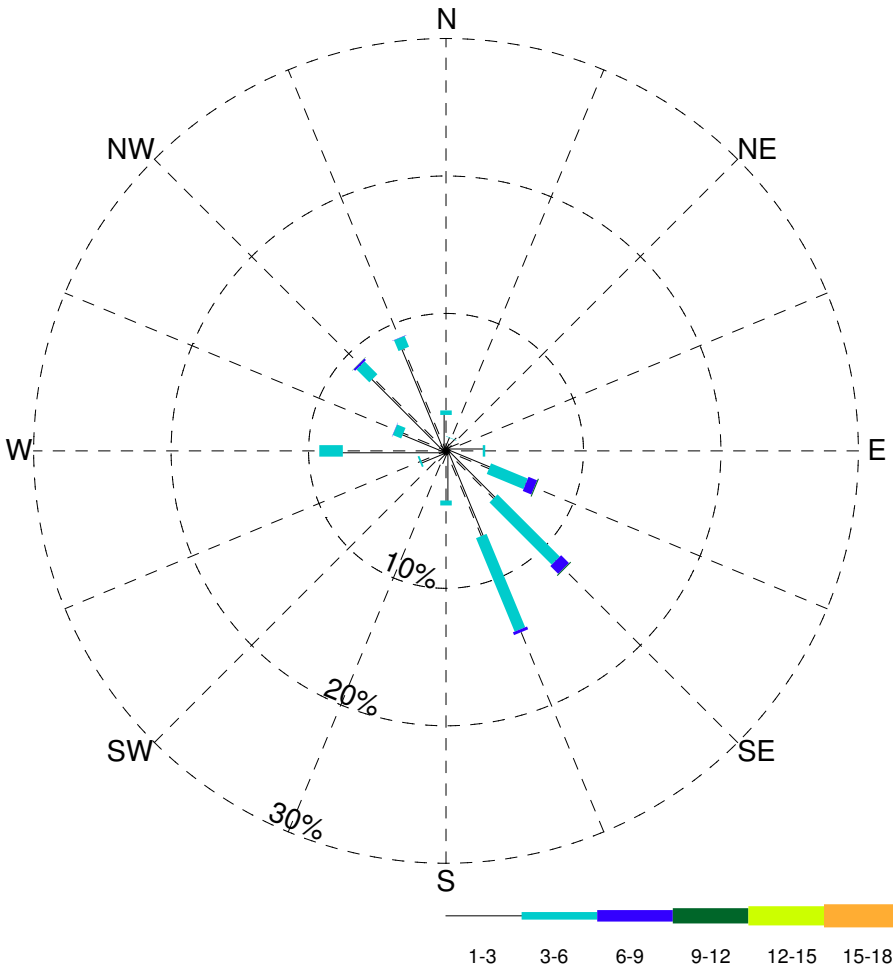
Winter: October-March
Saturna Island

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE
EBA-VANC

DATE
December 07, 2012

Figure A.38



Sechelt

Location:

N49° 28' 12.0" W123° 46' 12.0"

Elevation: 22.9 m

Sea level: -

Length of Record

Start Date: July 11, 2007

End Date: November 12, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	1.02	-	-	-	-	-	-	1.02
NE	-	1.16	-	-	-	-	-	-	1.17
NNE	-	0.97	0.03	-	-	-	-	-	1.00
N	-	2.62	0.33	-	-	-	-	-	2.94
NNW	-	8.03	0.85	0.02	-	-	-	-	8.90
NW	-	7.47	1.33	0.15	0.02	-	-	-	8.98
WNW	-	3.36	0.66	0.02	-	-	-	-	4.04
W	-	7.51	1.71	-	-	-	-	-	9.23
WSW	-	1.93	0.14	-	-	-	-	-	2.07
SW	-	0.88	-	-	-	-	-	-	0.88
SSW	-	0.93	-	-	-	-	-	-	0.93
S	-	3.61	0.36	-	-	-	-	-	3.97
SSE	-	6.70	7.36	0.22	-	-	-	-	14.28
SE	-	4.89	6.40	0.81	0.08	-	-	-	12.18
ESE	-	3.38	2.89	0.68	0.08	-	-	-	7.03
E	-	2.67	0.18	-	-	-	-	-	2.86
Calm	18.53	-	-	-	-	-	-	-	18.53
Total (%)	18.53	57.12	22.24	1.92	0.19	-	-	-	100.00

NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Summer: April-September
Sechelt

STATUS
ISSUED FOR USE

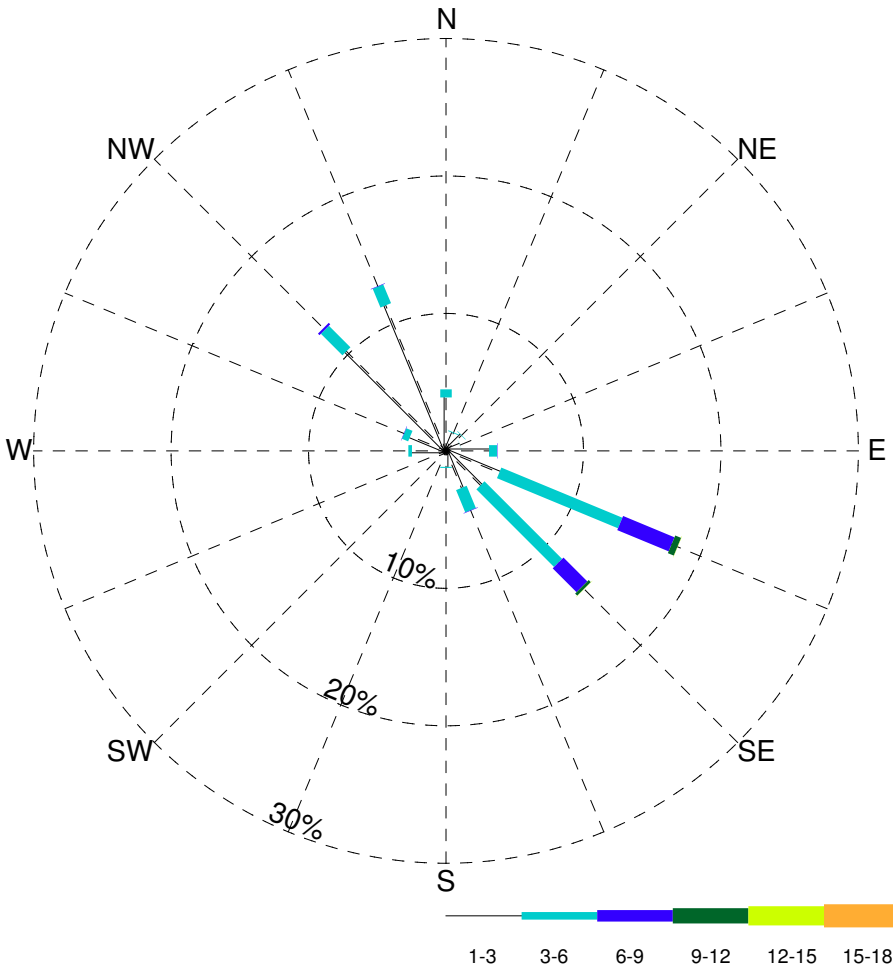
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 07, 2012

Figure A.39



Sechelt

Location:

N49° 28’ 12.0" W123° 46’ 12.0"

Elevation: 22.9 m

Sea level: -

Length of Record

Start Date: July 11, 2007

End Date: November 12, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	1.08	0.01	-	-	-	-	-	1.10
NE	-	1.57	0.04	-	-	-	-	-	1.61
NNE	-	1.39	0.06	-	-	-	-	-	1.45
N	-	3.89	0.59	-	-	-	-	-	4.48
NNW	-	11.46	1.48	0.03	-	-	-	-	12.98
NW	-	10.24	2.22	0.16	-	-	-	-	12.62
WNW	-	2.81	0.49	0.03	-	-	-	-	3.32
W	-	2.48	0.26	-	-	-	-	-	2.74
WSW	-	0.57	-	-	-	-	-	-	0.57
SW	-	0.25	-	-	-	-	-	-	0.25
SSW	-	0.24	-	-	-	-	-	-	0.25
S	-	1.16	0.07	-	-	-	-	-	1.24
SSE	-	2.92	1.75	0.04	-	-	-	-	4.71
SE	-	3.55	7.99	2.45	0.22	0.02	-	-	14.22
ESE	-	4.18	9.53	4.05	0.46	0.02	-	-	18.24
E	-	3.13	0.58	0.03	-	-	-	-	3.74
Calm	16.48	-	-	-	-	-	-	-	16.48
Total (%)	16.48	50.93	25.08	6.78	0.69	0.04	-	-	100.00

NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Winter: October-March
Sechelt

STATUS
ISSUED FOR USE

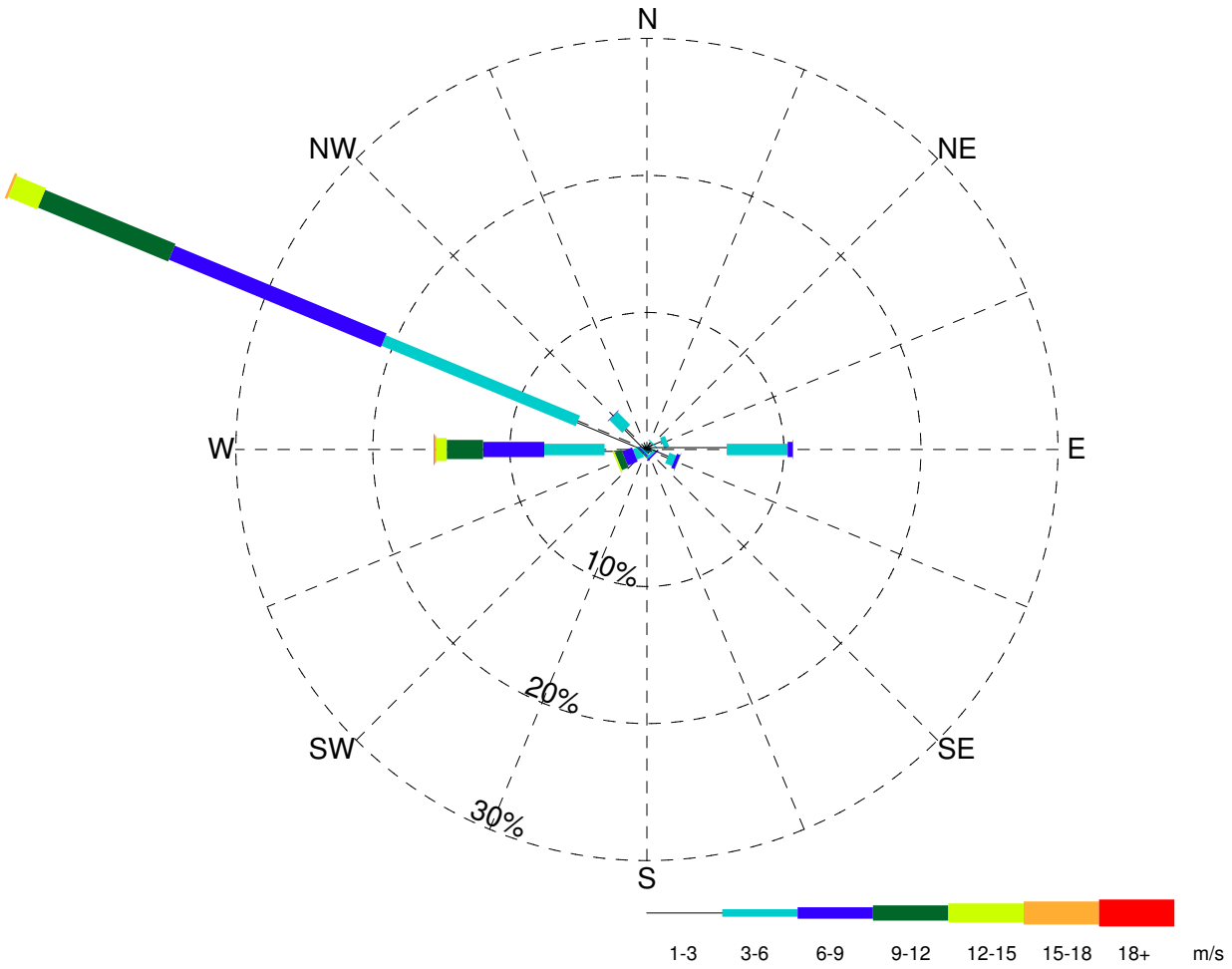
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 07, 2012

Figure A.40



Sheringham Point

Location:

N48° 22' 48.0" W123° 55' 12.0"

Elevation: 22.3 m

Sea level: -

Length of Record

Start Date: January 31, 1994

End Date: November 12, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	1.20	0.38	-	-	-	-	-	1.59
NE	-	0.55	0.08	-	-	-	-	-	0.64
NNE	-	0.20	0.02	-	-	-	-	-	0.22
N	-	0.23	-	-	-	-	-	-	0.23
NNW	-	0.32	-	-	-	-	-	-	0.32
NW	-	2.13	1.32	0.05	-	-	-	-	3.51
WNW	-	5.45	15.35	16.73	10.29	2.31	0.19	-	50.33
W	-	3.09	4.40	4.47	2.65	0.77	0.12	0.05	15.54
WSW	-	0.41	0.55	0.78	0.53	0.12	0.01	-	2.39
SW	-	0.18	0.10	0.10	0.08	0.02	-	-	0.48
SSW	-	0.08	0.03	0.02	-	-	-	-	0.13
S	-	0.14	0.01	-	-	-	-	-	0.16
SSE	-	0.16	0.02	-	-	-	-	-	0.19
SE	-	0.37	0.17	0.12	-	-	-	-	0.66
ESE	-	1.61	0.54	0.25	0.03	-	-	-	2.43
E	-	5.83	4.45	0.37	0.03	-	-	-	10.68
Calm	10.49	-	-	-	-	-	-	-	10.49
Total (%)	10.49	21.95	27.44	22.90	13.61	3.22	0.32	0.05	100.00

NOTES

STATUS
ISSUED FOR USE

CLIENT
Kinder Morgan

A TETRA TECH COMPANY

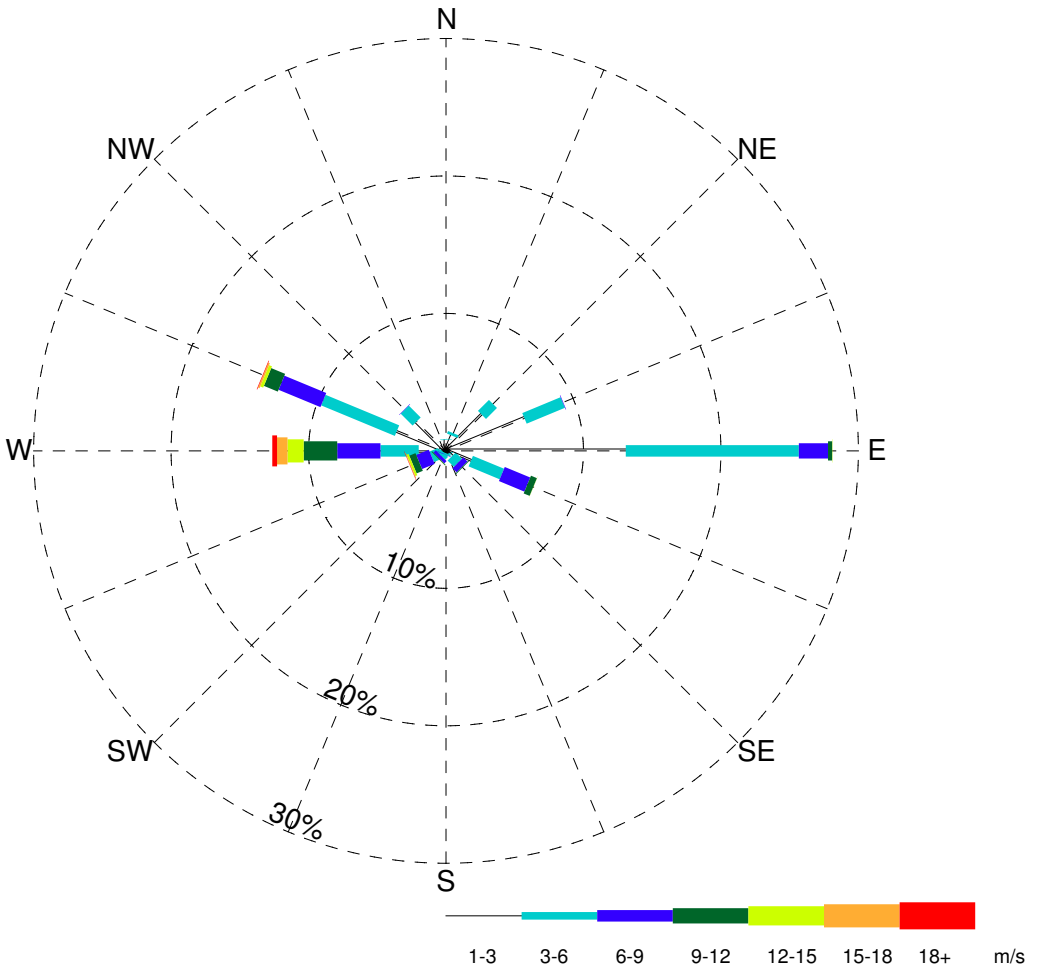
METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Summer: April-September
Sheringham Point

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC
DATE: December 07, 2012

Figure A.41



Sheringham Point

Location:

N48° 22' 48.0" W123° 55' 12.0"

Elevation: 22.3 m

Sea level: -

Length of Record

Start Date: January 31, 1994

End Date: November 12, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	6.18	3.02	0.04	-	-	-	-	9.24
NE	-	3.70	1.13	-	-	-	-	-	4.84
NNE	-	1.19	0.20	-	-	-	-	-	1.40
N	-	0.81	0.04	-	-	-	-	-	0.85
NNW	-	0.79	0.01	-	-	-	-	-	0.80
NW	-	3.02	1.22	0.03	-	-	-	-	4.28
WNW	-	3.86	5.80	3.30	1.09	0.22	0.12	0.05	14.44
W	-	1.98	2.79	3.14	2.44	1.18	0.76	0.35	12.64
WSW	-	0.45	0.67	0.99	0.49	0.15	0.05	0.02	2.83
SW	-	0.20	0.29	0.24	0.06	0.01	-	-	0.81
SSW	-	0.15	0.10	0.04	-	-	-	-	0.29
S	-	0.25	0.07	-	-	-	-	-	0.34
SSE	-	0.24	0.08	-	-	-	-	-	0.32
SE	-	0.58	0.64	0.43	0.07	-	-	-	1.72
ESE	-	1.95	2.45	2.00	0.47	0.01	-	-	6.89
E	-	13.08	12.59	2.12	0.30	0.02	-	-	28.13
Calm	10.19	-	-	-	-	-	-	-	10.19
Total (%)	10.19	38.44	31.11	12.35	4.94	1.60	0.95	0.42	100.00

NOTES

STATUS
ISSUED FOR USE

CLIENT
Kinder Morgan

A TETRA TECH COMPANY

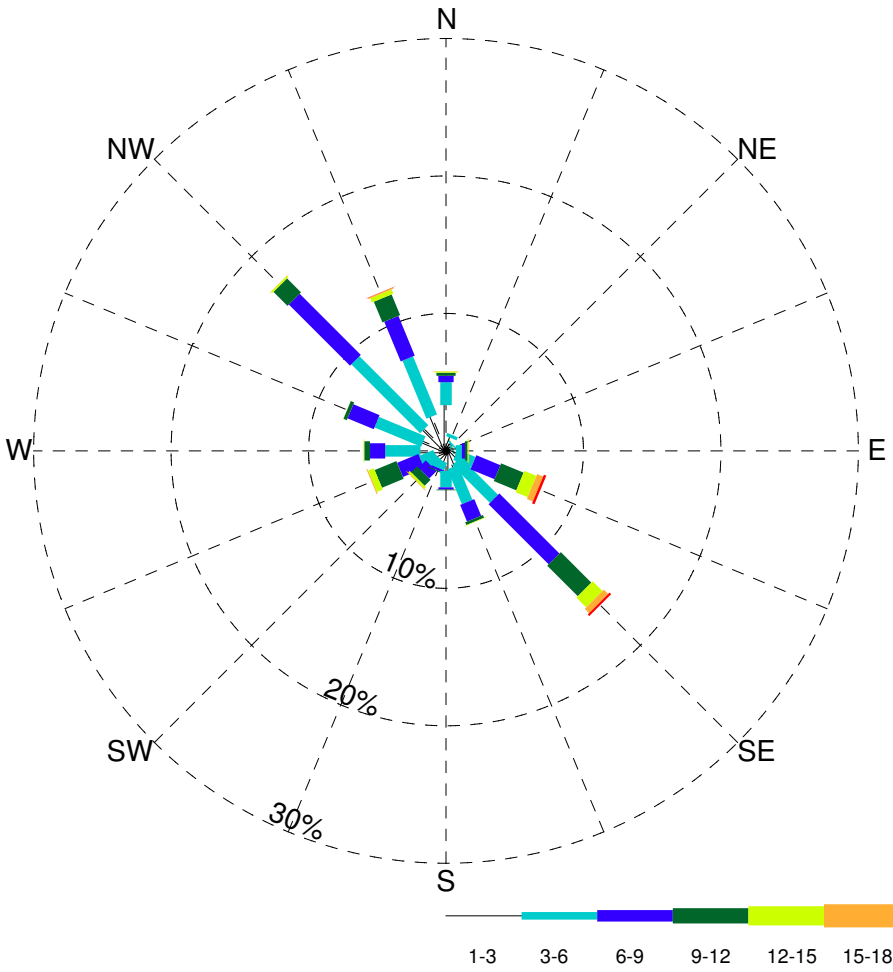
METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Winter: October-March
Sheringham Point

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC
DATE: December 07, 2012

Figure A.42



Sisters Island

Location:

N49° 29' 24.0" W124° 25' 48.0"

Elevation: 20.0 m

Sea level: -

Length of Record

Start Date: January 31, 1994

End Date: November 12, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	0.40	0.10	0.02	0.03	0.02	0.01	-	0.57
NE	-	0.58	0.11	-	-	-	-	-	0.70
NNE	-	1.00	0.24	-	-	-	-	-	1.25
N	-	3.33	1.67	0.46	0.23	0.09	0.01	-	5.80
NNW	-	2.70	4.57	3.13	1.63	0.33	0.09	0.02	12.47
NW	-	2.23	7.09	6.29	1.44	0.13	0.02	-	17.20
WNW	-	1.79	3.67	2.06	0.26	0.01	-	-	7.80
W	-	1.86	2.57	1.10	0.42	0.06	-	-	6.01
WSW	-	0.83	1.11	1.67	1.71	0.46	0.07	-	5.86
SW	-	0.71	0.82	0.75	0.61	0.17	0.04	-	3.10
SSW	-	0.78	0.58	0.18	0.07	-	-	-	1.62
S	-	1.45	1.20	0.16	0.05	-	-	-	2.87
SSE	-	1.28	2.75	1.31	0.22	0.04	-	-	5.59
SE	-	1.06	3.87	6.18	3.14	1.01	0.44	0.16	15.86
ESE	-	0.75	1.41	1.89	1.77	0.95	0.47	0.19	7.43
E	-	0.71	0.44	0.23	0.18	0.09	0.03	-	1.69
Calm	4.15	-	-	-	-	-	-	-	4.15
Total (%)	4.15	21.47	32.21	25.46	11.77	3.36	1.19	0.39	100.00

NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Summer: April-September
Sisters Island

STATUS
ISSUED FOR USE

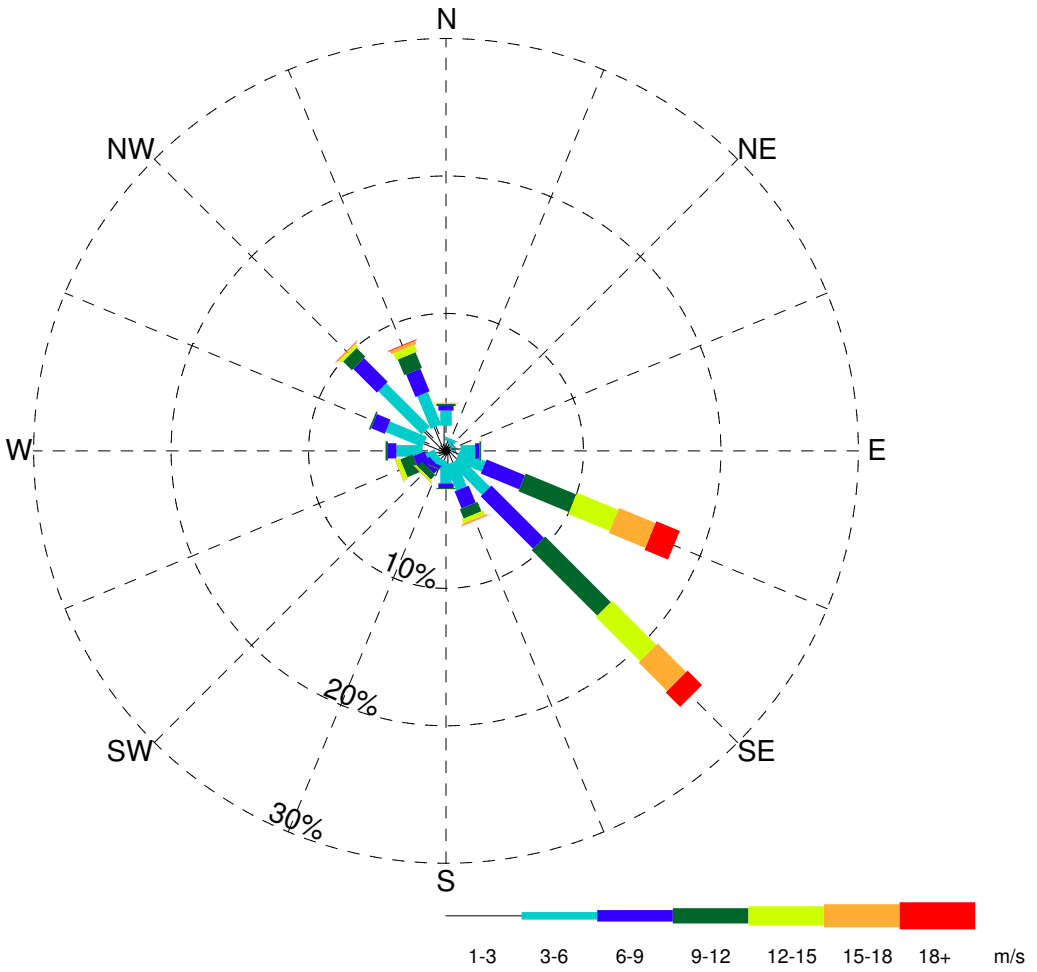
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 07, 2012

Figure A.43



Sisters Island

Location:

N49° 29' 24.0" W124° 25' 48.0"

Elevation: 20.0 m

Sea level: -

Length of Record

Start Date: January 31, 1994

End Date: November 12, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	0.43	0.18	0.05	0.02	-	-	-	0.68
NE	-	0.49	0.15	0.03	0.02	0.01	-	-	0.70
NNE	-	0.70	0.21	0.02	0.01	-	-	-	0.95
N	-	1.82	1.11	0.33	0.16	0.05	0.03	-	3.51
NNW	-	1.90	2.57	1.78	1.24	0.53	0.26	0.06	8.33
NW	-	2.09	4.46	2.44	0.90	0.24	0.09	0.04	10.26
WNW	-	1.68	2.91	1.07	0.12	-	-	-	5.80
W	-	1.70	1.91	0.62	0.18	0.02	-	-	4.43
WSW	-	0.72	0.72	0.90	0.97	0.33	0.05	-	3.71
SW	-	0.65	0.52	0.62	0.47	0.12	0.05	-	2.44
SSW	-	0.67	0.47	0.20	0.07	0.02	-	-	1.44
S	-	1.15	1.22	0.34	0.07	0.03	-	-	2.81
SSE	-	0.94	2.03	1.34	0.74	0.31	0.12	0.01	5.50
SE	-	0.99	3.12	5.39	6.76	4.54	2.93	1.49	25.22
ESE	-	0.93	2.05	3.02	3.98	3.25	2.87	1.84	17.94
E	-	1.06	1.05	0.32	0.11	0.05	0.02	-	2.61
Calm	3.66	-	-	-	-	-	-	-	3.66
Total (%)	3.66	17.92	24.68	18.49	15.83	9.51	6.44	3.46	100.00

NOTES

STATUS
ISSUED FOR USE

CLIENT
Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Winter: October-March
Sisters Island

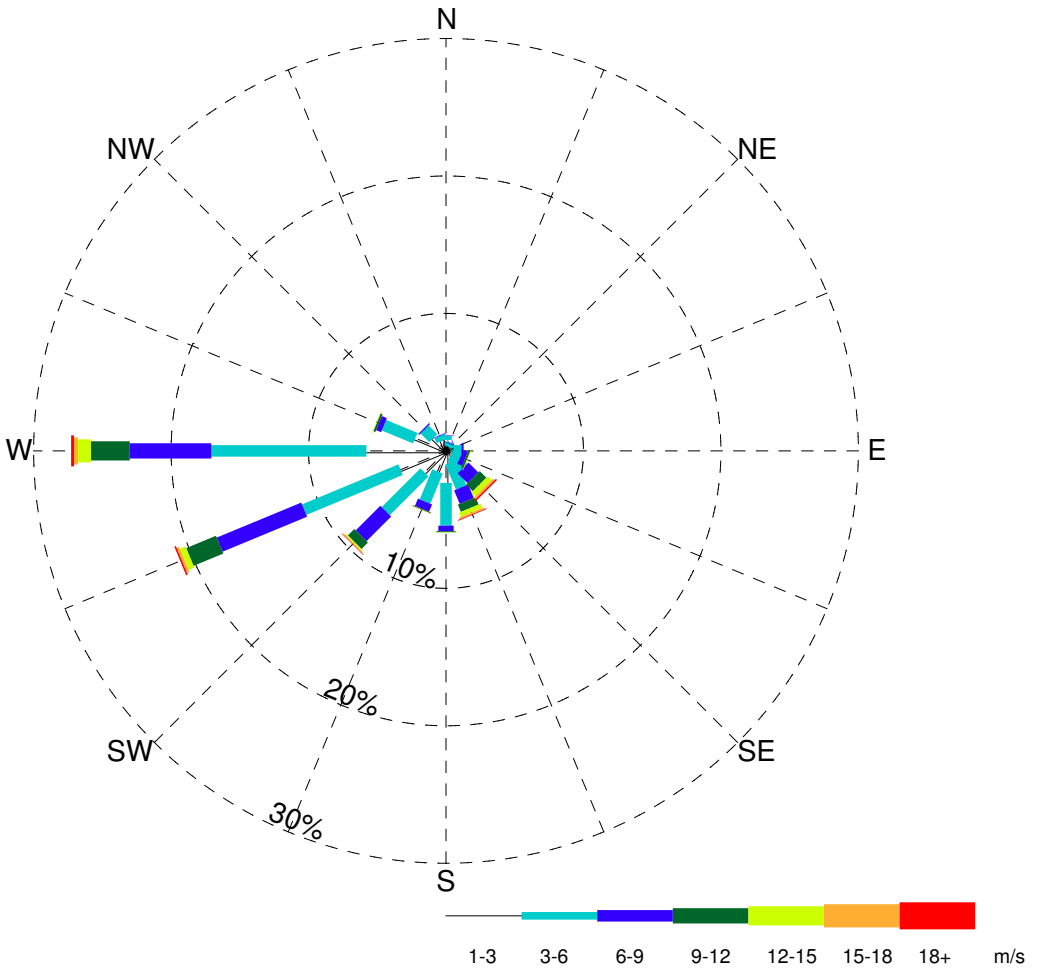
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 07, 2012

Figure A.44



Smith Island

Location:

N48° 19' 1.2" W122° 49' 58.8"

Elevation: 18.0 m

Sea level: -

Length of Record

Start Date: April 11, 1985

End Date: November 01, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	0.36	0.30	0.05	-	-	-	-	0.72
NE	-	0.34	0.26	0.02	-	-	-	-	0.63
NNE	-	0.35	0.22	0.05	0.01	-	-	-	0.63
N	-	0.79	0.30	0.04	-	-	-	-	1.14
NNW	-	0.79	0.39	0.05	-	-	-	-	1.24
NW	-	1.32	0.88	0.09	0.01	-	-	-	2.31
WNW	-	2.42	2.46	0.39	0.16	0.04	0.01	-	5.49
W	-	5.79	11.28	5.93	2.82	0.95	0.28	0.21	27.28
WSW	-	3.58	7.59	6.66	2.34	0.45	0.19	0.12	20.93
SW	-	2.21	3.99	2.53	0.66	0.11	0.08	0.04	9.62
SSW	-	1.62	2.37	0.57	0.06	0.03	0.01	-	4.66
S	-	2.33	3.11	0.40	0.08	0.02	-	-	5.95
SSE	-	0.88	2.00	1.06	0.57	0.33	0.13	0.06	5.04
SE	-	0.54	1.21	1.02	0.69	0.38	0.16	0.12	4.12
ESE	-	0.45	0.68	0.37	0.14	0.05	-	-	1.71
E	-	0.56	0.56	0.15	0.01	-	-	-	1.29
Calm	7.23	-	-	-	-	-	-	-	7.23
Total (%)	7.23	24.33	37.61	19.38	7.60	2.39	0.89	0.56	100.00

NOTES

STATUS
ISSUED FOR USE

CLIENT
Kinder Morgan

A TETRA TECH COMPANY

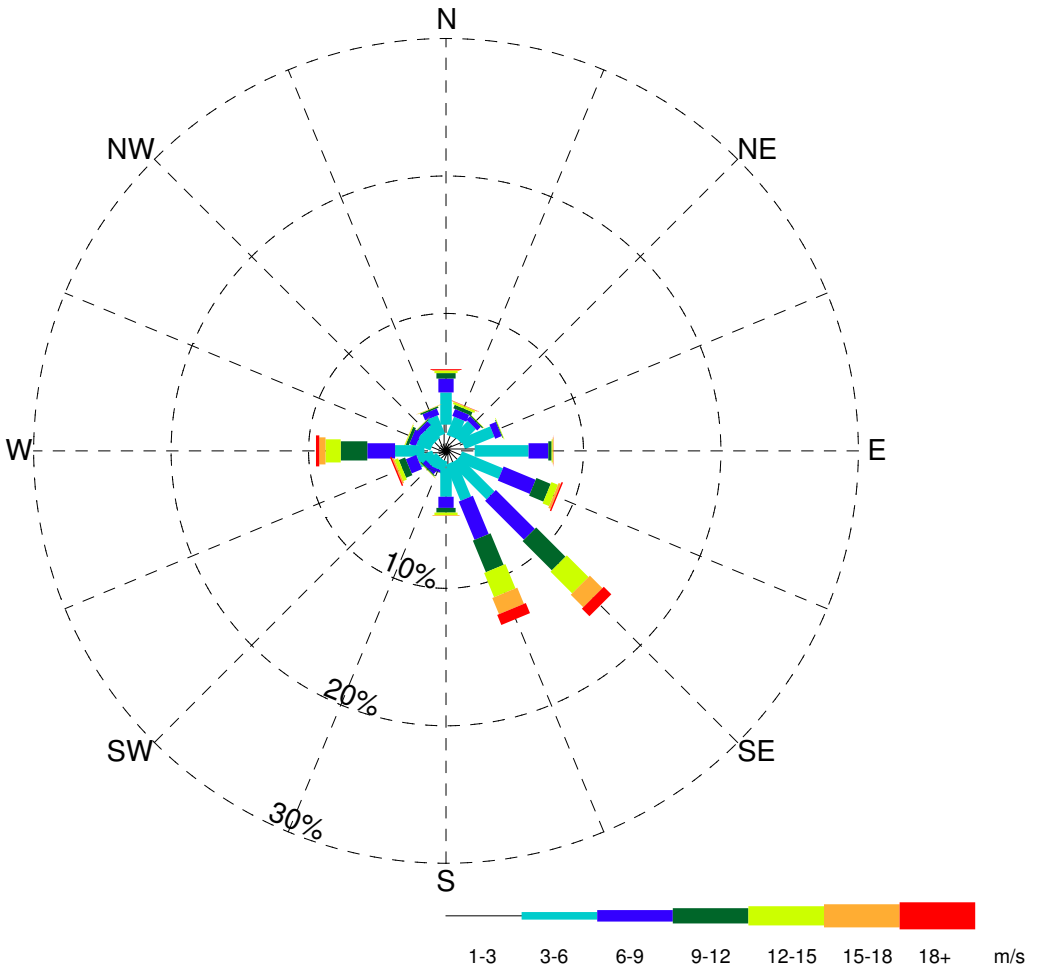
METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Summer: April-September
Smith Island

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC
DATE: December 07, 2012

Figure A.45



Smith Island

Location:

N48° 19' 1.2" W122° 49' 58.8"

Elevation: 18.0 m

Sea level: -

Length of Record

Start Date: April 11, 1985

End Date: November 01, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	1.33	2.32	0.51	0.06	0.04	-	-	4.26
NE	-	1.18	1.48	0.37	0.09	0.04	-	-	3.16
NNE	-	1.11	1.42	0.54	0.28	0.16	0.04	0.02	3.56
N	-	1.91	2.35	1.01	0.40	0.16	0.07	0.06	5.95
NNW	-	1.18	1.44	0.49	0.12	0.03	0.02	-	3.29
NW	-	1.00	1.11	0.38	0.08	0.02	0.01	-	2.61
WNW	-	1.06	1.10	0.50	0.22	0.07	0.01	-	2.97
W	-	1.57	2.14	2.02	1.93	1.11	0.45	0.24	9.46
WSW	-	0.93	1.19	0.82	0.50	0.28	0.12	0.10	3.94
SW	-	0.62	0.89	0.32	0.08	0.04	0.01	-	1.98
SSW	-	0.68	0.76	0.18	0.03	-	-	-	1.67
S	-	1.26	2.08	0.81	0.34	0.18	0.06	-	4.73
SSE	-	0.92	2.84	3.02	2.49	1.91	1.27	0.80	13.24
SE	-	0.99	3.59	4.00	3.01	2.23	1.29	0.78	15.89
ESE	-	1.09	3.22	2.52	1.13	0.51	0.17	0.11	8.75
E	-	2.09	3.92	1.44	0.24	0.08	0.05	0.01	7.83
Calm	6.72	-	-	-	-	-	-	-	6.72
Total (%)	6.72	18.92	31.84	18.92	10.98	6.86	3.61	2.15	100.00

NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Winter: October-March
Smith Island

STATUS
ISSUED FOR USE

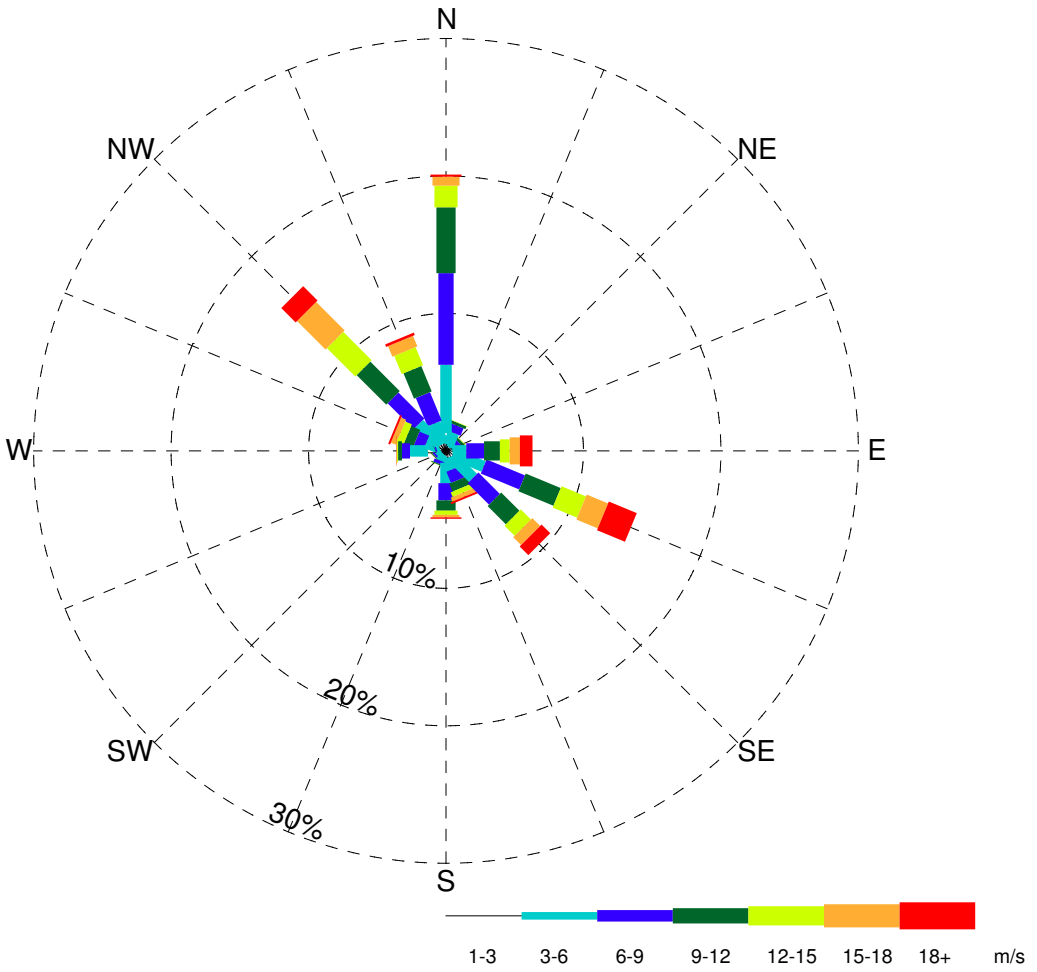
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 07, 2012

Figure A.46



Solander Island

Location:

N50° 6' 36.0" W127° 56' 24.0"

Elevation: 98.7 m

Sea level: -

Length of Record

Start Date: January 31, 1994

End Date: November 12, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	0.15	0.03	0.01	-	-	-	-	0.19
NE	-	0.33	0.43	0.33	0.20	0.04	-	-	1.34
NNE	-	0.47	0.96	0.58	0.21	0.04	-	-	2.26
N	-	1.29	4.97	6.67	4.79	1.58	0.65	0.16	20.10
NNW	-	0.54	1.62	2.23	2.00	1.43	0.83	0.20	8.85
NW	-	0.74	2.05	2.67	3.04	2.92	2.93	1.48	15.82
WNW	-	0.58	0.97	0.77	0.72	0.51	0.38	0.15	4.09
W	-	1.31	1.31	0.58	0.28	0.08	0.04	0.02	3.63
WSW	-	0.35	0.24	0.11	0.02	-	-	-	0.73
SW	-	0.29	0.39	0.15	0.08	0.01	0.01	-	0.94
SSW	-	0.36	0.47	0.24	0.08	0.02	-	-	1.17
S	-	0.86	1.49	1.25	0.75	0.31	0.18	0.10	4.94
SSE	-	0.51	0.91	0.88	0.62	0.36	0.31	0.15	3.73
SE	-	0.75	2.03	2.20	1.88	1.04	0.80	0.89	9.60
ESE	-	0.61	2.36	3.03	2.76	1.93	1.68	2.20	14.56
E	-	0.47	1.01	1.29	1.15	0.71	0.74	0.92	6.29
Calm	1.76	-	-	-	-	-	-	-	1.76
Total (%)	1.76	9.59	21.21	23.00	18.58	10.98	8.59	6.28	100.00

NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Summer: April-September
Solander Island

STATUS
ISSUED FOR USE

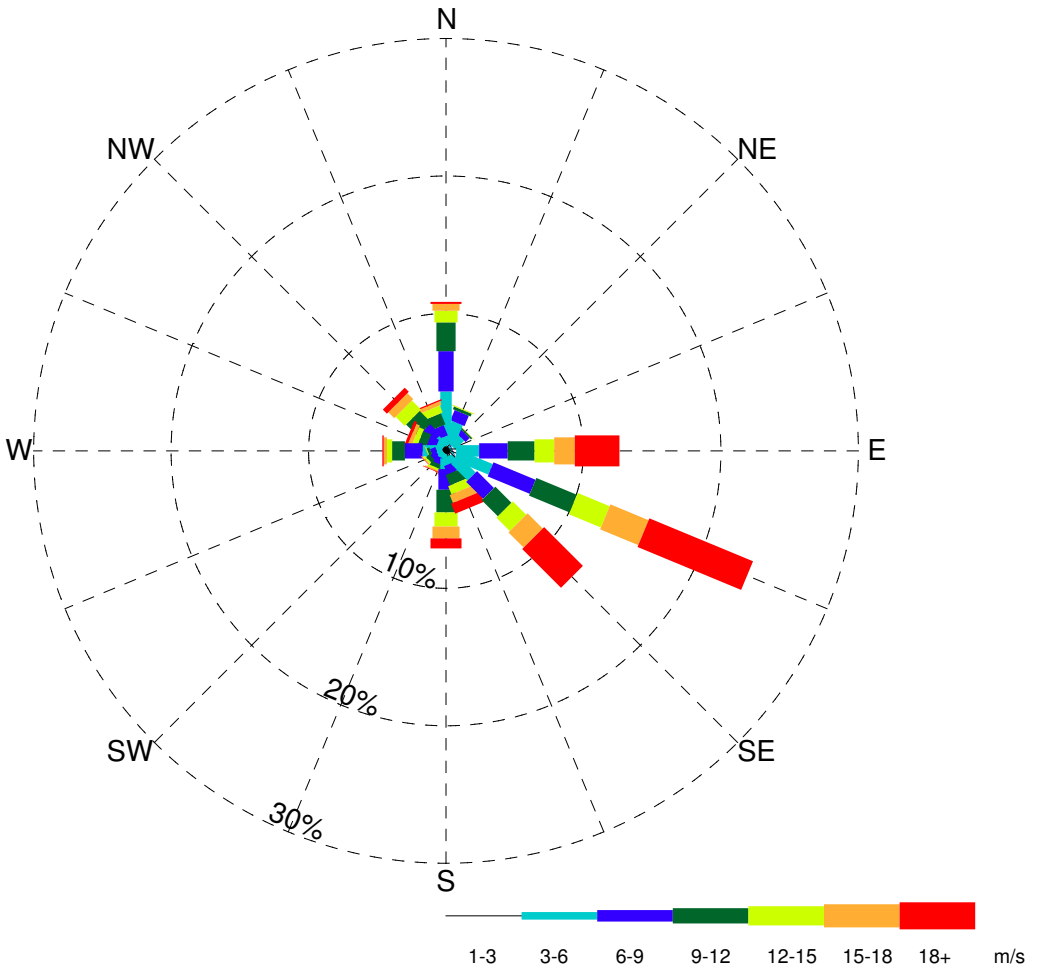
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 07, 2012

Figure A.47



Solander Island

Location:

N50° 6' 36.0" W127° 56' 24.0"

Elevation: 98.7 m

Sea level: -

Length of Record

Start Date: January 31, 1994

End Date: November 12, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	0.29	0.13	0.05	0.02	-	-	-	0.49
NE	-	0.54	0.92	0.42	0.13	0.02	0.01	-	2.04
NNE	-	0.70	1.49	0.81	0.22	0.07	0.01	-	3.30
N	-	1.14	3.18	2.93	2.10	0.85	0.49	0.15	10.84
NNW	-	0.33	0.67	0.80	0.88	0.55	0.28	0.10	3.61
NW	-	0.37	0.75	1.07	1.22	0.93	0.61	0.42	5.37
WNW	-	0.29	0.49	0.67	0.63	0.38	0.28	0.22	2.97
W	-	0.51	1.19	1.28	0.94	0.37	0.23	0.10	4.63
WSW	-	0.22	0.39	0.41	0.22	0.06	0.03	-	1.33
SW	-	0.19	0.39	0.46	0.32	0.14	0.07	0.03	1.60
SSW	-	0.21	0.38	0.48	0.31	0.14	0.09	0.04	1.67
S	-	0.54	0.78	1.50	1.65	1.02	0.86	0.73	7.09
SSE	-	0.41	0.56	0.64	0.82	0.64	0.62	0.79	4.48
SE	-	0.93	1.71	1.74	1.66	1.37	1.56	3.99	12.96
ESE	-	0.77	2.74	3.32	3.20	2.51	3.00	8.16	23.71
E	-	0.74	1.67	2.08	1.95	1.43	1.50	3.25	12.62
Calm	1.29	-	-	-	-	-	-	-	1.29
Total (%)	1.29	8.18	17.45	18.67	16.26	10.50	9.65	17.99	100.00

NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Winter: October-March
Solander Island

STATUS
ISSUED FOR USE

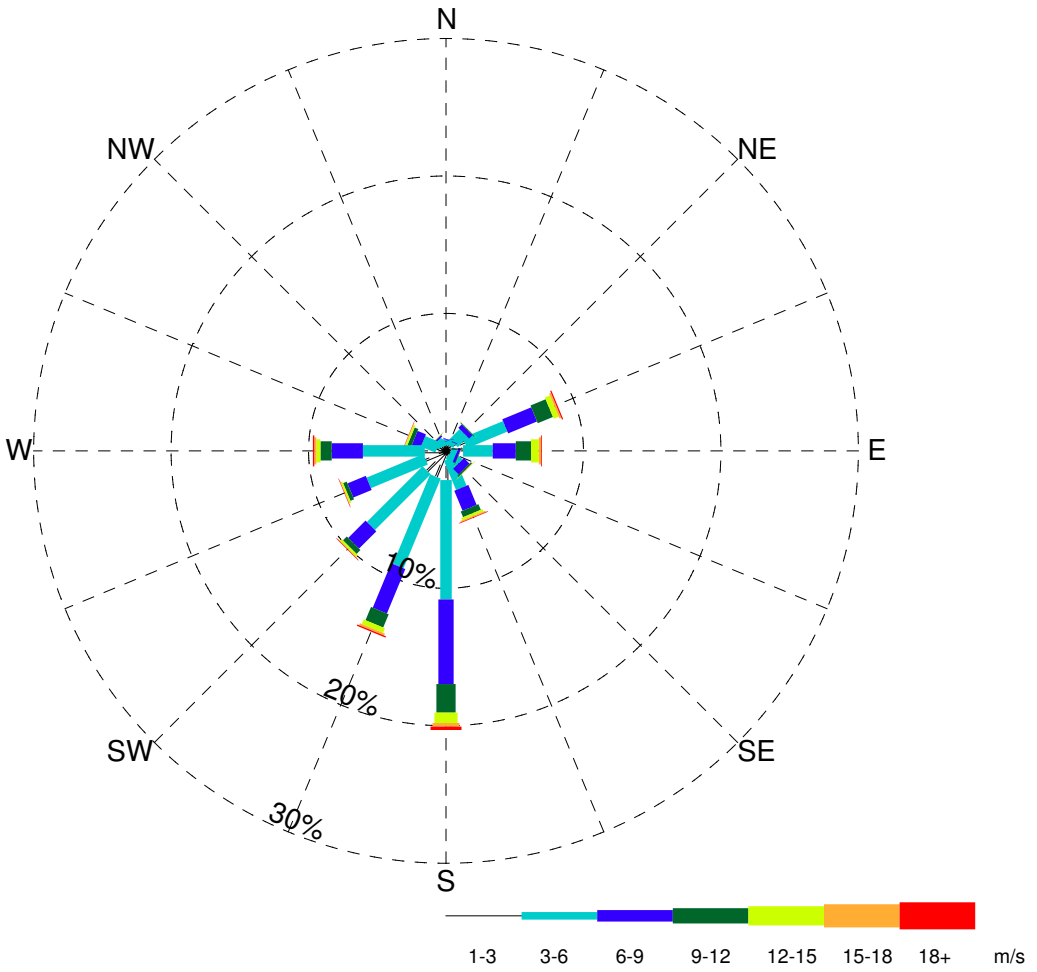
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 07, 2012

Figure A.48



Tatoosh Island

Location:

N48° 22' 58.8" W124° 43' 58.8"

Elevation: 48.0 m

Sea level: -

Length of Record

Start Date: May 01, 1985

End Date: November 01, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	1.49	3.17	2.28	1.19	0.40	0.14	0.09	8.76
NE	-	0.80	1.02	0.35	0.06	0.02	-	-	2.25
NNE	-	0.42	0.34	0.05	-	-	-	-	0.82
N	-	0.47	0.33	0.02	-	-	-	-	0.82
NNW	-	0.36	0.26	0.03	-	-	-	-	0.66
NW	-	0.45	0.49	0.12	0.03	0.02	0.01	-	1.13
WNW	-	0.68	1.13	0.66	0.29	0.14	0.05	0.02	2.96
W	-	1.54	4.51	2.27	0.82	0.30	0.15	0.10	9.68
WSW	-	1.61	4.48	1.44	0.29	0.13	0.04	0.04	8.02
SW	-	1.99	5.73	1.78	0.40	0.17	0.04	0.04	10.16
SSW	-	2.01	7.06	3.50	1.04	0.36	0.15	0.10	14.24
S	-	2.12	8.69	6.16	2.08	0.75	0.27	0.25	20.31
SSE	-	0.62	2.29	1.57	0.45	0.19	0.09	0.05	5.26
SE	-	0.35	0.94	0.58	0.12	0.03	0.02	-	2.05
ESE	-	0.33	0.43	0.19	0.04	0.01	-	-	1.00
E	-	1.24	2.16	1.68	1.11	0.56	0.16	0.06	6.97
Calm	4.91	-	-	-	-	-	-	-	4.91
Total (%)	4.91	16.47	43.04	22.69	7.92	3.08	1.12	0.76	100.00

NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Summer: April-September
Tatoosh Island

STATUS
ISSUED FOR USE

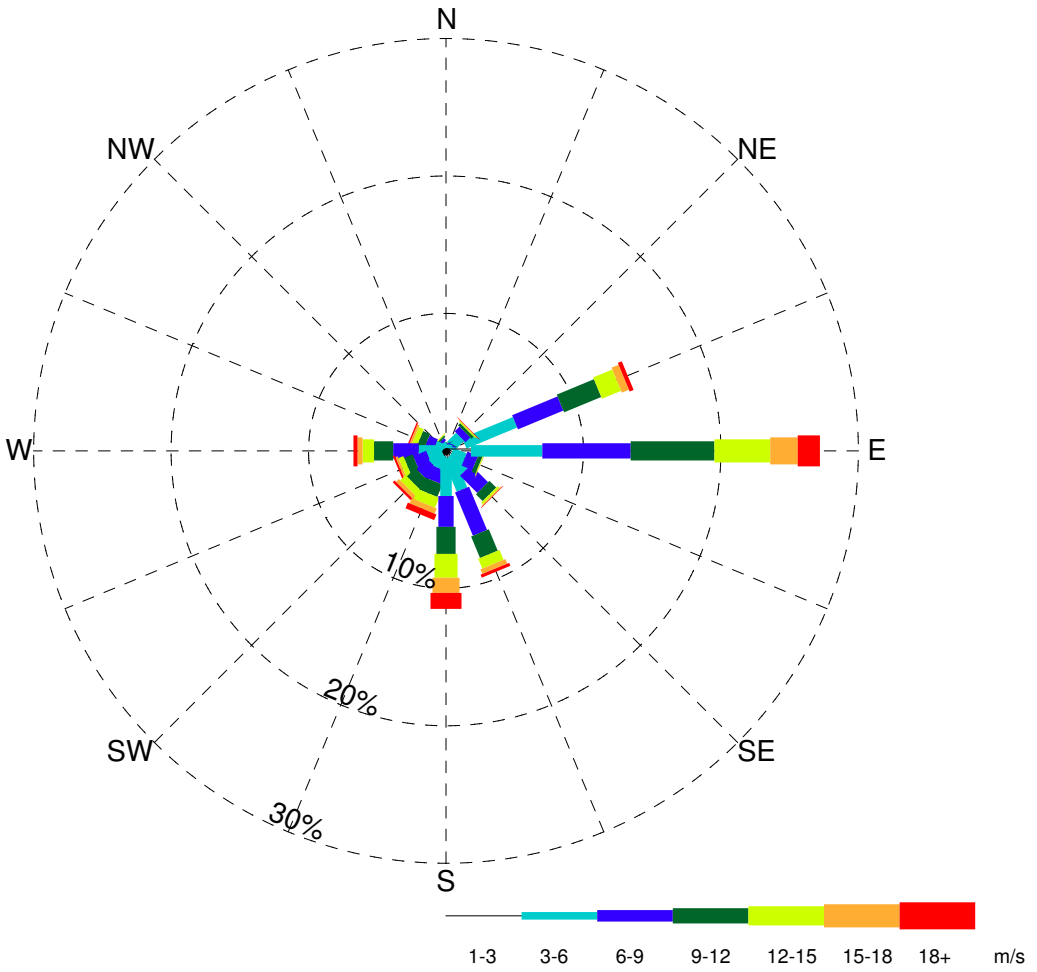
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 07, 2012

Figure A.49



Tatoosh Island

Location:

N48° 22' 58.8" W124° 43' 58.8"

Elevation: 48.0 m

Sea level: -

Length of Record

Start Date: May 01, 1985

End Date: November 01, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	1.44	4.00	3.57	2.93	1.51	0.55	0.31	14.31
NE	-	0.52	0.93	0.49	0.22	0.10	0.04	0.04	2.33
NNE	-	0.23	0.24	0.09	0.03	-	-	-	0.60
N	-	0.25	0.18	0.04	-	-	-	-	0.48
NNW	-	0.19	0.19	0.07	0.02	-	-	-	0.48
NW	-	0.22	0.33	0.21	0.14	0.07	0.02	-	0.99
WNW	-	0.25	0.63	0.67	0.56	0.39	0.16	0.10	2.76
W	-	0.46	1.53	1.86	1.39	0.84	0.37	0.29	6.73
WSW	-	0.28	1.05	1.02	0.67	0.38	0.17	0.15	3.72
SW	-	0.36	1.02	1.08	0.87	0.54	0.29	0.19	4.36
SSW	-	0.39	0.98	1.00	0.98	0.79	0.41	0.44	4.98
S	-	0.83	2.45	2.24	1.97	1.73	1.10	1.16	11.49
SSE	-	0.51	2.54	3.41	1.69	0.77	0.36	0.23	9.52
SE	-	0.45	1.55	1.78	0.69	0.18	0.07	0.04	4.76
ESE	-	0.44	1.03	0.84	0.32	0.07	0.03	-	2.72
E	-	1.81	5.19	6.43	6.09	4.06	2.00	1.62	27.20
Calm	2.56	-	-	-	-	-	-	-	2.56
Total (%)	2.56	8.62	23.84	24.78	18.59	11.44	5.59	4.58	100.00

NOTES

STATUS
ISSUED FOR USE

CLIENT
Kinder Morgan

A TETRA TECH COMPANY

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

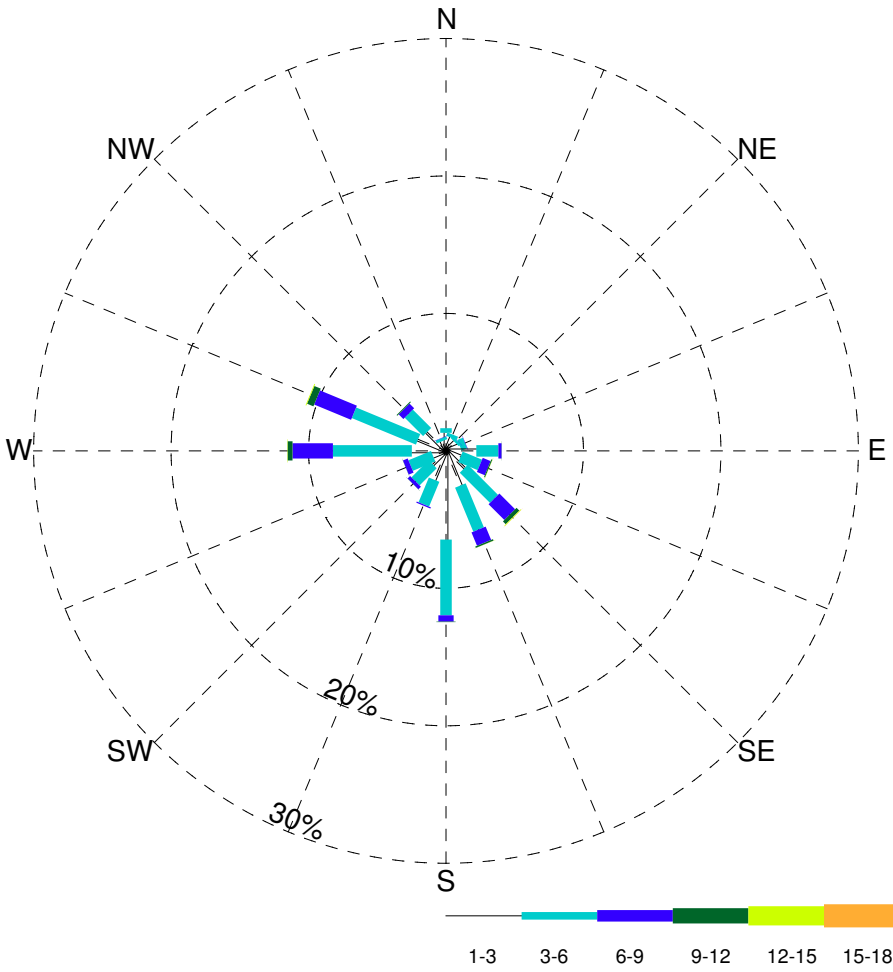
Winter: October-March
Tatoosh Island

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 07, 2012

Figure A.50



Tofino Airport

Location:

N49° 4' 48.0" W125° 46' 12.0"

Elevation: 24.45 m

Sea level: -

Length of Record

Start Date: January 01, 1960

End Date: November 12, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	1.06	0.44	0.03	-	-	-	-	1.53
NE	-	0.90	0.20	0.01	-	-	-	-	1.11
NNE	-	1.02	0.26	-	-	-	-	-	1.29
N	-	1.32	0.33	-	-	-	-	-	1.66
NNW	-	0.75	0.22	0.02	-	-	-	-	1.00
NW	-	1.94	1.89	0.49	0.07	-	-	-	4.39
WNW	-	2.20	5.05	2.91	0.50	0.06	-	-	10.72
W	-	2.49	5.74	2.94	0.35	0.03	-	-	11.56
WSW	-	1.01	1.77	0.38	0.01	-	-	-	3.18
SW	-	1.37	1.76	0.26	0.01	-	-	-	3.41
SSW	-	2.27	1.95	0.09	-	-	-	-	4.31
S	-	6.45	5.51	0.46	0.04	-	-	-	12.47
SSE	-	2.73	3.46	1.05	0.11	0.01	-	-	7.37
SE	-	1.83	3.11	1.62	0.29	0.06	0.01	-	6.91
ESE	-	1.14	1.52	0.62	0.08	0.02	-	-	3.38
E	-	2.21	1.60	0.23	0.01	-	-	-	4.05
Calm	21.66	-	-	-	-	-	-	-	21.66
Total (%)	21.66	30.69	34.82	11.11	1.48	0.20	0.03	-	100.00

NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Summer: April-September
Tofino Airport

STATUS
ISSUED FOR USE

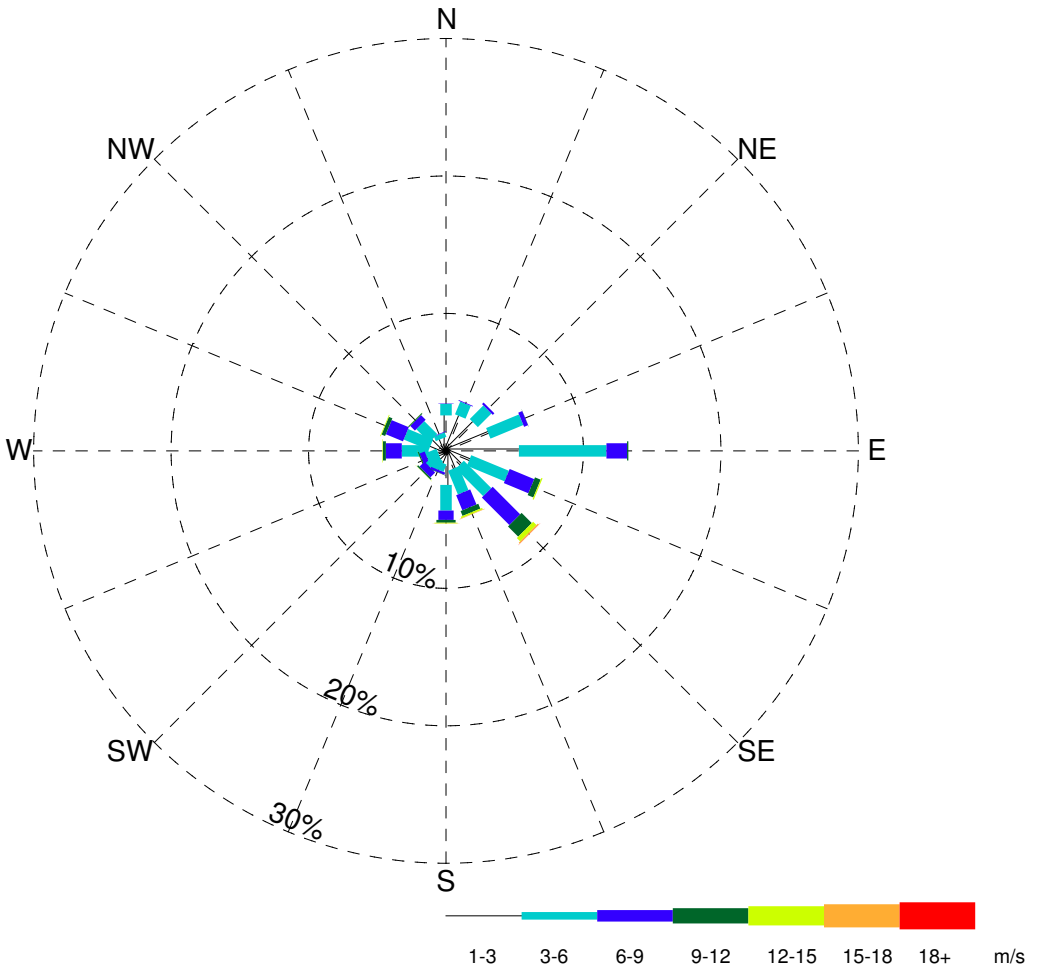
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 07, 2012

Figure A.51



Tofino Airport

Location:

N49° 4' 48.0" W125° 46' 12.0"

Elevation: 24.45 m

Sea level: -

Length of Record

Start Date: January 01, 1960

End Date: November 12, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	3.33	2.59	0.31	0.01	-	-	-	6.24
NE	-	2.86	1.40	0.16	-	-	-	-	4.43
NNE	-	2.71	1.01	0.06	-	-	-	-	3.78
N	-	2.58	0.84	0.03	-	-	-	-	3.45
NNW	-	0.94	0.35	0.05	-	-	-	-	1.34
NW	-	1.31	1.34	0.48	0.08	0.01	-	-	3.22
WNW	-	1.19	1.97	1.35	0.28	0.05	-	-	4.85
W	-	1.26	1.96	1.16	0.21	0.04	-	-	4.64
WSW	-	0.58	0.88	0.40	0.08	0.01	-	-	1.95
SW	-	0.70	0.97	0.50	0.11	0.02	-	-	2.31
SSW	-	0.91	0.58	0.17	0.02	-	-	-	1.69
S	-	2.48	1.86	0.68	0.20	0.05	0.01	-	5.29
SSE	-	1.40	1.87	1.19	0.38	0.12	0.03	-	5.00
SE	-	1.42	2.82	2.83	1.05	0.34	0.10	0.01	8.57
ESE	-	1.82	2.96	1.93	0.45	0.09	-	-	7.26
E	-	5.30	6.37	1.50	0.09	-	-	-	13.27
Calm	22.72	-	-	-	-	-	-	-	22.72
Total (%)	22.72	30.78	29.76	12.80	2.99	0.75	0.17	0.03	100.00

NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Winter: October-March
Tofino Airport

STATUS
ISSUED FOR USE

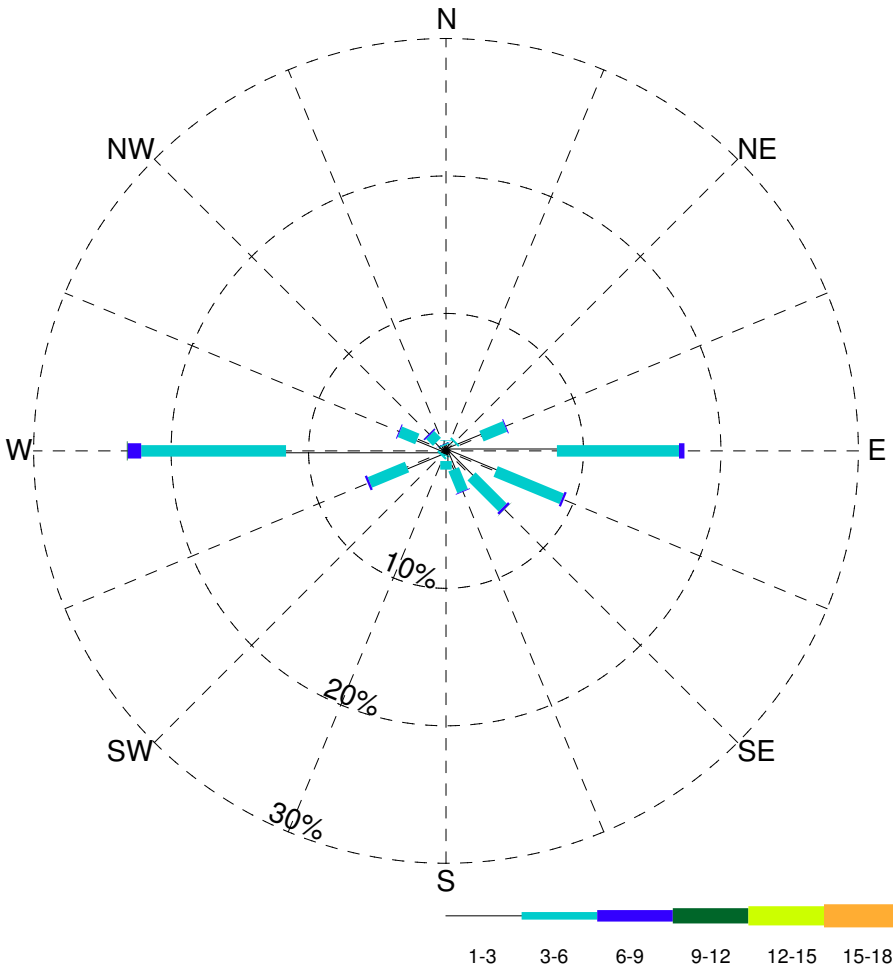
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 07, 2012

Figure A.52



Vancouver Harbour

Location:

N49° 18' 0.0" W123° 7' 1.2"

Elevation: 3.0 m

Sea level: -

Length of Record

Start Date: March 01, 1980

End Date: December 01, 2010

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	**0-1 m/s**	**1-3 m/s**	**3-6 m/s**	**6-9 m/s**	**9-12 m/s**	**12-15 m/s**	**15-18 m/s**	**18+ m/s**	**Total (%)**
ENE	-	2.79	1.86	0.07	-	-	-	-	4.73
NE	-	0.83	0.15	-	-	-	-	-	0.99
NNE	-	0.59	0.03	-	-	-	-	-	0.62
N	-	0.73	0.04	-	-	-	-	-	0.77
NNW	-	0.39	0.10	0.02	-	-	-	-	0.51
NW	-	0.93	0.71	0.11	0.01	-	-	-	1.76
WNW	-	2.26	1.38	0.08	-	-	-	-	3.72
W	-	11.64	10.54	0.99	0.06	-	-	-	23.22
WSW	-	3.07	2.93	0.17	-	-	-	-	6.17
SW	-	0.34	0.16	-	-	-	-	-	0.51
SSW	-	0.26	0.10	-	-	-	-	-	0.36
S	-	0.74	0.63	-	-	-	-	-	1.37
SSE	-	1.45	1.72	0.06	-	-	-	-	3.23
SE	-	2.62	3.20	0.19	0.02	-	-	-	6.04
ESE	-	3.91	5.20	0.17	-	-	-	-	9.28
E	-	8.07	8.88	0.40	-	-	-	-	17.35
Calm	19.37	-	-	-	-	-	-	-	19.37
Total (%)	19.37	40.62	37.63	2.27	0.10	-	-	-	100.00

NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Summer: April-September
Vancouver Harbour

STATUS
ISSUED FOR USE

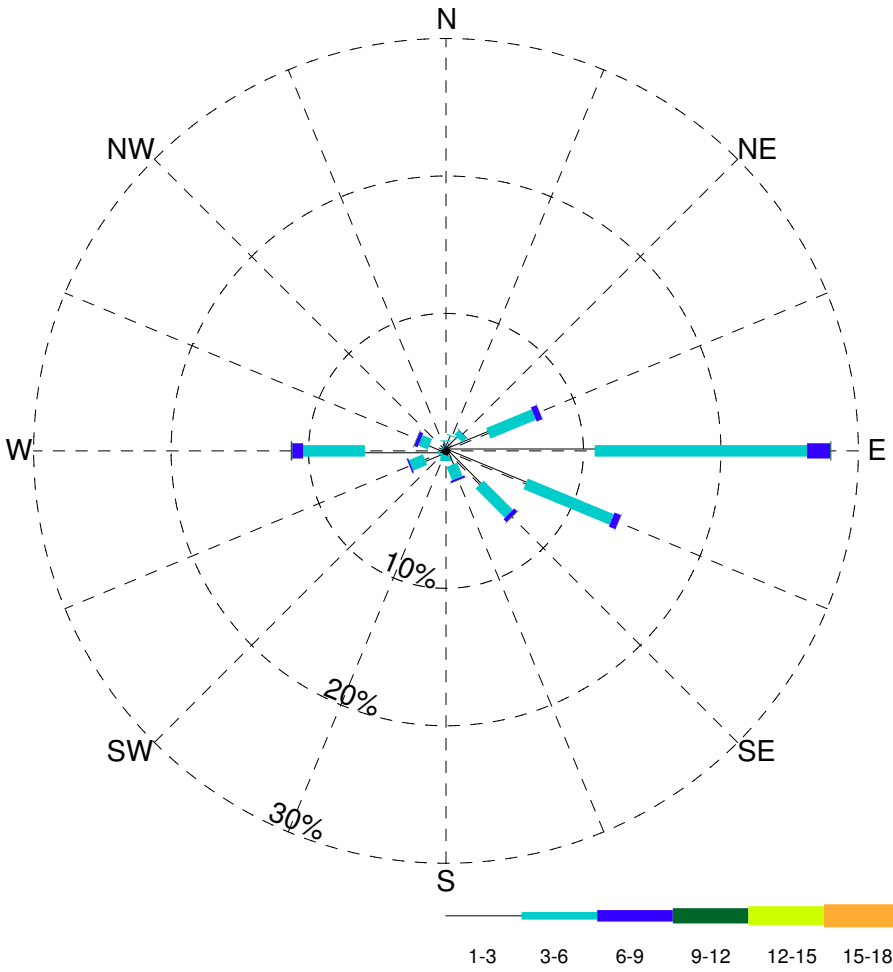
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 07, 2012

Figure A.53



Vancouver Harbour

Location:

N49° 18' 0.0" W123° 7' 1.2"

Elevation: 3.0 m

Sea level: -

Length of Record

Start Date: March 01, 1980

End Date: December 01, 2010

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	**0-1 m/s**	**1-3 m/s**	**3-6 m/s**	**6-9 m/s**	**9-12 m/s**	**12-15 m/s**	**15-18 m/s**	**18+ m/s**	**Total (%)**
ENE	-	3.34	3.58	0.45	0.02	-	-	-	7.38
NE	-	1.28	0.45	0.04	-	-	-	-	1.76
NNE	-	1.12	0.07	-	-	-	-	-	1.20
N	-	0.69	0.07	-	-	-	-	-	0.77
NNW	-	0.18	0.01	-	-	-	-	-	0.19
NW	-	0.27	0.05	0.01	-	-	-	-	0.33
WNW	-	1.27	0.75	0.27	0.04	-	-	-	2.33
W	-	5.90	4.49	0.79	0.11	-	-	-	11.30
WSW	-	1.65	1.10	0.11	0.01	-	-	-	2.88
SW	-	0.37	0.13	-	-	-	-	0.01	0.52
SSW	-	0.31	0.12	-	-	-	-	-	0.44
S	-	0.39	0.34	0.01	-	-	-	-	0.74
SSE	-	1.10	1.05	0.15	0.02	-	-	-	2.33
SE	-	3.46	3.02	0.31	0.03	-	-	-	6.82
ESE	-	6.27	6.78	0.51	0.03	-	-	-	13.59
E	-	10.81	15.46	1.69	0.07	0.01	-	-	28.04
Calm	19.39	-	-	-	-	-	-	-	19.39
Total (%)	19.39	38.42	37.48	4.34	0.34	0.01	-	0.01	100.00

NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Winter: October-March
Vancouver Harbour

STATUS
ISSUED FOR USE

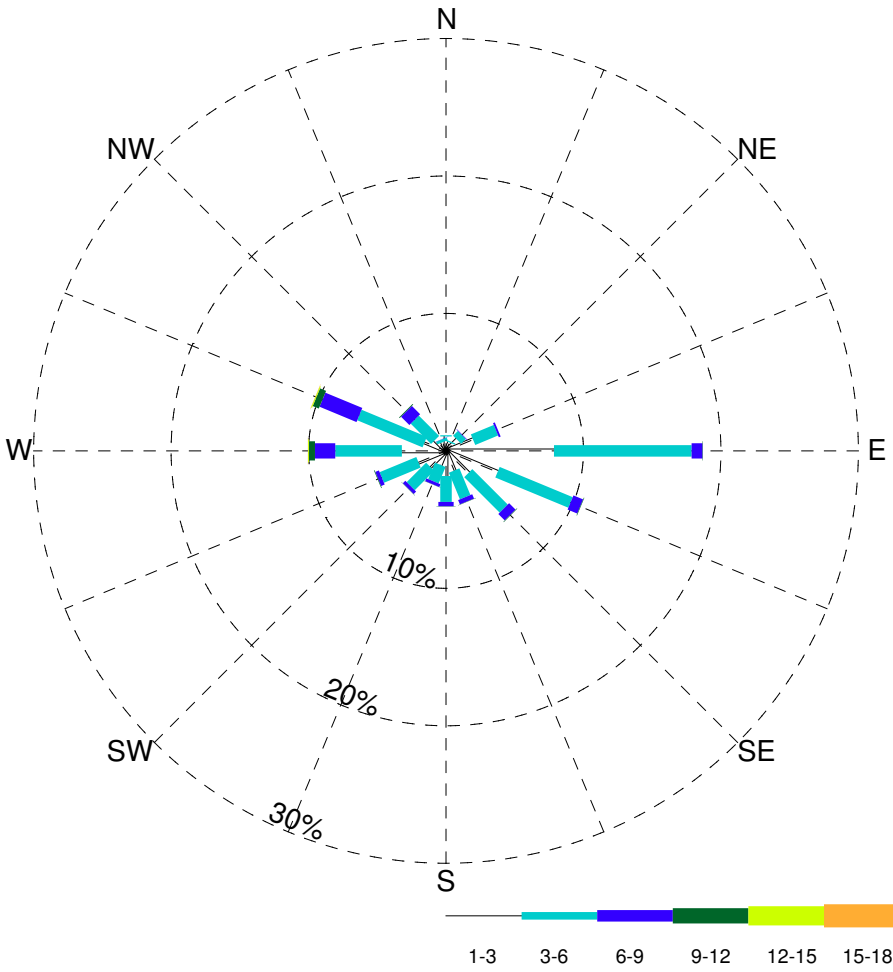
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 07, 2012

Figure A.54



Vancouver Intl Airport

Location:

N49° 12’ 0.0" W123° 10’ 48.0"

Elevation: 4.3 m

Sea level: -

Length of Record

Start Date: January 01, 1953

End Date: November 12, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	2.13	1.80	0.14	-	-	-	-	4.08
NE	-	1.14	0.49	0.04	-	-	-	-	1.67
NNE	-	0.66	0.10	-	-	-	-	-	0.76
N	-	1.05	0.09	-	-	-	-	-	1.14
NNW	-	0.67	0.21	0.02	-	-	-	-	0.91
NW	-	1.13	2.09	0.86	0.06	-	-	-	4.14
WNW	-	1.68	5.14	2.91	0.47	0.08	0.02	-	10.30
W	-	3.21	4.85	1.48	0.44	0.07	0.01	-	10.05
WSW	-	2.17	2.89	0.28	0.05	-	-	-	5.40
SW	-	1.63	2.00	0.25	0.02	-	-	-	3.90
SSW	-	1.10	1.30	0.23	0.02	-	-	-	2.64
S	-	1.83	1.88	0.32	0.02	-	-	-	4.06
SSE	-	1.55	2.10	0.34	0.02	-	-	-	4.01
SE	-	2.29	3.65	0.66	0.04	-	-	-	6.64
ESE	-	4.05	5.75	0.76	0.04	-	-	-	10.61
E	-	7.86	10.01	0.79	0.03	-	-	-	18.69
Calm	11.01	-	-	-	-	-	-	-	11.01
Total (%)	11.01	34.14	44.35	9.09	1.21	0.16	0.04	-	100.00

NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Summer: April-September
Vancouver Intl Airport

STATUS
ISSUED FOR USE

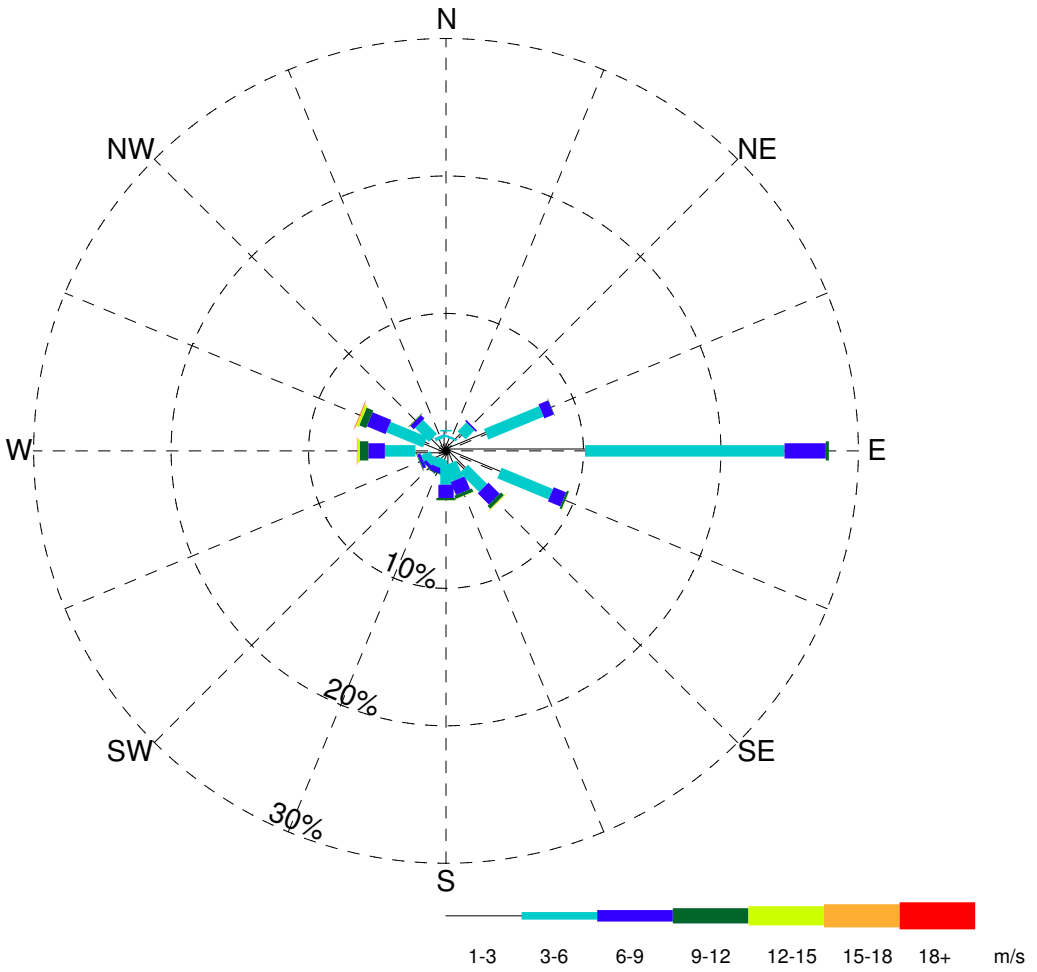
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 07, 2012

Figure A.55



Vancouver Intl Airport

Location:

N49° 12’ 0.0" W123° 10’ 48.0"

Elevation: 4.3 m

Sea level: -

Length of Record

Start Date: January 01, 1953

End Date: November 12, 2012

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	3.16	4.35	0.76	0.03	-	-	-	8.30
NE	-	1.60	0.92	0.13	-	-	-	-	2.65
NNE	-	0.93	0.15	0.02	-	-	-	-	1.09
N	-	1.41	0.11	-	-	-	-	-	1.53
NNW	-	0.92	0.24	0.02	-	-	-	-	1.18
NW	-	1.35	1.43	0.36	0.05	0.01	-	-	3.20
WNW	-	1.64	2.90	1.47	0.53	0.19	0.06	0.02	6.82
W	-	2.22	2.23	1.21	0.61	0.17	0.05	0.01	6.49
WSW	-	1.06	0.75	0.23	0.06	-	-	-	2.10
SW	-	0.88	0.63	0.23	0.04	-	-	-	1.79
SSW	-	0.62	0.70	0.40	0.05	-	-	-	1.77
S	-	1.09	1.38	0.97	0.16	0.01	-	-	3.61
SSE	-	0.94	1.29	1.02	0.26	0.03	-	-	3.54
SE	-	1.84	1.98	1.15	0.29	0.05	0.02	-	5.33
ESE	-	4.21	4.05	0.98	0.16	0.02	-	-	9.42
E	-	10.11	14.51	3.01	0.22	-	-	-	27.86
Calm	13.33	-	-	-	-	-	-	-	13.33
Total (%)	13.33	33.98	37.61	11.93	2.46	0.51	0.14	0.04	100.00

NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Winter: October-March
Vancouver Intl Airport

STATUS
ISSUED FOR USE

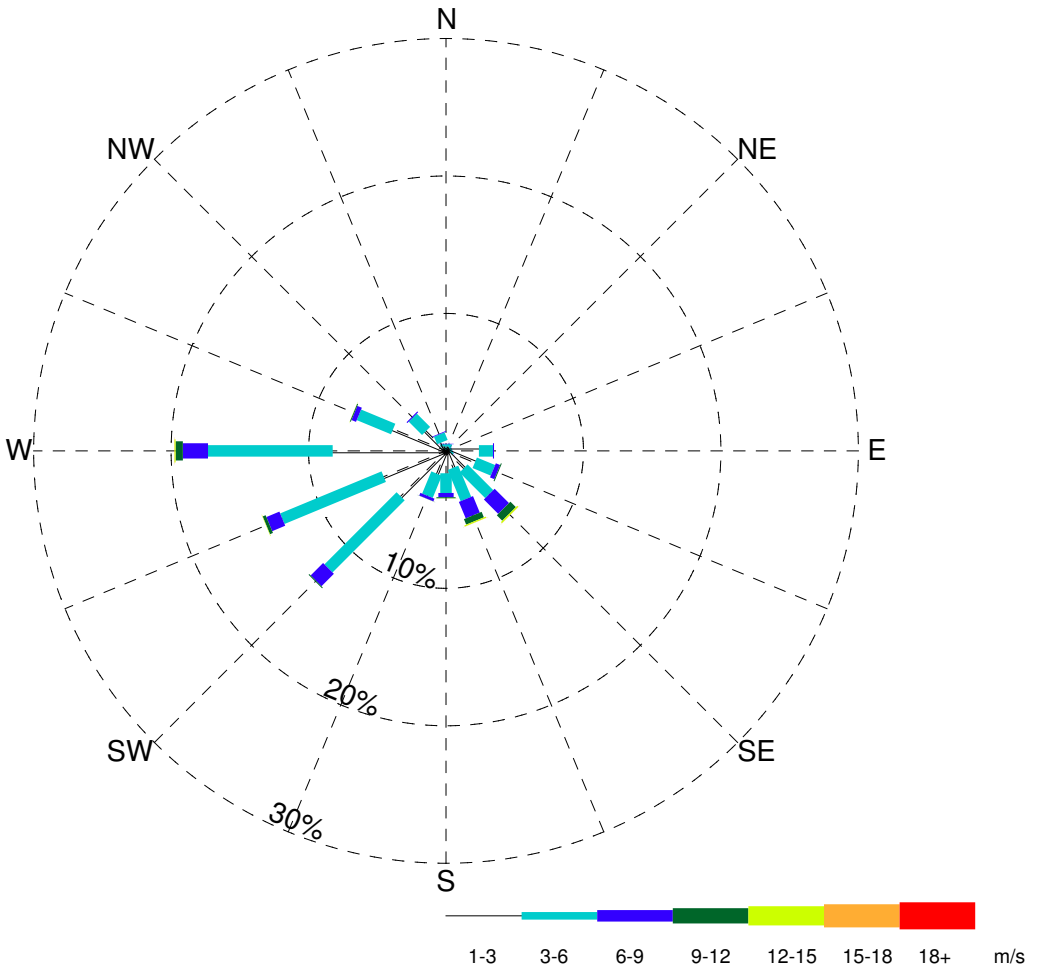
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 07, 2012

Figure A.56



Whidbey Island

Location:

N48° 21’ 0.0" W122° 40’ 1.2"

Elevation: 14.3 m

Sea level: -

Length of Record

Start Date: April 11, 1945

End Date: June 01, 2009

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	0.28	0.15	0.01	-	-	-	-	0.45
NE	-	0.16	0.04	-	-	-	-	-	0.21
NNE	-	0.09	0.03	-	-	-	-	-	0.13
N	-	0.32	0.16	0.03	-	-	-	-	0.52
NNW	-	0.69	0.60	0.05	-	-	-	-	1.35
NW	-	2.05	1.37	0.08	-	-	-	-	3.51
WNW	-	4.16	2.70	0.35	0.07	0.01	-	-	7.30
W	-	8.24	9.07	1.83	0.53	0.09	0.01	-	19.77
WSW	-	4.90	7.99	1.03	0.23	0.03	-	-	14.18
SW	-	4.67	7.42	1.28	0.08	-	-	-	13.45
SSW	-	1.79	1.75	0.21	0.01	-	-	-	3.76
S	-	1.63	1.43	0.31	0.07	0.01	-	-	3.46
SSE	-	1.33	2.46	1.30	0.43	0.09	0.01	-	5.62
SE	-	1.81	2.64	1.48	0.56	0.11	0.01	-	6.61
ESE	-	2.26	1.43	0.34	0.07	-	-	-	4.11
E	-	2.39	1.02	0.08	-	-	-	-	3.50
Calm	12.08	-	-	-	-	-	-	-	12.08
Total (%)	12.08	36.78	40.27	8.39	2.08	0.35	0.05	-	100.00

NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Summer: April-September
Whidbey Island

STATUS
ISSUED FOR USE

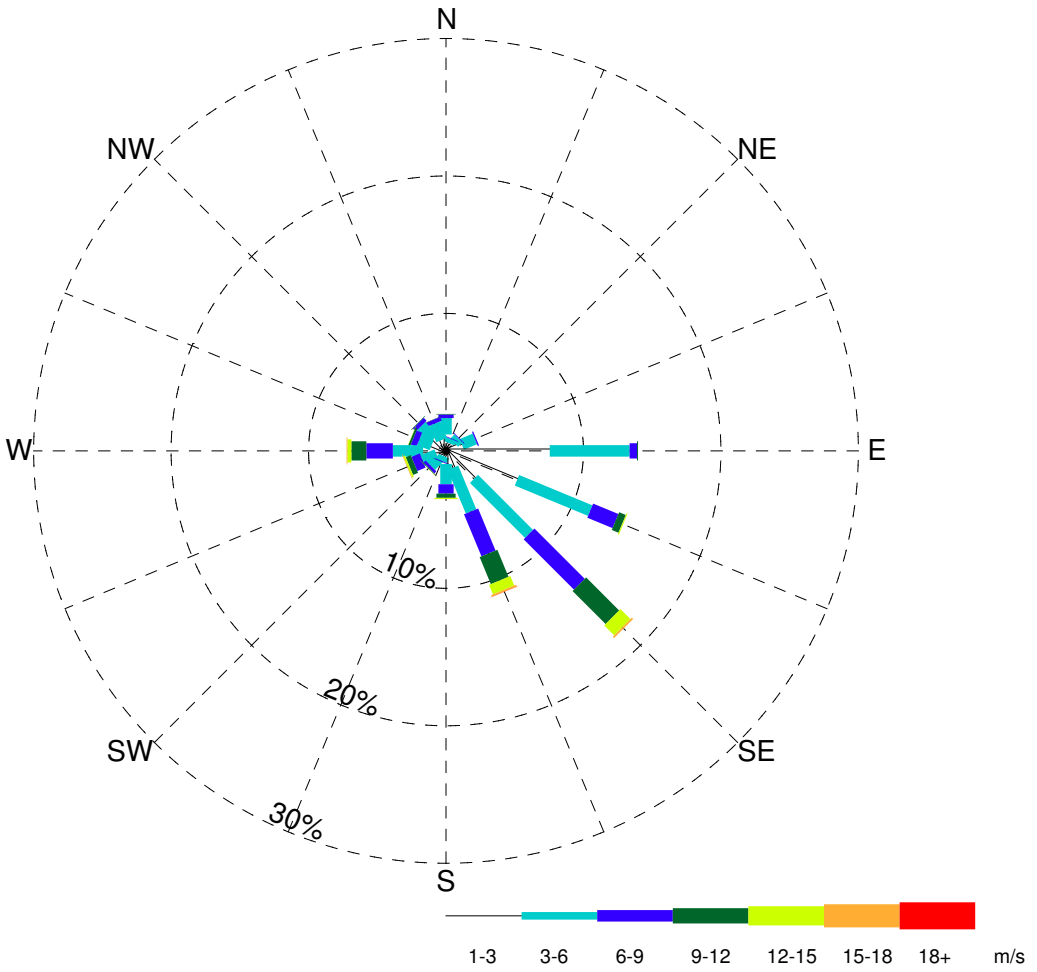
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 07, 2012

Figure A.57



Whidbey Island

Location:

N48° 21’ 0.0" W122° 40’ 1.2"

Elevation: 14.3 m

Sea level: -

Length of Record

Start Date: April 11, 1945

End Date: June 01, 2009

Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	1.24	1.03	0.09	-	-	-	-	2.38
NE	-	0.84	0.45	0.05	-	-	-	-	1.35
NNE	-	0.60	0.34	0.05	-	-	-	-	1.00
N	-	1.19	1.19	0.26	0.04	-	-	-	2.69
NNW	-	0.85	1.30	0.30	0.03	-	-	-	2.48
NW	-	1.25	1.30	0.30	0.04	-	-	-	2.89
WNW	-	1.12	0.98	0.44	0.15	0.03	-	-	2.73
W	-	1.66	2.20	1.93	1.09	0.29	0.05	-	7.24
WSW	-	0.74	1.10	0.65	0.40	0.14	0.04	-	3.08
SW	-	0.68	0.86	0.21	0.06	0.01	-	-	1.84
SSW	-	0.42	0.37	0.07	0.01	-	-	-	0.87
S	-	0.96	1.47	0.68	0.31	0.08	0.01	-	3.51
SSE	-	1.33	3.44	3.31	2.13	0.74	0.14	0.01	11.10
SE	-	2.88	5.66	5.18	3.39	1.02	0.14	-	18.28
ESE	-	5.59	5.77	1.99	0.53	0.07	-	-	13.95
E	-	7.55	5.81	0.54	0.07	-	-	-	13.98
Calm	10.63	-	-	-	-	-	-	-	10.63
Total (%)	10.63	28.89	33.29	16.06	8.27	2.42	0.40	0.04	100.00

NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Winter: October-March
Whidbey Island

STATUS
ISSUED FOR USE

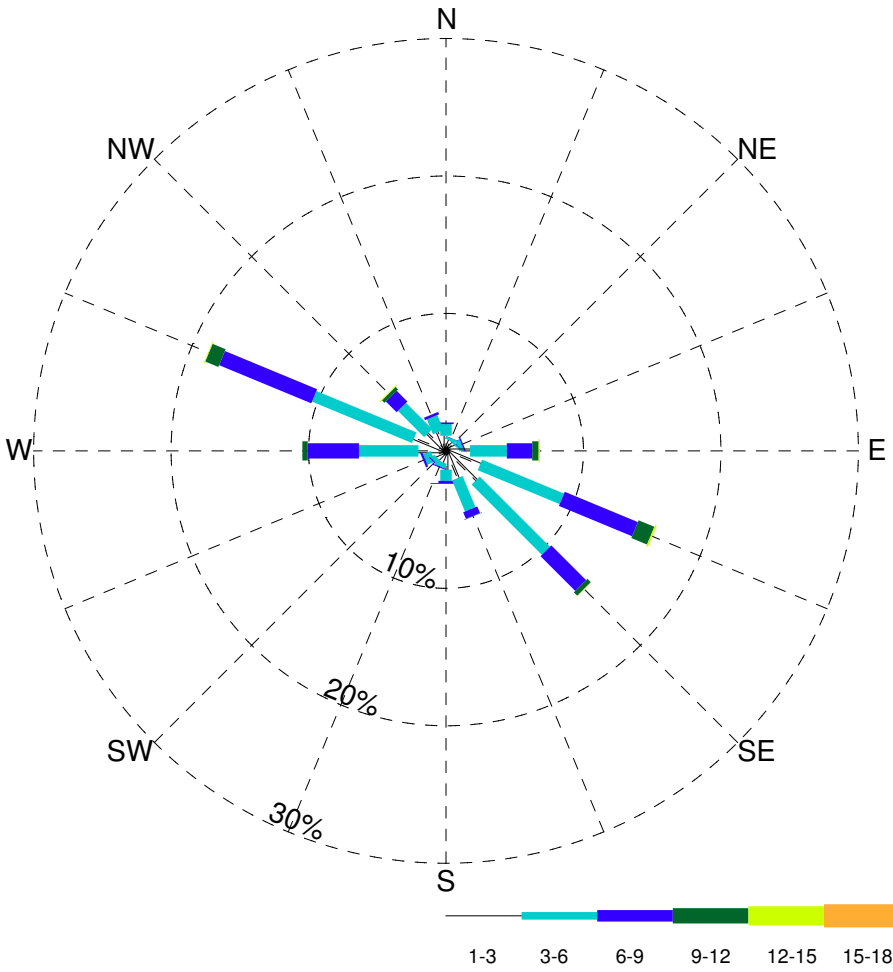
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 07, 2012

Figure A.58



Canadian Buoy C46146
Location:Halibut Bank, SOG
N49° 20' 24.0" W123° 43' 48.0"
Elevation: Sea Level
Sea level: -
Length of Record
Start Date: Mar 13, 1992
End Date: Nov 12, 2012
Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	0.88	0.35	0.10	0.02	-	-	-	1.34
NE	-	0.71	0.11	0.03	-	-	-	-	0.86
NNE	-	0.80	0.19	0.02	-	-	-	-	1.01
N	-	1.10	0.85	0.12	0.01	-	-	-	2.08
NNW	-	1.47	1.18	0.19	0.01	-	-	-	2.85
NW	-	1.83	2.69	1.11	0.26	0.07	-	-	5.97
WNW	-	2.50	7.88	7.26	1.03	0.06	-	-	18.74
W	-	2.01	4.33	3.72	0.39	-	-	-	10.46
WSW	-	1.03	0.60	0.16	0.01	-	-	-	1.81
SW	-	0.81	0.34	0.08	-	-	-	-	1.22
SSW	-	0.85	0.37	0.08	-	-	-	-	1.30
S	-	1.37	0.81	0.16	-	-	-	0.08	2.42
SSE	-	2.15	2.45	0.52	0.04	-	-	-	5.16
SE	-	3.05	7.23	3.58	0.35	0.02	-	-	14.23
ESE	-	2.67	6.45	5.76	1.24	0.13	-	-	16.26
E	-	1.75	2.67	1.85	0.47	0.09	-	-	6.84
Calm	7.47	-	-	-	-	-	-	-	7.47
Total (%)	7.47	24.98	38.50	24.72	3.84	0.38	0.03	0.08	100.00

NOTES

STATUS
ISSUED FOR USE

CLIENT
Kinder Morgan

A TETRA TECH COMPANY

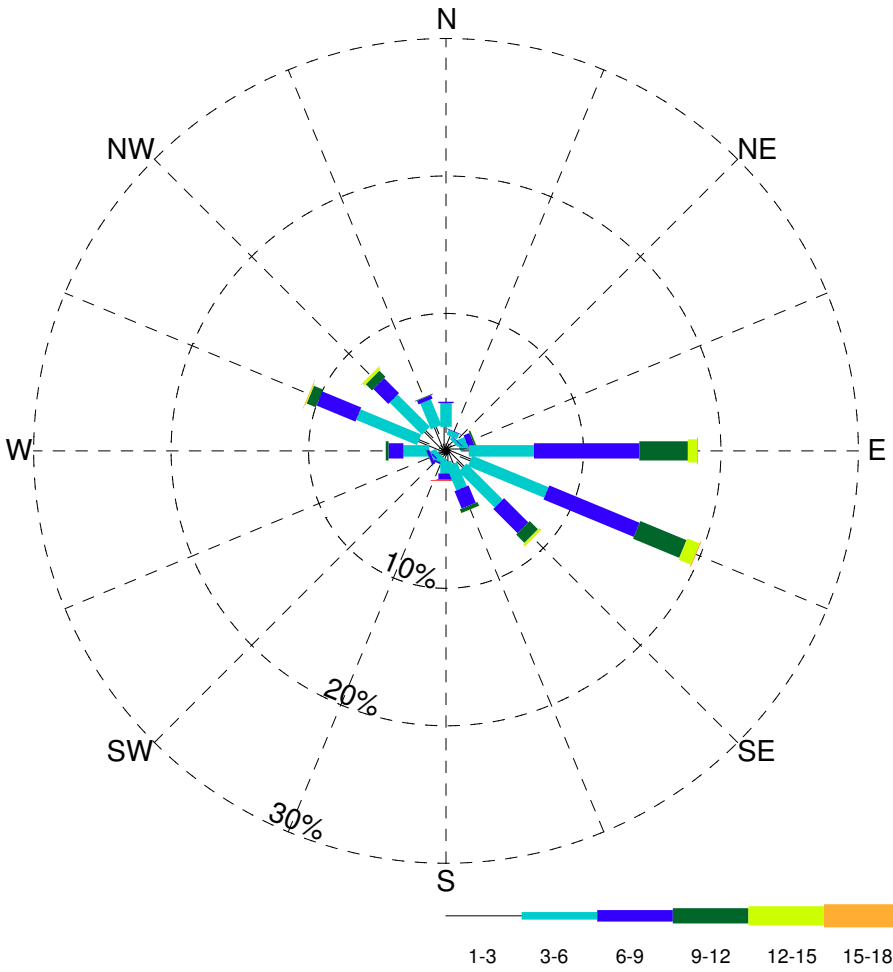
METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Summer: April-September
Halibut Bank, Strait of Georgia

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	AL	JAS	JAS	0

OFFICE: EBA-VANC
DATE: November 14, 2012

Figure A.59



Canadian Buoy C46146
Location:Halibut Bank, SOG
N49° 20' 24.0" W123° 43' 48.0"
Elevation: Sea Level
Sea level: -
Length of Record
Start Date: Mar 13, 1992
End Date: Nov 12, 2012
Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	**0-1 m/s**	**1-3 m/s**	**3-6 m/s**	**6-9 m/s**	**9-12 m/s**	**12-15 m/s**	**15-18 m/s**	**18+ m/s**	**Total (%)**
ENE	-	0.97	0.63	0.46	0.12	0.02	-	-	2.21
NE	-	0.81	0.23	0.05	0.02	-	-	-	1.11
NNE	-	1.11	0.39	0.05	-	-	-	-	1.55
N	-	1.75	1.72	0.11	-	-	-	-	3.59
NNW	-	1.87	2.03	0.28	0.05	-	-	-	4.24
NW	-	2.07	3.32	1.53	0.64	0.19	0.04	-	7.80
WNW	-	2.12	4.78	3.07	0.72	0.09	-	0.01	10.80
W	-	1.23	1.87	1.08	0.21	0.02	-	-	4.41
WSW	-	0.61	0.49	0.21	0.03	-	-	-	1.34
SW	-	0.47	0.36	0.10	0.01	-	-	-	0.95
SSW	-	0.54	0.38	0.12	0.01	-	-	-	1.06
S	-	0.73	0.91	0.43	0.05	-	-	0.05	2.18
SSE	-	1.06	1.88	1.37	0.30	0.02	-	-	4.63
SE	-	1.70	3.72	2.49	0.85	0.19	0.02	-	8.97
ESE	-	1.90	6.01	7.11	3.64	0.95	0.09	-	19.70
E	-	1.66	4.74	7.67	3.53	0.67	0.06	-	18.33
Calm	7.14	-	-	-	-	-	-	-	7.14
Total (%)	7.14	20.60	33.45	26.14	10.20	2.17	0.22	0.09	100.00

NOTES

CLIENT
Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Winter: October-March
Halibut Bank, Strait of Georgia

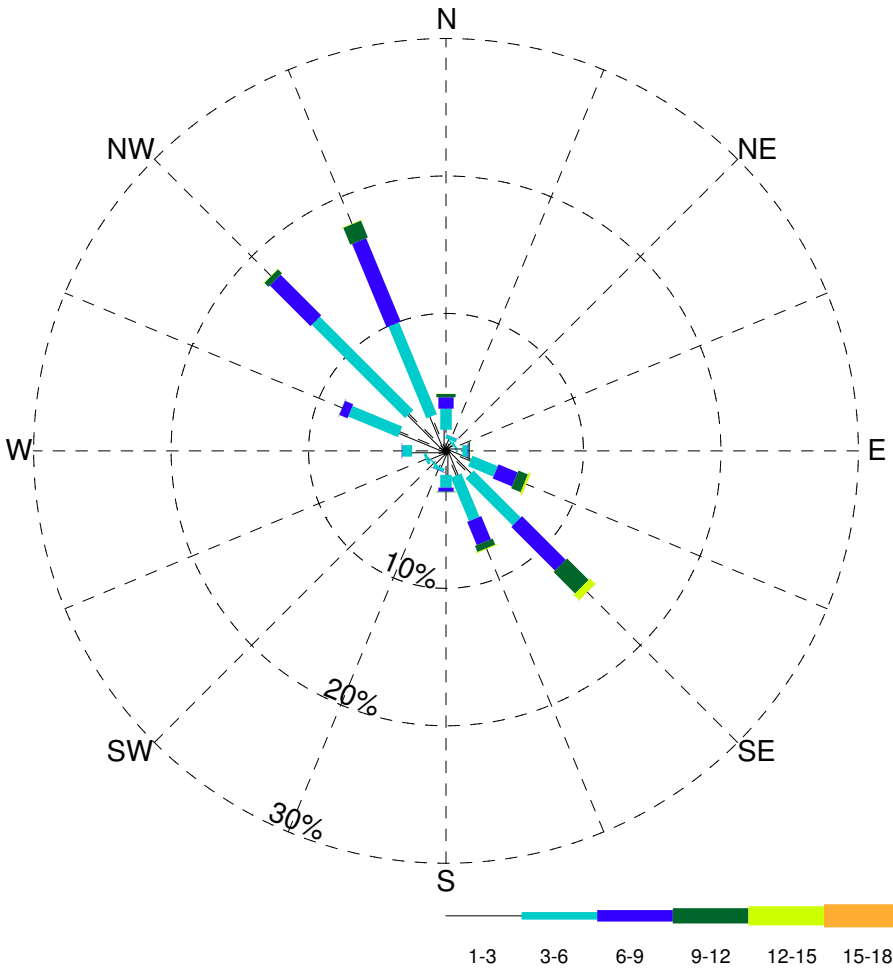
STATUS
ISSUED FOR USE

A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	AL	JAS	JAS	0

OFFICE: EBA-VANC
DATE: November 14, 2012

Figure A.60



Canadian Buoy C46131
Location:Sentry Shoal, SOG
N49° 54' 36.0" W124° 59' 24.0"
Elevation: Sea Level
Sea level: -
Length of Record
Start Date: Oct 20, 1992
End Date: Nov 9, 2012
Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	0.66	0.12	-	-	-	-	-	0.79
NE	-	0.63	0.12	-	-	-	-	-	0.75
NNE	-	0.83	0.28	0.02	-	-	-	-	1.13
N	-	1.53	1.53	0.83	0.24	0.01	-	-	4.15
NNW	-	2.72	7.23	6.57	1.33	0.05	-	-	17.90
NW	-	3.79	9.61	4.18	0.42	0.04	-	-	18.02
WNW	-	3.62	3.91	0.64	0.03	-	-	-	8.20
W	-	2.46	0.72	0.04	-	-	-	-	3.23
WSW	-	1.39	0.21	-	-	-	-	-	1.61
SW	-	1.17	0.12	-	-	-	-	-	1.31
SSW	-	1.24	0.26	0.03	-	-	-	-	1.52
S	-	1.75	0.92	0.29	0.05	-	-	-	3.01
SSE	-	1.94	3.42	1.83	0.48	0.07	-	-	7.75
SE	-	2.43	4.84	4.49	2.21	0.54	0.03	-	14.55
ESE	-	1.92	1.99	1.51	0.74	0.15	0.02	-	6.33
E	-	1.19	0.37	0.08	0.09	0.02	-	-	1.76
Calm	8.00	-	-	-	-	-	-	-	8.00
Total (%)	8.00	29.29	35.67	20.52	5.60	0.87	0.05	-	100.00

NOTES

STATUS
ISSUED FOR USE

CLIENT
Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

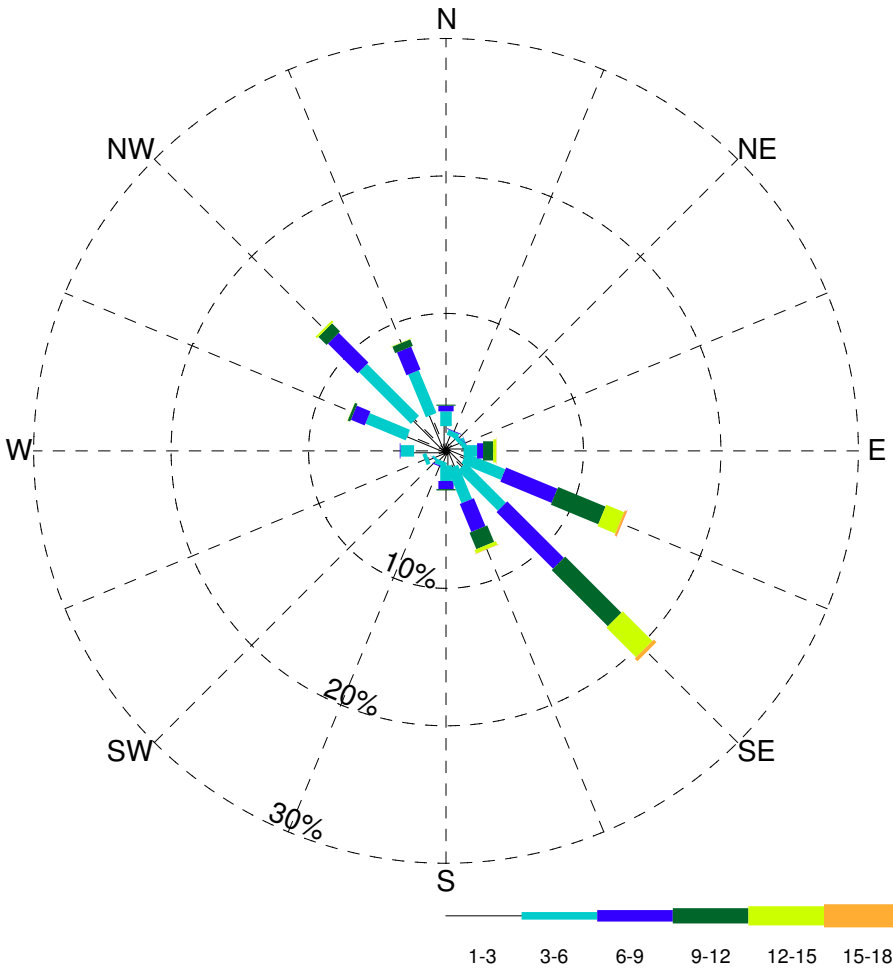
Summer: April-September
Sentry Shoal, Strait of Georgia

A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	AL	JAS	JAS	0

OFFICE: EBA-VANC
DATE: November 14, 2012

Figure A.61



Canadian Buoy C46131
Location:Sentry Shoal, SOG
N49° 54' 36.0" W124° 59' 24.0"
Elevation: Sea Level
Sea level: -
Length of Record
Start Date: Oct 20, 1992
End Date: Nov 9, 2012
Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	1.17	0.37	0.02	-	-	-	-	1.55
NE	-	1.04	0.32	0.02	-	-	-	-	1.38
NNE	-	1.11	0.40	0.06	0.01	-	-	-	1.57
N	-	1.80	1.08	0.41	0.08	-	-	-	3.37
NNW	-	2.82	3.36	1.80	0.52	0.03	-	-	8.54
NW	-	3.19	5.34	3.06	0.84	0.15	-	-	12.59
WNW	-	3.01	3.17	1.08	0.19	0.02	-	-	7.48
W	-	2.32	0.99	0.05	-	-	-	-	3.37
WSW	-	1.39	0.30	-	-	-	-	-	1.70
SW	-	0.87	0.17	0.01	-	-	-	-	1.05
SSW	-	0.78	0.38	0.08	-	-	-	-	1.24
S	-	1.05	1.14	0.59	0.10	-	-	-	2.88
SSE	-	1.26	2.69	2.20	1.30	0.27	0.03	-	7.76
SE	-	1.62	4.13	5.82	5.78	3.05	0.27	-	20.67
ESE	-	1.40	3.10	4.05	3.73	1.40	0.16	0.01	13.85
E	-	1.28	0.98	0.43	0.74	0.23	0.02	-	3.68
Calm	7.31	-	-	-	-	-	-	-	7.31
Total (%)	7.31	26.10	27.91	19.69	13.30	5.16	0.50	0.03	100.00

NOTES

STATUS
ISSUED FOR USE

CLIENT
Kinder Morgan

A TETRA TECH COMPANY

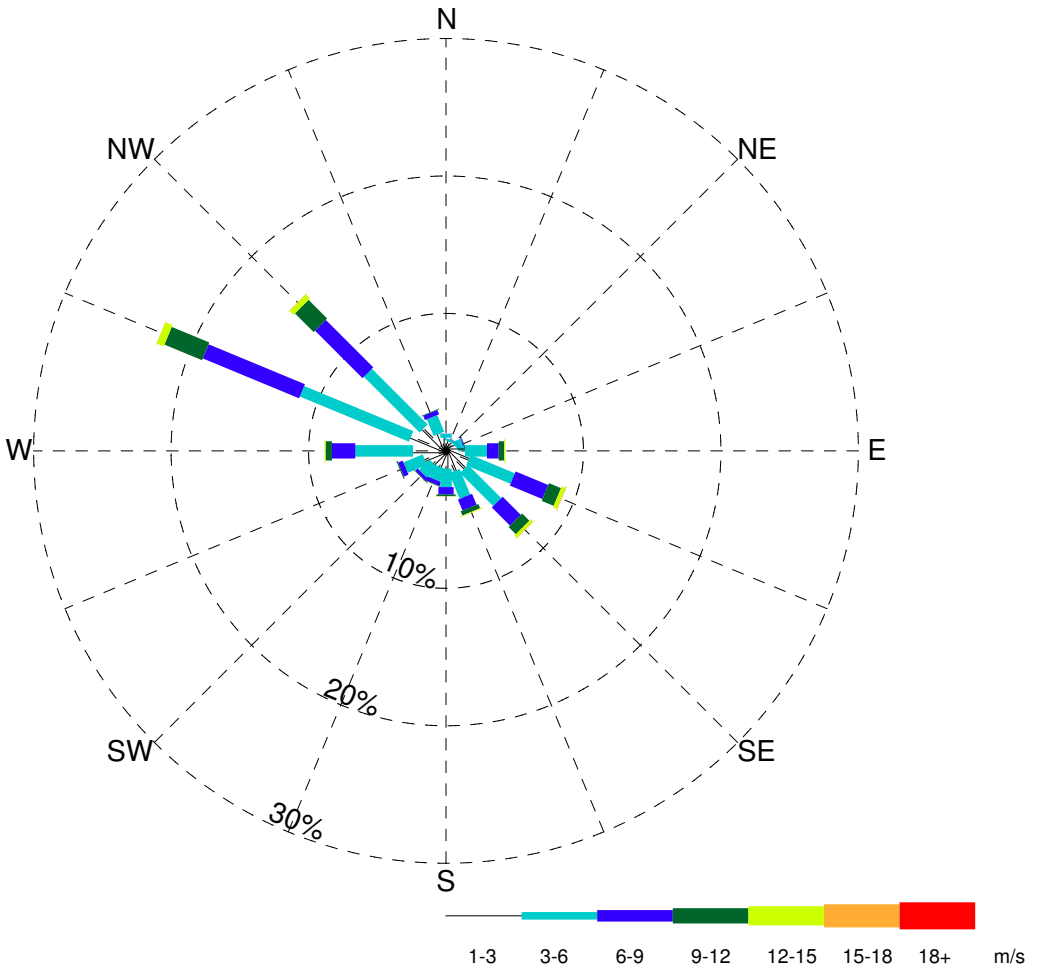
METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Winter: October-March
Sentry Shoal, Strait of Georgia

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	AL	JAS	JAS	0

OFFICE: EBA-VANC
DATE: November 14, 2012

Figure A.62



Canadian Buoy C46206
Location:La Perouse Bank
N48° 50' 6.0" W125° 59' 52.0"
Elevation: Sea Level
Sea level: -
Length of Record
Start Date: Nov 22, 1988
End Date: Aug 26, 2012
Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	0.83	0.49	0.07	0.03	-	-	-	1.42
NE	-	0.71	0.18	0.02	-	-	-	-	0.91
NNE	-	0.70	0.14	0.01	-	-	-	-	0.86
N	-	0.96	0.28	0.02	-	-	-	-	1.25
NNW	-	1.34	1.31	0.34	0.05	-	-	-	3.04
NW	-	2.30	5.73	4.89	1.91	0.41	0.03	-	15.28
WNW	-	2.74	8.60	7.59	2.96	0.55	0.02	-	22.46
W	-	2.40	4.20	1.70	0.46	0.08	-	-	8.84
WSW	-	1.67	1.52	0.37	0.08	-	-	-	3.63
SW	-	1.29	1.07	0.23	0.04	-	-	-	2.64
SSW	-	1.23	1.00	0.31	0.05	0.01	-	-	2.61
S	-	1.30	1.34	0.53	0.13	0.02	-	-	3.31
SSE	-	1.59	2.02	0.87	0.33	0.06	0.01	-	4.88
SE	-	1.85	3.42	1.87	0.75	0.23	0.04	-	8.15
ESE	-	1.75	3.50	2.56	0.95	0.30	0.05	-	9.12
E	-	1.38	1.61	0.85	0.40	0.08	0.01	-	4.32
Calm	7.27	-	-	-	-	-	-	-	7.27
Total (%)	7.27	24.04	36.40	22.22	8.14	1.76	0.17	-	100.00

NOTES

CLIENT
Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Summer: April-September
La Perouse Bank

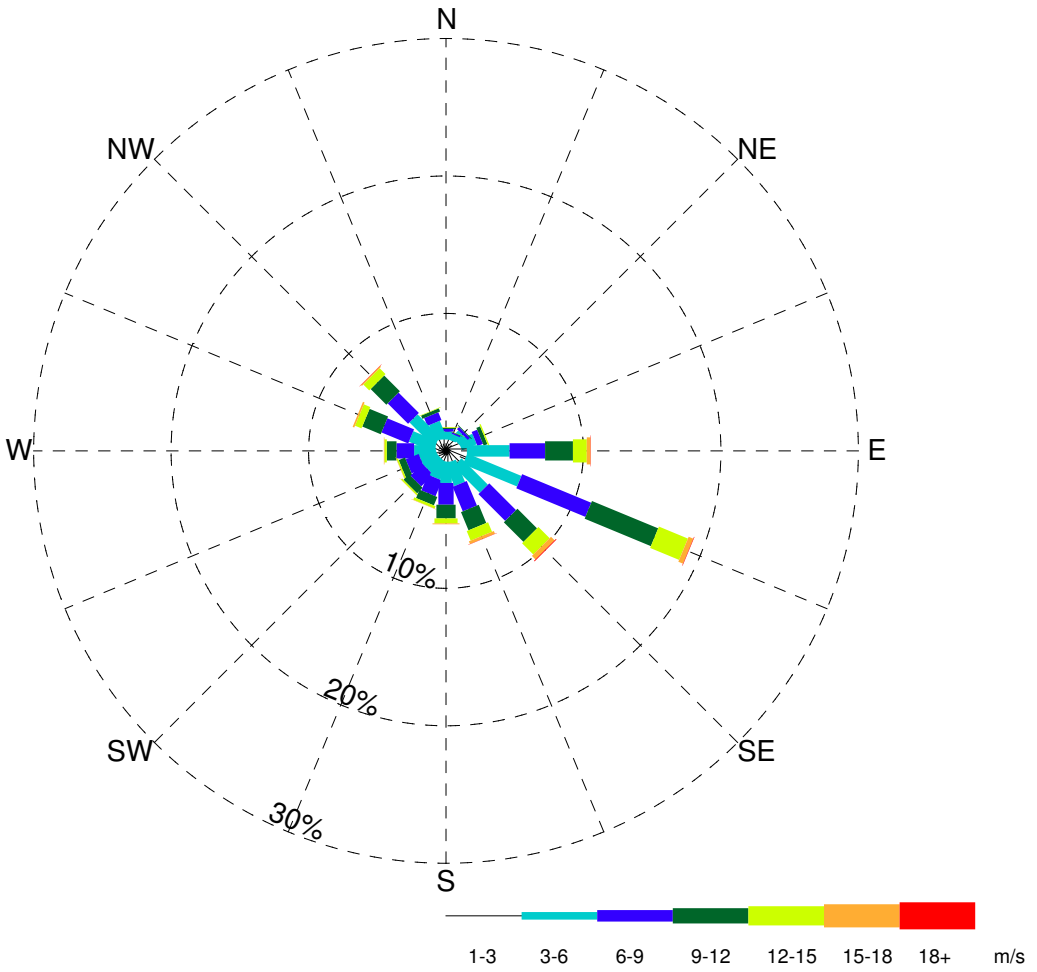
STATUS
ISSUED FOR USE

A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	AL	JAS	JAS	0

OFFICE: EBA-VANC
DATE: November 14, 2012

Figure A.63



NOAA Buoy 46088
Location:La Perouse Bank
N48° 50' 6.0" W125° 59' 52.0"
Elevation: Sea Level
Sea level: -
Length of Record
Start Date: Nov 22, 1988
End Date: Aug 26, 2012
Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	**0-1 m/s**	**1-3 m/s**	**3-6 m/s**	**6-9 m/s**	**9-12 m/s**	**12-15 m/s**	**15-18 m/s**	**18+ m/s**	**Total (%)**
ENE	-	1.09	1.16	0.43	0.29	0.10	-	-	3.08
NE	-	1.00	0.69	0.22	0.06	-	-	-	1.97
NNE	-	0.83	0.48	0.11	0.04	0.02	-	-	1.47
N	-	0.83	0.58	0.19	0.08	0.05	0.01	-	1.74
NNW	-	0.92	1.28	0.61	0.25	0.04	-	-	3.11
NW	-	1.04	2.30	2.10	1.62	0.61	0.09	0.02	7.78
WNW	-	0.85	1.89	2.10	1.46	0.51	0.13	-	6.95
W	-	0.75	1.57	1.28	0.70	0.17	0.04	-	4.52
WSW	-	0.67	1.25	1.02	0.49	0.12	0.02	-	3.58
SW	-	0.62	1.26	1.22	0.57	0.11	0.01	-	3.80
SSW	-	0.73	1.37	1.24	0.66	0.19	0.02	-	4.22
S	-	0.78	1.55	1.58	1.00	0.36	0.07	-	5.34
SSE	-	0.86	1.74	1.93	1.43	0.75	0.21	0.02	6.95
SE	-	1.18	2.72	2.75	2.02	1.15	0.36	0.06	10.24
ESE	-	1.51	4.26	5.44	5.21	2.28	0.36	0.04	19.10
E	-	1.52	3.10	2.58	2.03	1.01	0.26	0.03	10.54
Calm	5.61	-	-	-	-	-	-	-	5.61
Total (%)	5.61	15.19	27.20	24.82	17.91	7.49	1.59	0.19	100.00

NOTES

CLIENT
Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Winter: October-March
La Perouse Bank

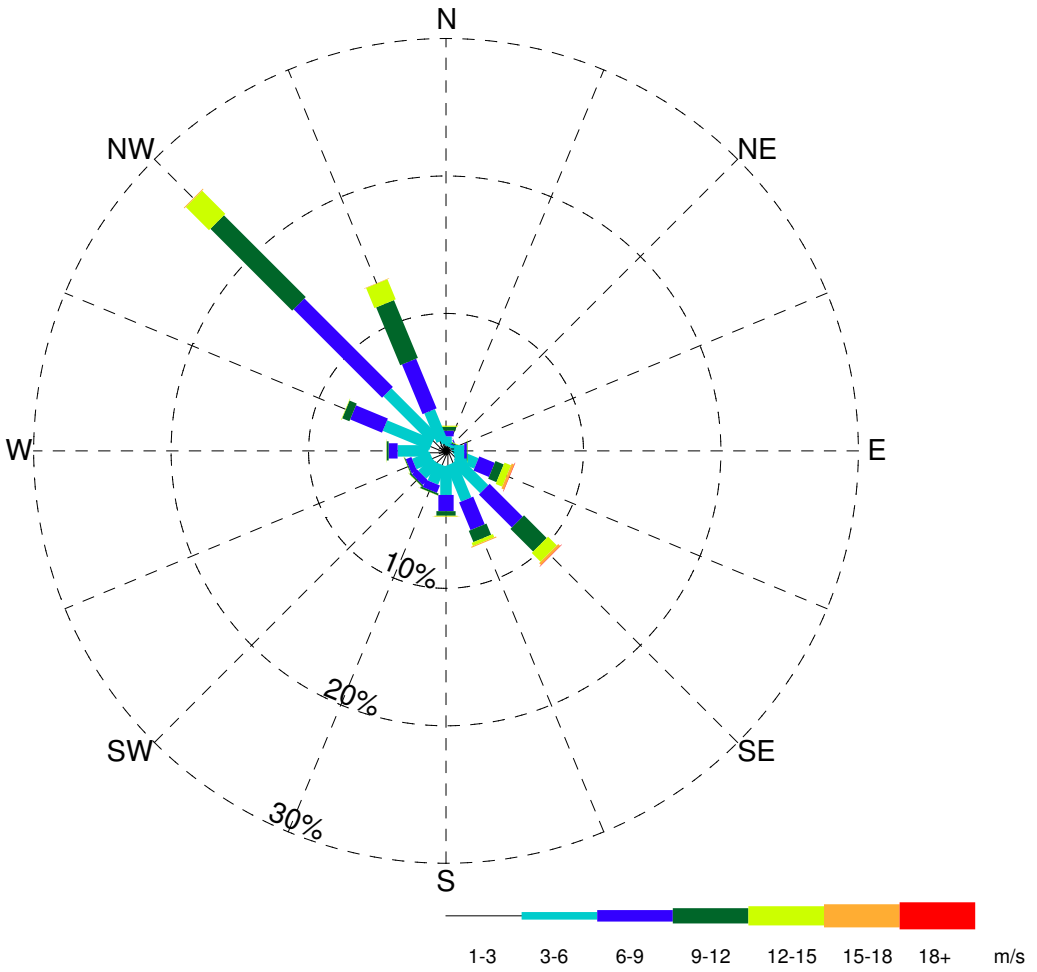
STATUS
ISSUED FOR USE

A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	AL	JAS	JAS	0

OFFICE: EBA-VANC
DATE: November 14, 2012

Figure A.64



Canadian Buoy C46132
Location:South Brooks
N49° 43' 48.0" W127° 55' 12.0"
Elevation: Sea Level
Sea level: -
Length of Record
Start Date: May 5, 1994
End Date: Nov 9, 2012
Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	0.40	0.32	0.08	0.01	-	-	-	0.81
NE	-	0.38	0.21	0.05	0.02	-	-	-	0.67
NNE	-	0.35	0.22	0.07	0.08	0.04	-	-	0.76
N	-	0.51	0.54	0.41	0.28	0.08	0.01	-	1.84
NNW	-	0.80	2.32	3.91	4.56	1.58	0.03	-	13.20
NW	-	1.19	4.83	9.10	8.42	2.39	0.07	-	26.00
WNW	-	1.15	3.66	2.51	0.56	0.04	-	-	7.92
W	-	1.27	2.25	0.65	0.15	0.02	-	-	4.34
WSW	-	1.13	1.37	0.44	0.07	0.02	-	-	3.04
SW	-	1.10	1.35	0.52	0.10	0.02	-	-	3.09
SSW	-	1.05	1.45	0.58	0.13	0.02	-	-	3.24
S	-	1.13	2.07	1.18	0.33	0.06	0.02	-	4.79
SSE	-	1.00	2.83	2.18	0.89	0.25	0.08	-	7.23
SE	-	0.97	2.97	3.39	2.33	0.90	0.19	0.03	10.79
ESE	-	0.78	1.61	1.22	0.65	0.51	0.19	0.03	4.99
E	-	0.59	0.73	0.19	0.05	0.03	-	-	1.59
Calm	5.70	-	-	-	-	-	-	-	5.70
Total (%)	5.70	13.81	28.74	26.49	18.64	5.96	0.60	0.07	100.00

NOTES

CLIENT
Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Summer: April-September
South Brooks

STATUS
ISSUED FOR USE

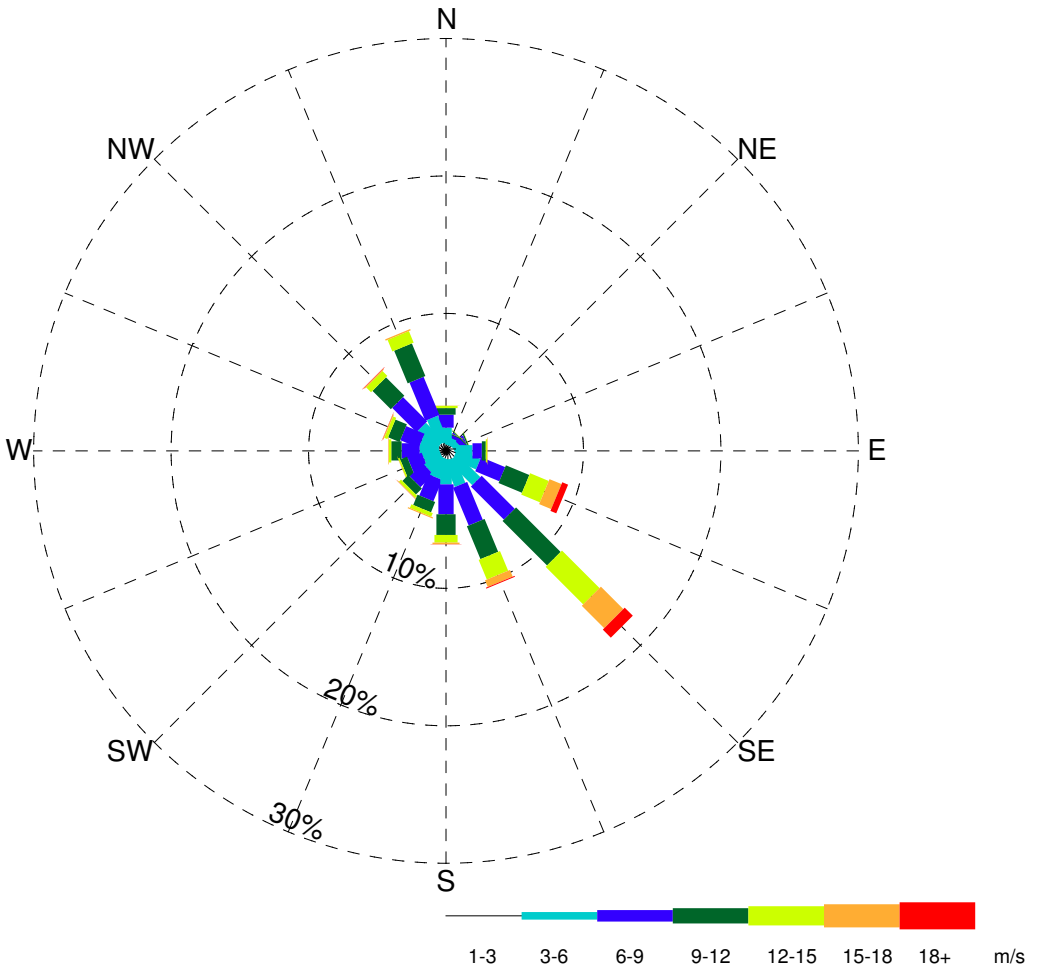
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	AL	JAS	JAS	0

OFFICE
EBA-VANC

DATE
November 14, 2012

Figure A.65



Canadian Buoy C46132
Location:South Brooks
N49° 43' 48.0" W127° 55' 12.0"
Elevation: Sea Level
Sea level: -
Length of Record
Start Date: May 5, 1994
End Date: Nov 9, 2012
Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	0.56	0.68	0.34	0.10	0.02	-	-	1.71
NE	-	0.50	0.49	0.34	0.07	0.02	-	-	1.43
NNE	-	0.43	0.57	0.21	0.06	0.03	-	-	1.32
N	-	0.59	1.10	0.94	0.48	0.17	0.01	-	3.29
NNW	-	0.61	1.99	3.01	2.57	0.91	0.10	-	9.19
NW	-	0.64	1.84	2.50	1.89	0.50	0.08	0.03	7.48
WNW	-	0.58	1.35	1.45	0.90	0.24	0.07	0.01	4.60
W	-	0.53	1.39	1.31	0.75	0.18	0.05	-	4.21
WSW	-	0.44	1.26	1.09	0.54	0.12	0.02	-	3.46
SW	-	0.49	1.36	1.33	0.61	0.21	0.05	0.01	4.06
SSW	-	0.53	1.53	1.68	0.81	0.29	0.08	-	4.93
S	-	0.61	1.82	2.18	1.50	0.56	0.12	0.02	6.80
SSE	-	0.67	2.00	2.97	2.59	1.55	0.52	0.07	10.38
SE	-	0.81	2.31	3.40	4.58	3.86	2.31	0.83	18.09
ESE	-	0.69	1.84	1.89	1.85	1.47	0.94	0.46	9.15
E	-	0.73	1.20	0.68	0.28	0.10	0.04	-	3.03
Calm	6.86	-	-	-	-	-	-	-	6.86
Total (%)	6.86	9.40	22.72	25.33	19.59	10.23	4.41	1.46	100.00

NOTES

CLIENT
Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION
Winter: October-March
South Brooks

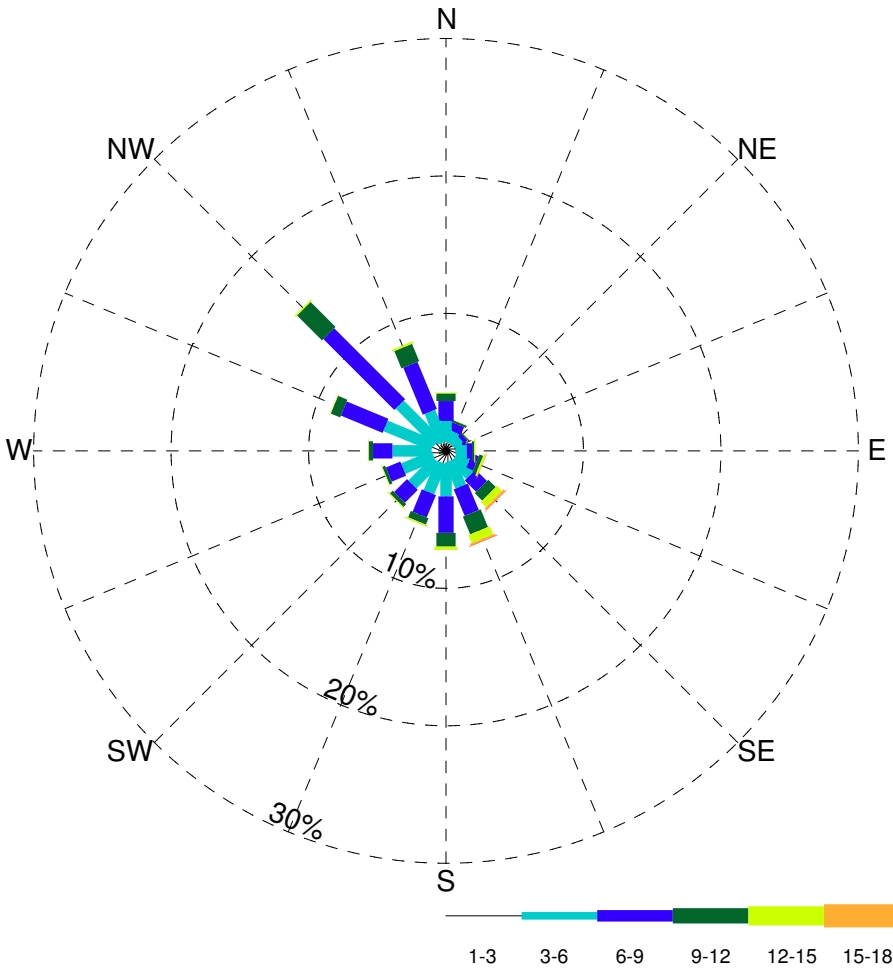
STATUS
ISSUED FOR USE

A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	AL	JAS	JAS	0

OFFICE: EBA-VANC
DATE: November 14, 2012

Figure A.66



Canadian Buoy C46207
Location:East Dellwood
N50° 51' 36.0" W129° 54' 36.0"
Elevation: Sea Level
Sea level: -
Length of Record
Start Date: Oct 18, 1989
End Date: Nov 9, 2012
Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	0.62	0.65	0.25	0.08	0.02	-	-	1.63
NE	-	0.59	0.76	0.28	0.11	0.03	-	-	1.78
NNE	-	0.59	0.92	0.59	0.17	0.03	-	-	2.30
N	-	0.63	1.54	1.45	0.55	0.07	-	-	4.25
NNW	-	0.64	2.43	3.70	1.37	0.15	-	-	8.31
NW	-	0.88	3.89	7.29	2.57	0.12	-	-	14.75
WNW	-	1.02	3.75	3.29	0.74	0.05	-	-	8.85
W	-	1.06	2.84	1.41	0.31	0.04	0.01	-	5.67
WSW	-	0.98	2.39	1.14	0.22	0.05	-	-	4.79
SW	-	1.03	2.43	1.33	0.28	0.06	0.02	-	5.16
SSW	-	0.90	2.35	1.76	0.50	0.10	0.03	-	5.64
S	-	0.92	2.39	2.65	1.00	0.23	0.02	-	7.22
SSE	-	0.76	2.04	2.09	1.40	0.62	0.16	0.03	7.10
SE	-	0.81	1.68	1.17	0.77	0.51	0.17	0.02	5.13
ESE	-	0.79	1.04	0.53	0.29	0.15	0.05	-	2.85
E	-	0.69	0.83	0.37	0.16	0.08	0.01	-	2.14
Calm	12.44	-	-	-	-	-	-	-	12.44
Total (%)	12.44	12.91	31.94	29.31	10.52	2.33	0.50	0.06	100.00

NOTES

STATUS
ISSUED FOR USE

CLIENT
Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

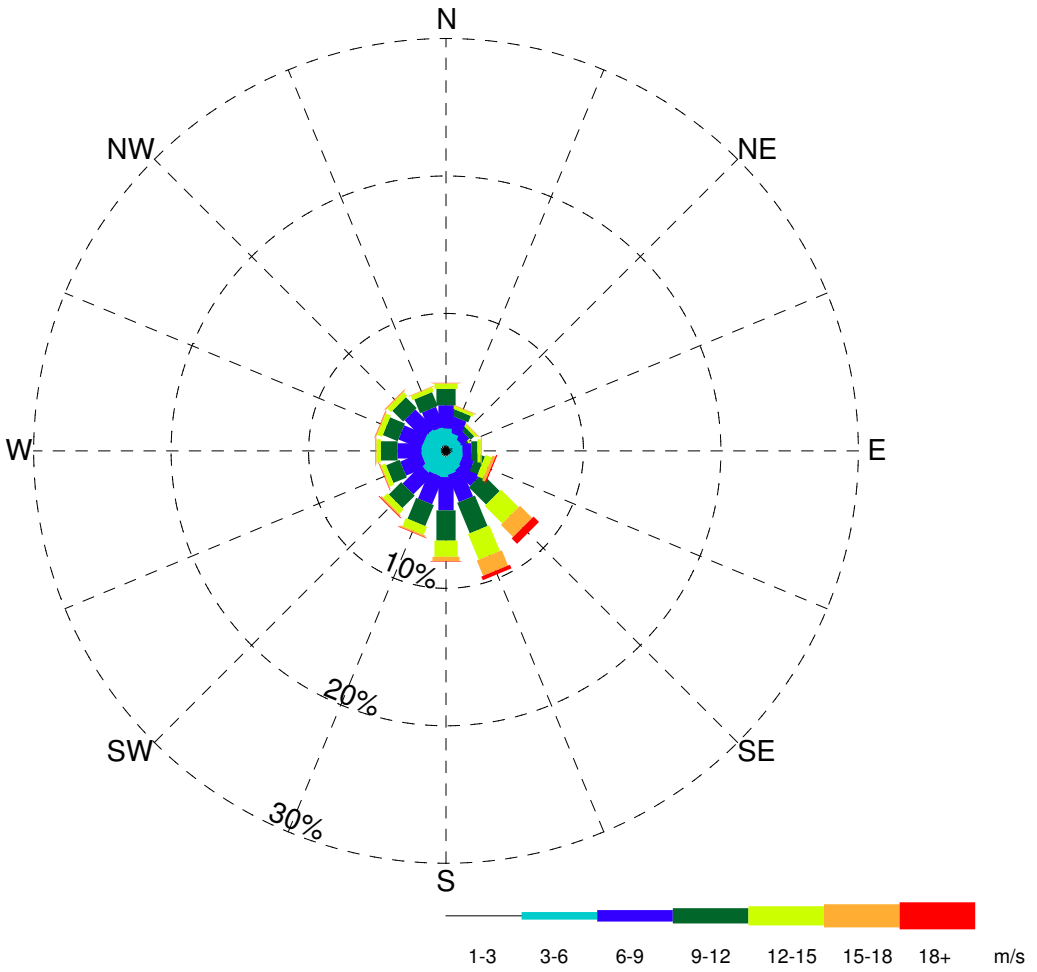
Summer: April-September
East Dellwood

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	AL	JAS	JAS	0

OFFICE: EBA-VANC
DATE: November 14, 2012

Figure A.67

A TETRA TECH COMPANY



Canadian Buoy C46207
Location:East Dellwood
N50° 51' 36.0" W129° 54' 36.0"
Elevation: Sea Level
Sea level: -
Length of Record
Start Date: Oct 18, 1989
End Date: Nov 9, 2012
Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	0.30	0.63	0.51	0.27	0.12	0.03	-	1.86
NE	-	0.37	0.78	0.69	0.37	0.19	0.06	-	2.46
NNE	-	0.39	0.97	1.17	0.51	0.21	0.07	-	3.33
N	-	0.50	1.13	1.69	1.19	0.39	0.04	0.01	4.95
NNW	-	0.42	1.28	1.55	1.09	0.33	0.06	-	4.74
NW	-	0.43	1.36	1.92	1.12	0.38	0.08	0.01	5.30
WNW	-	0.43	1.30	1.79	1.18	0.39	0.09	0.02	5.19
W	-	0.38	1.39	1.75	1.22	0.33	0.07	0.01	5.15
WSW	-	0.37	1.37	1.63	1.06	0.34	0.07	0.03	4.88
SW	-	0.42	1.60	1.89	1.28	0.44	0.12	0.06	5.82
SSW	-	0.42	1.43	2.13	1.65	0.63	0.12	0.04	6.42
S	-	0.43	1.47	2.42	2.20	1.17	0.31	0.04	8.05
SSE	-	0.44	1.23	2.13	2.40	2.02	1.20	0.29	9.72
SE	-	0.36	1.12	1.57	1.77	1.81	1.25	0.56	8.44
ESE	-	0.48	0.79	0.89	0.63	0.47	0.23	0.09	3.57
E	-	0.47	0.74	0.62	0.45	0.24	0.07	-	2.61
Calm	17.53	-	-	-	-	-	-	-	17.53
Total (%)	17.53	6.62	18.62	24.34	18.38	9.46	3.87	1.18	100.00

NOTES

CLIENT
Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION
Winter: October-March
East Dellwood

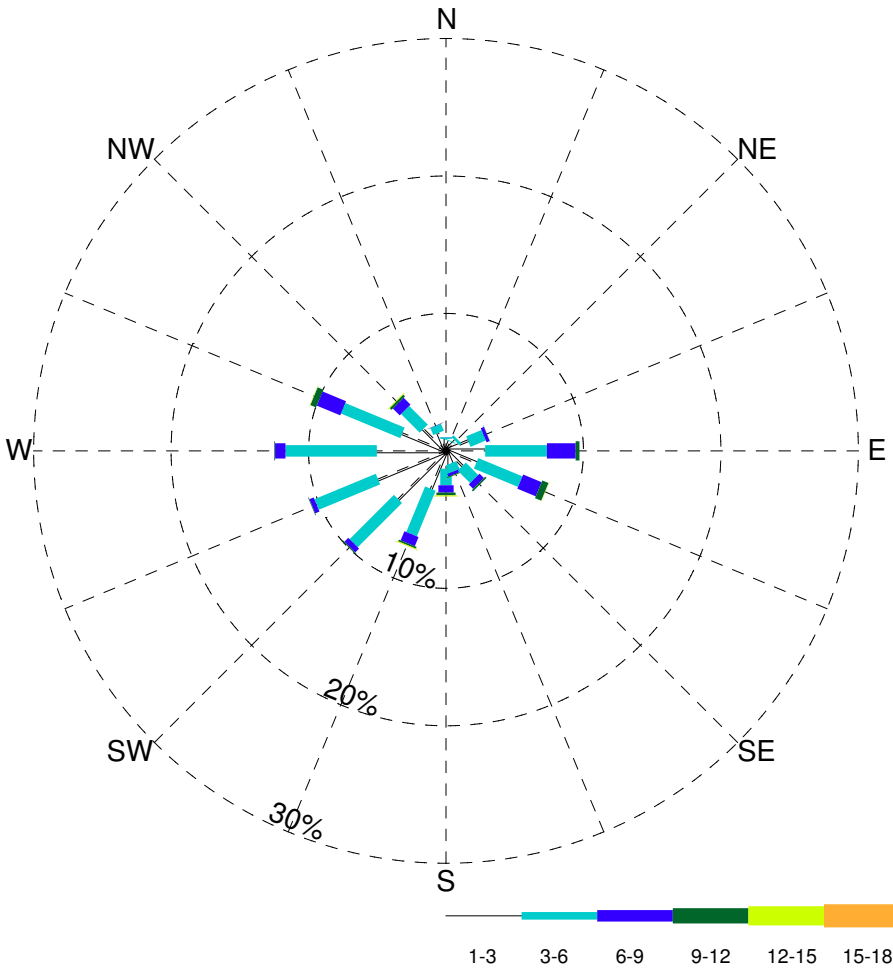
PROJECT NO.	DWN	CHK	APVD	REV
V13203022	AL	JAS	JAS	0

OFFICE: EBA-VANC
DATE: November 14, 2012

STATUS
ISSUED FOR USE

A TETRA TECH COMPANY

Figure A.68



NOAA Buoy 46087
Location:Neah Bay
N48° 29' 37.0" W124° 43' 39.0"
Elevation: Sea Level
Sea level: -
Length of Record
Start Date: July 9, 2004
End Date: Sep 30, 2012
Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	1.76	1.20	0.25	0.02	-	-	-	3.23
NE	-	0.99	0.20	-	-	-	-	-	1.19
NNE	-	0.74	0.06	-	-	-	-	-	0.81
N	-	0.87	0.12	0.01	-	-	-	-	1.00
NNW	-	1.42	0.55	0.02	0.01	-	-	-	2.01
NW	-	2.29	1.92	0.70	0.19	0.06	-	-	5.16
WNW	-	3.43	4.67	1.85	0.45	0.03	-	-	10.44
W	-	5.03	6.65	0.75	0.06	-	-	-	12.49
WSW	-	5.36	4.84	0.33	0.05	-	-	-	10.58
SW	-	4.94	4.56	0.40	0.08	-	-	-	9.98
SSW	-	2.97	3.59	0.72	0.14	0.06	0.01	-	7.49
S	-	1.30	1.20	0.53	0.20	0.08	0.01	-	3.32
SSE	-	0.97	0.62	0.21	0.08	0.01	-	-	1.89
SE	-	1.62	1.28	0.45	0.13	-	-	-	3.47
ESE	-	2.37	3.48	1.45	0.49	0.03	-	-	7.82
E	-	2.85	4.50	2.09	0.28	-	-	-	9.71
Calm	9.43	-	-	-	-	-	-	-	9.43
Total (%)	9.43	38.90	39.43	9.76	2.16	0.30	0.02	-	100.00

NOTES

CLIENT
Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Summer: April-September
Neah Bay, Juan de Fuca Strait

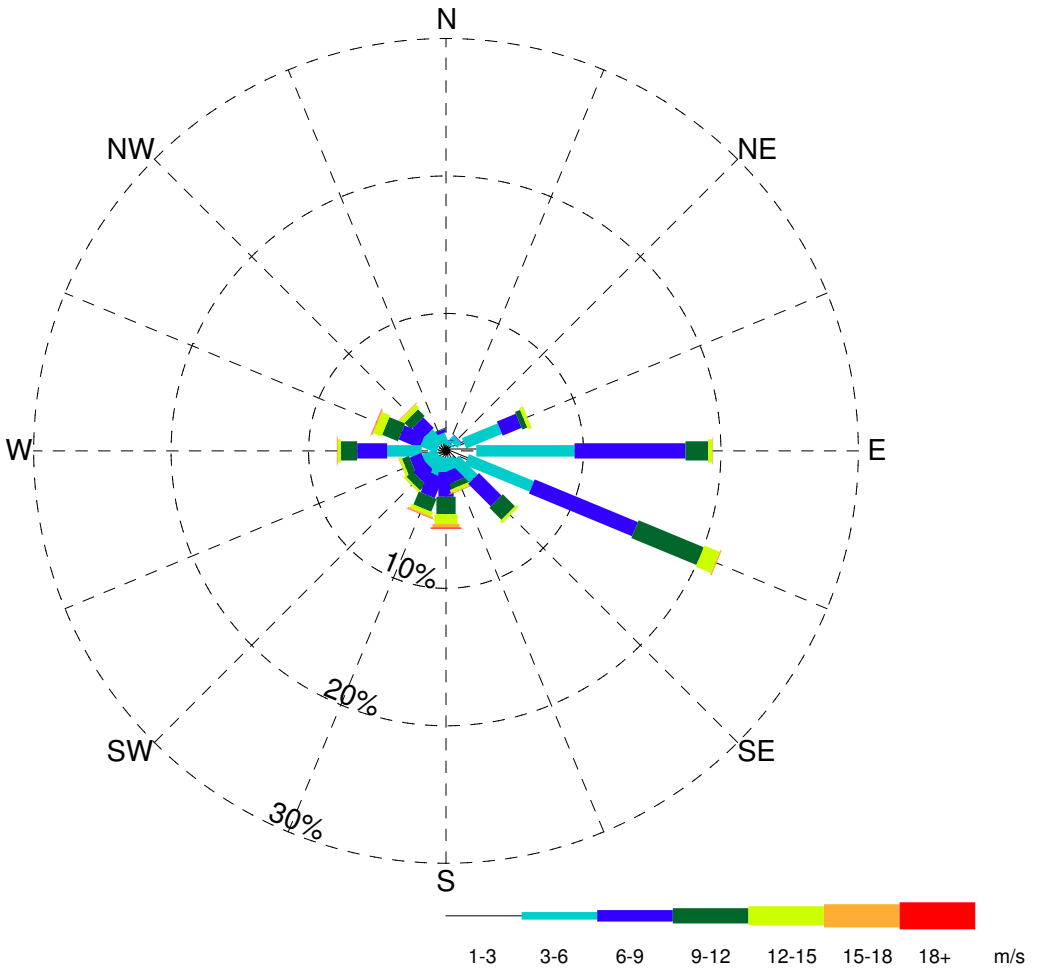
STATUS
ISSUED FOR USE

A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	AL	JAS	JAS	0

OFFICE: EBA-VANC
DATE: November 14, 2012

Figure A.69



NOAA Buoy 46087
Location:Neah Bay
N48° 29' 37.0" W124° 43' 39.0"
Elevation: Sea Level
Sea level: -
Length of Record
Start Date: July 9, 2004
End Date: Sep 30, 2012
Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	1.43	2.81	1.49	0.40	0.27	0.02	-	6.40
NE	-	0.73	0.48	0.05	-	-	-	-	1.25
NNE	-	0.42	0.16	0.01	-	-	-	-	0.60
N	-	0.54	0.22	0.04	-	-	-	-	0.81
NNW	-	0.58	0.69	0.25	0.07	-	-	-	1.60
NW	-	0.68	1.14	1.08	0.69	0.36	0.07	-	4.03
WNW	-	0.61	1.26	1.64	1.24	0.62	0.12	0.02	5.51
W	-	1.77	2.51	2.19	1.19	0.23	0.04	0.02	7.94
WSW	-	0.61	1.11	0.92	0.55	0.19	0.05	-	3.41
SW	-	0.63	1.00	1.15	0.59	0.16	0.03	-	3.56
SSW	-	0.49	1.40	1.60	1.02	0.30	0.13	0.02	4.96
S	-	0.48	1.05	1.80	1.27	0.72	0.25	0.08	5.66
SSE	-	0.54	0.86	0.90	0.43	0.25	0.06	0.01	3.06
SE	-	0.90	1.94	2.32	1.24	0.21	0.01	-	6.62
ESE	-	1.64	5.12	8.12	5.12	1.21	0.10	-	21.31
E	-	2.20	7.15	8.07	1.65	0.31	0.05	-	19.43
Calm	3.84	-	-	-	-	-	-	-	3.84
Total (%)	3.84	14.24	28.88	31.65	15.44	4.84	0.94	0.16	100.00

NOTES

STATUS
ISSUED FOR USE

CLIENT
Kinder Morgan

A TETRA TECH COMPANY

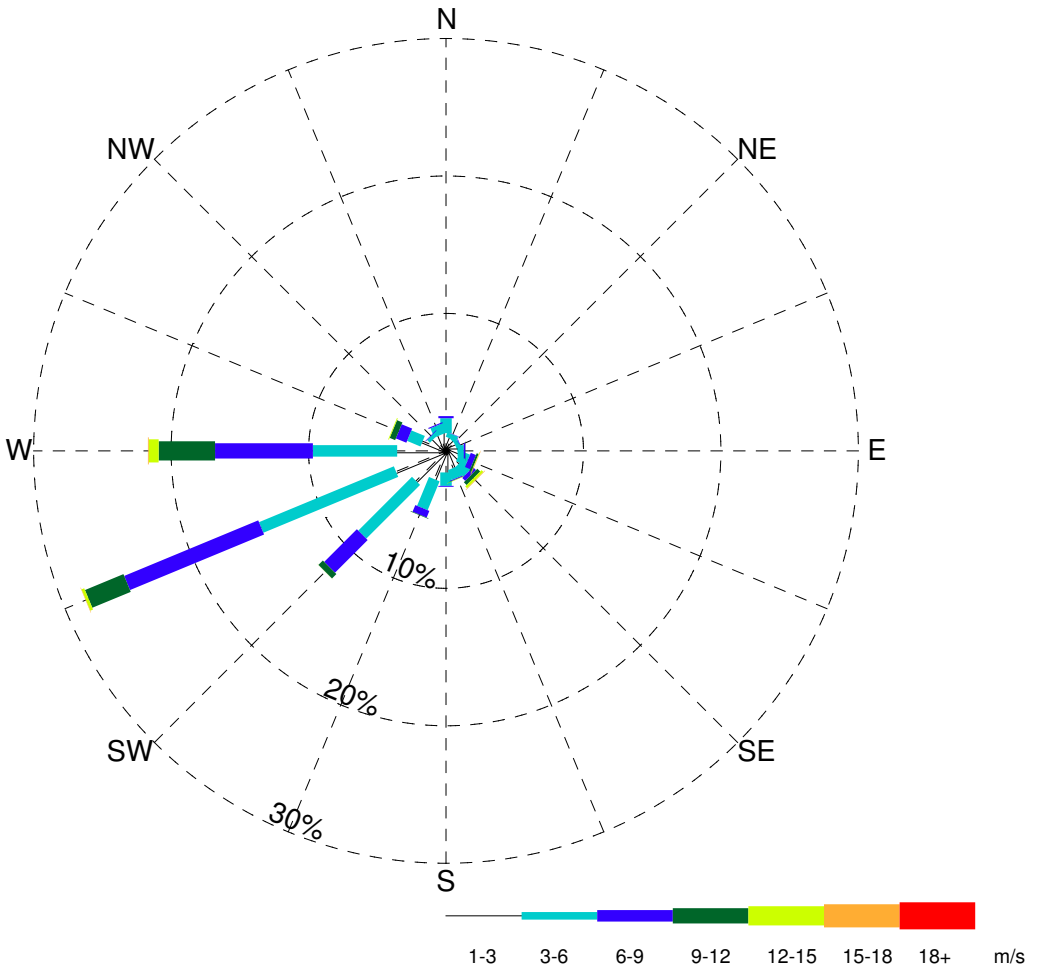
METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Winter: October-March
Neah Bay, Juan de Fuca Strait

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	AL	JAS	JAS	0

OFFICE: EBA-VANC
DATE: November 14, 2012

Figure A.70



NOAA Buoy 46088
Location:Juan de Fuca Strait
N48° 20' 8.0" W123° 9' 31.0"
Elevation: Sea Level
Sea level: -
Length of Record
Start Date: July 1, 2004
End Date: Sep 30, 2012
Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	0.78	0.31	0.04	-	-	-	-	1.13
NE	-	0.83	0.22	0.02	-	-	-	-	1.06
NNE	-	0.95	0.35	0.03	-	-	-	-	1.32
N	-	1.29	1.09	0.15	-	-	-	-	2.54
NNW	-	1.22	0.74	0.08	-	-	-	-	2.04
NW	-	1.25	0.28	0.04	-	-	-	-	1.58
WNW	-	1.84	1.06	0.82	0.43	0.06	-	-	4.22
W	-	3.55	6.13	7.12	4.11	0.72	0.05	-	21.68
WSW	-	3.93	10.62	10.56	3.03	0.21	0.03	-	28.39
SW	-	3.09	5.53	3.36	0.45	0.01	-	-	12.44
SSW	-	2.22	2.27	0.52	0.04	-	-	-	5.06
S	-	1.57	0.98	0.07	-	-	-	-	2.62
SSE	-	1.35	0.77	0.06	0.03	0.03	-	-	2.23
SE	-	1.32	0.91	0.30	0.29	0.19	0.04	-	3.05
ESE	-	0.97	0.75	0.41	0.15	0.05	0.02	-	2.35
E	-	0.84	0.45	0.12	0.02	-	-	-	1.43
Calm	6.87	-	-	-	-	-	-	-	6.87
Total (%)	6.87	26.98	32.46	23.69	8.56	1.27	0.15	0.01	100.00

NOTES

CLIENT
Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Summer: April-September
New Dungeness, Juan de Fuca Strait

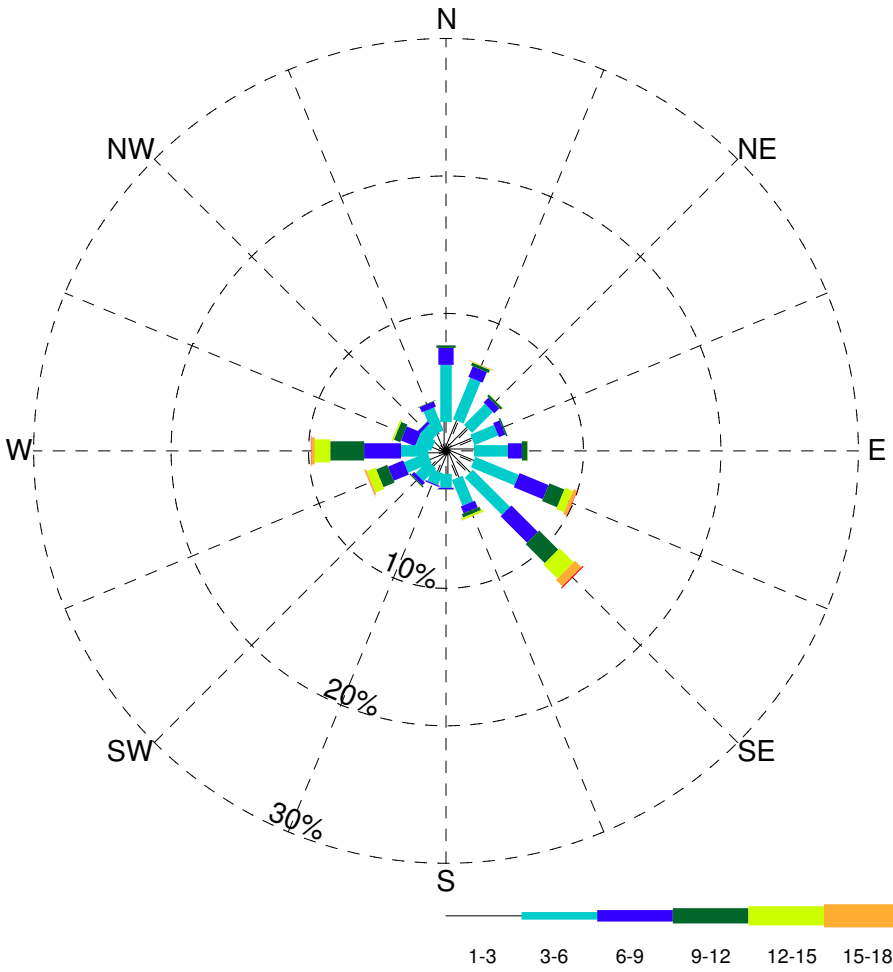
STATUS
ISSUED FOR USE

A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	AL	JAS	JAS	0

OFFICE: EBA-VANC
DATE: November 14, 2012

Figure A.71



NOAA Buoy 46088
Location:Juan de Fuca Strait
N48° 20' 8.0" W123° 9' 31.0"
Elevation: Sea Level
Sea level: -
Length of Record
Start Date: July 1, 2004
End Date: Sep 30, 2012
Comment: -

Wind Speed & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-1 m/s	1-3 m/s	3-6 m/s	6-9 m/s	9-12 m/s	12-15 m/s	15-18 m/s	18+ m/s	Total (%)
ENE	-	2.08	1.86	0.50	0.11	-	-	-	4.56
NE	-	2.27	2.15	0.52	0.17	0.04	-	-	5.15
NNE	-	2.33	3.27	0.83	0.24	0.04	0.04	-	6.76
N	-	2.10	4.16	1.24	0.18	-	-	-	7.68
NNW	-	1.43	1.83	0.41	0.04	0.01	-	-	3.72
NW	-	1.30	0.94	0.22	0.02	-	-	-	2.48
WNW	-	1.01	1.21	1.10	0.50	0.12	-	-	3.94
W	-	1.28	1.99	2.68	2.47	1.13	0.25	0.03	9.83
WSW	-	1.31	1.84	1.19	0.87	0.67	0.13	0.01	6.02
SW	-	1.42	1.30	0.28	0.10	0.02	-	-	3.11
SSW	-	1.60	0.93	0.10	-	-	-	-	2.64
S	-	1.67	1.01	0.11	0.02	-	-	-	2.81
SSE	-	2.13	2.03	0.54	0.27	0.16	0.02	-	5.14
SE	-	2.35	3.82	2.72	1.96	1.44	0.65	0.09	13.04
ESE	-	2.14	3.43	2.29	1.18	0.61	0.27	0.04	9.95
E	-	2.04	2.47	1.02	0.41	0.03	-	-	5.97
Calm	7.21	-	-	-	-	-	-	-	7.21
Total (%)	7.21	28.46	34.22	15.73	8.55	4.28	1.38	0.17	100.00

NOTES

CLIENT
Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION
Winter: October-March
New Dungeness, Juan de Fuca Strait

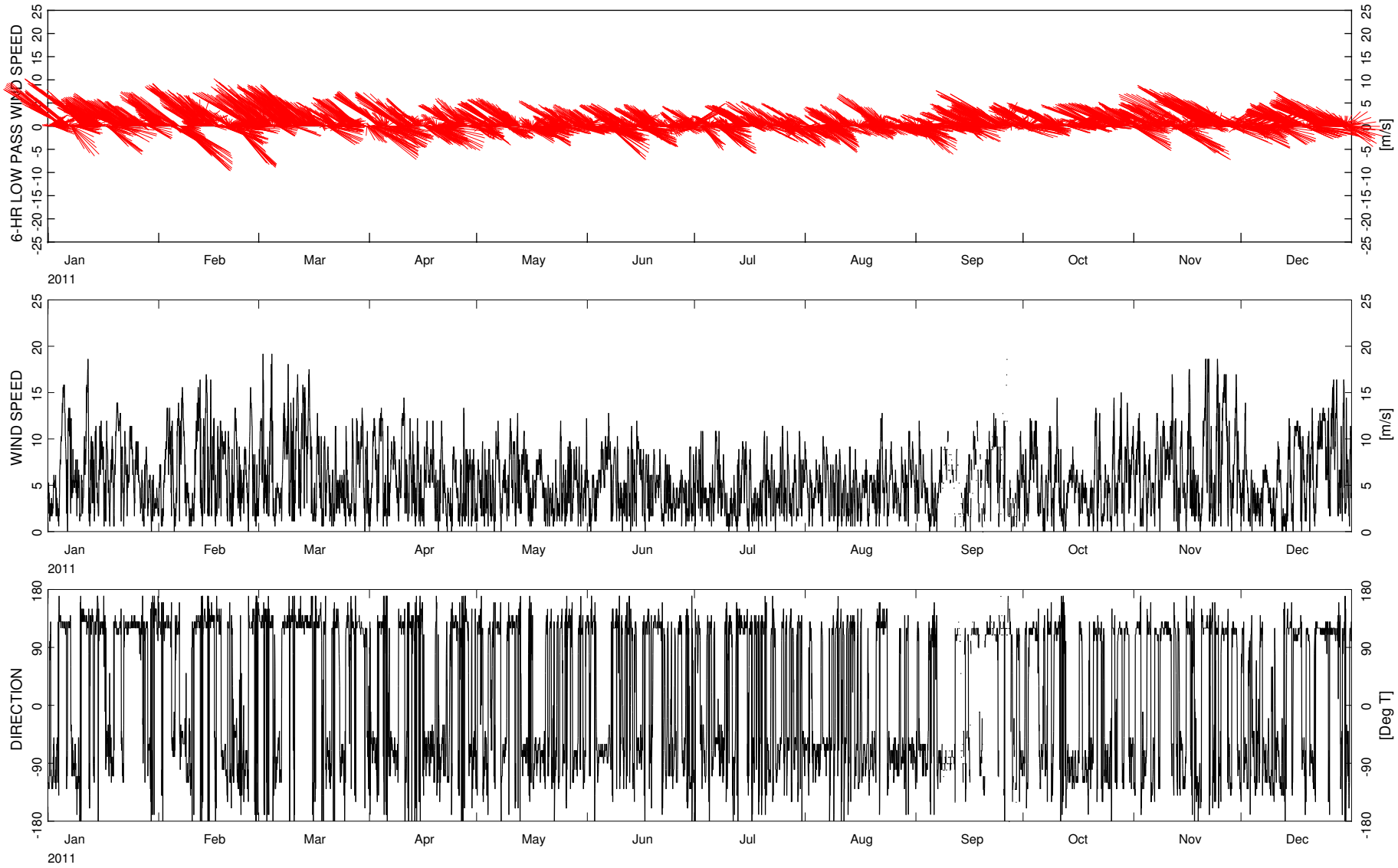
STATUS
ISSUED FOR USE

eba
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	AL	JAS	JAS	0

OFFICE: EBA-VANC
DATE: November 14, 2012

Figure A.72



NOTES

- 6-hour low pass hourly wind sticks are shown in the top panel
- Hourly wind speed and direction are shown in the middle and bottom panels

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Wind speed and direction at Ballenas Islands: 2011

STATUS
ISSUED FOR USE

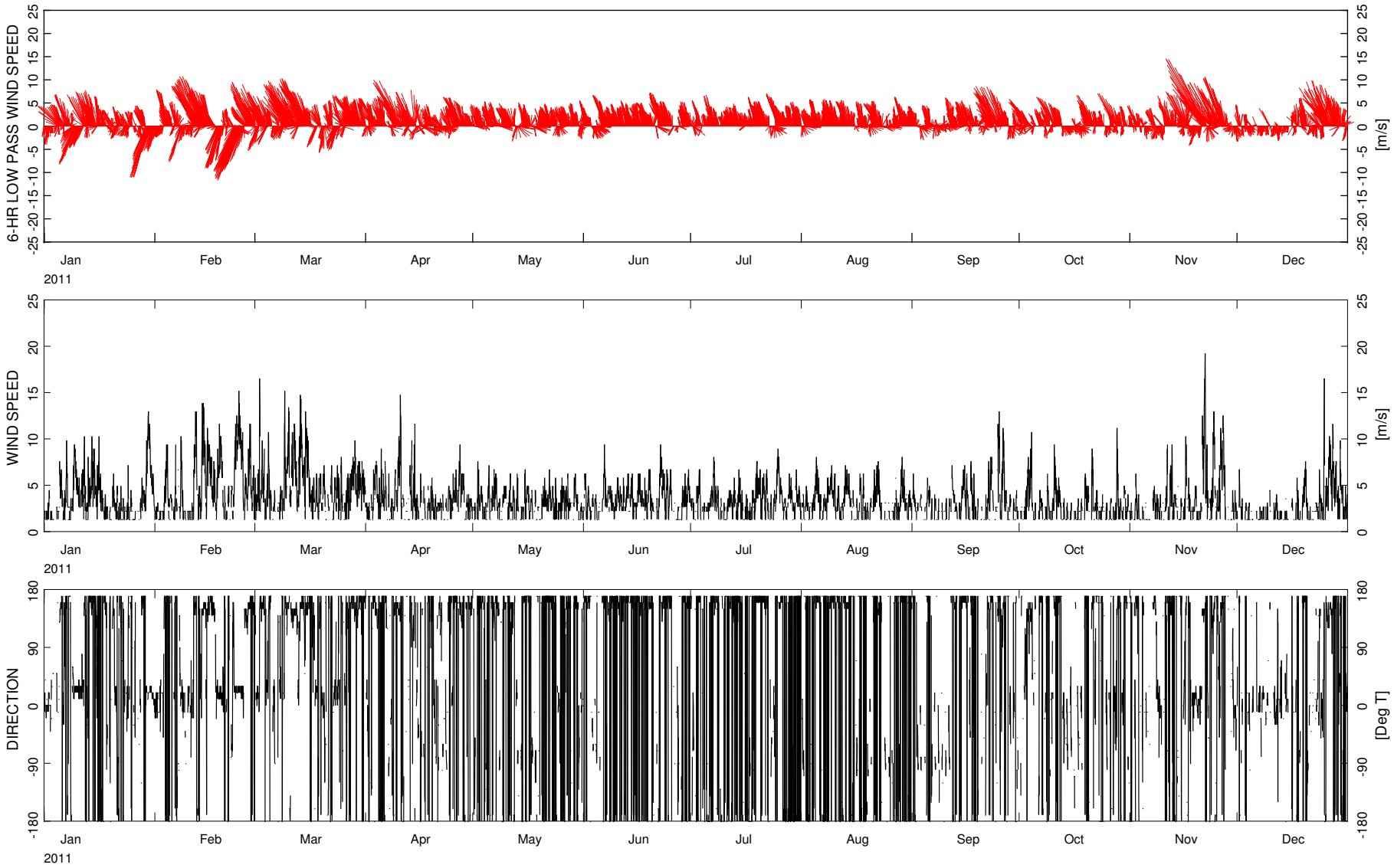
eba
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 11, 2012

Figure A.73

Tue Dec 11 12:27:20 2012:V:\V13203022 Trans Mountain\working\DD\01_EC\01_MetData_Scripts\Ballenas_Islands



NOTES

- 6-hour low pass hourly wind sticks are shown in the top panel
- Hourly wind speed and direction are shown in the middle and bottom panels

STATUS
ISSUED FOR USE

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

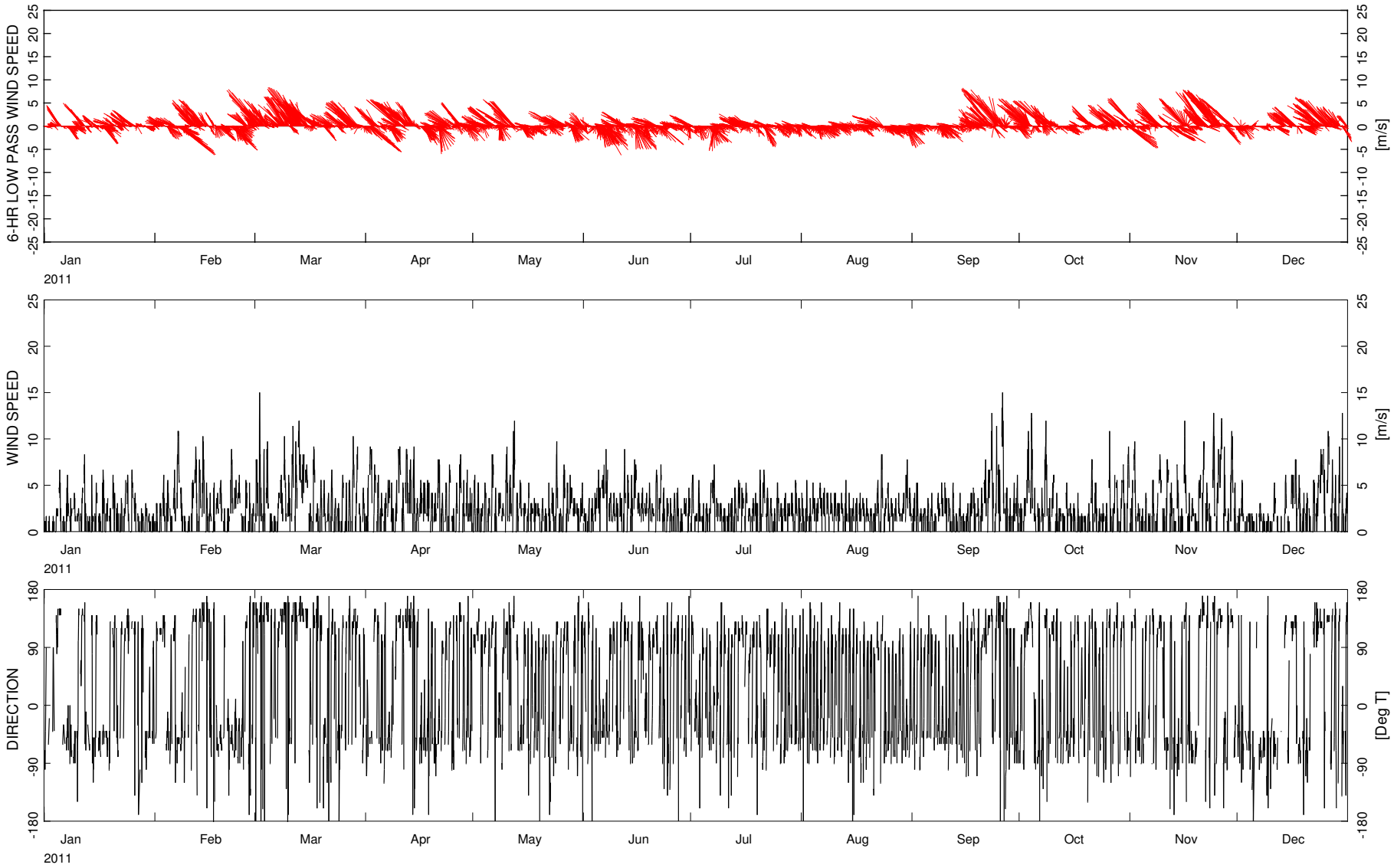
Wind speed and direction at Bellingham Intl: 2011

A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 11, 2012

Figure A.74



NOTES

- 6-hour low pass hourly wind sticks are shown in the top panel
- Hourly wind speed and direction are shown in the middle and bottom panels

STATUS
ISSUED FOR USE

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

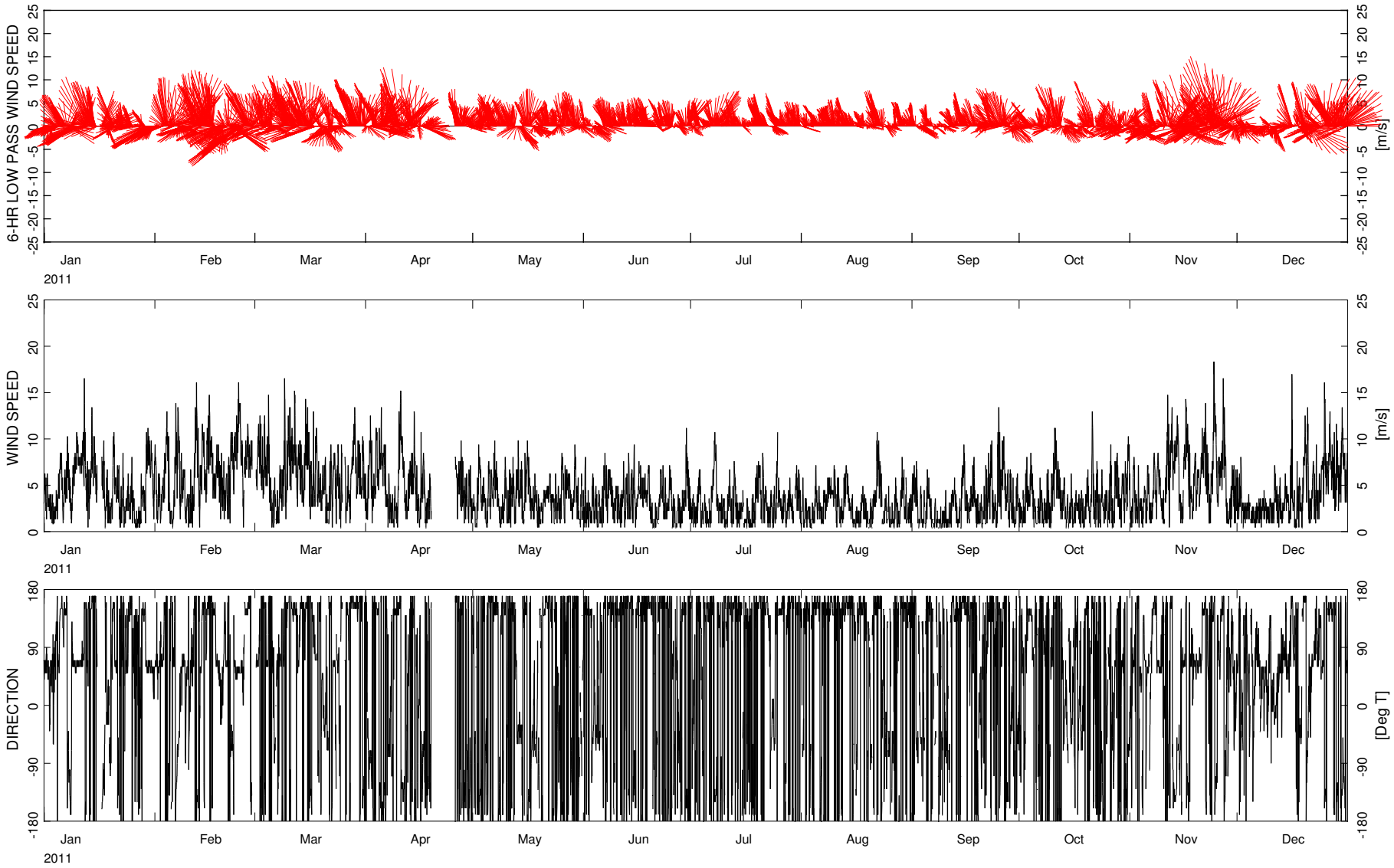
Wind speed and direction at Campbell River Airport: 2011

eba
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 11, 2012

Figure A.75



NOTES

- 6-hour low pass hourly wind sticks are shown in the top panel
- Hourly wind speed and direction are shown in the middle and bottom panels

STATUS
ISSUED FOR USE

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Wind speed and direction at Cherry Point: 2011

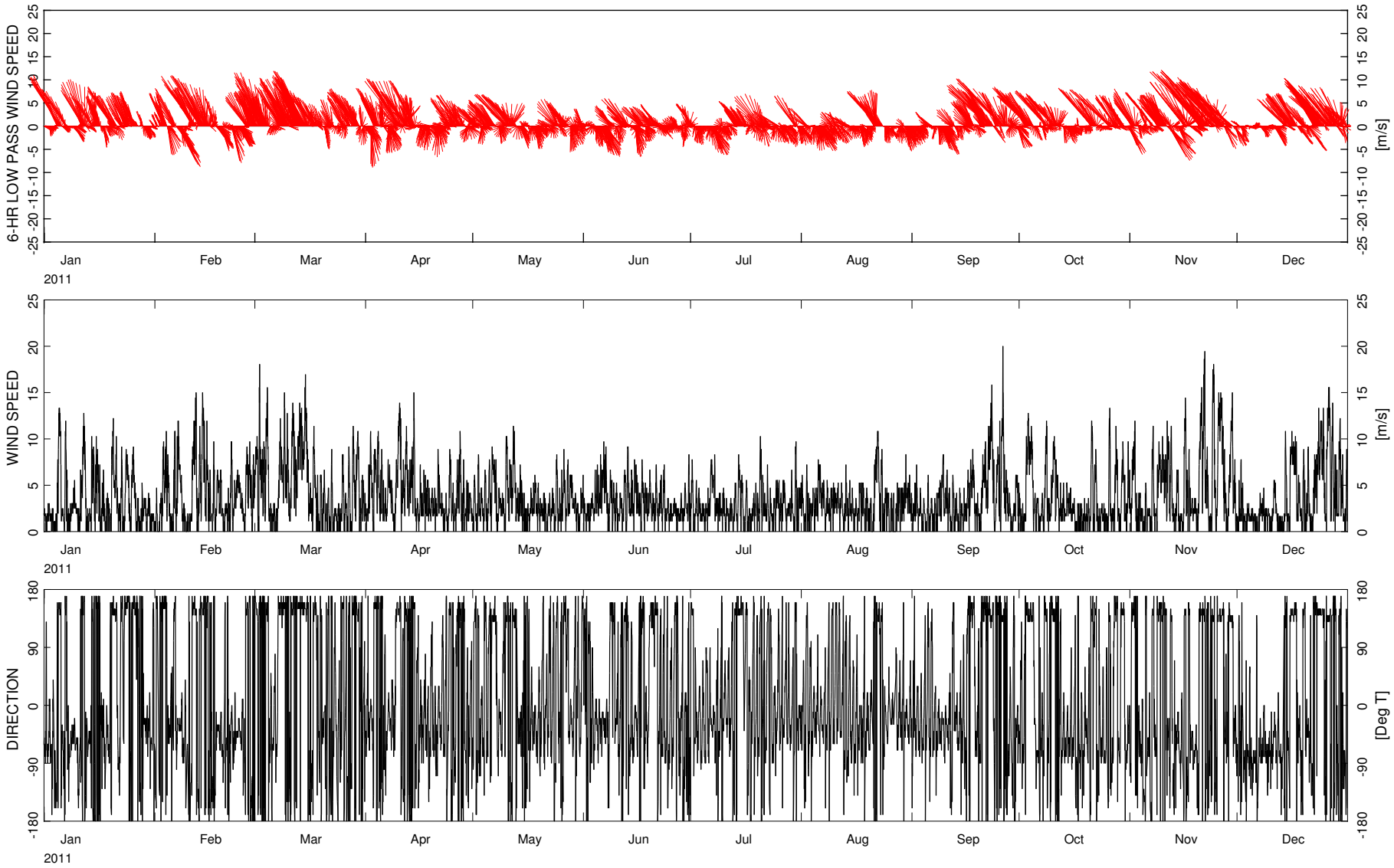
PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 11, 2012

Figure A.76

A TETRA TECH COMPANY

Tue Dec 11 12:30:15 2012:V:\V13203022 Trans Mountain\working\DD\02_NOAA_NCDC\01_MetData_Scripts\Cherry_Point



NOTES

- 6-hour low pass hourly wind sticks are shown in the top panel
- Hourly wind speed and direction are shown in the middle and bottom panels

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Wind speed and direction at Comox Airport: 2011

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

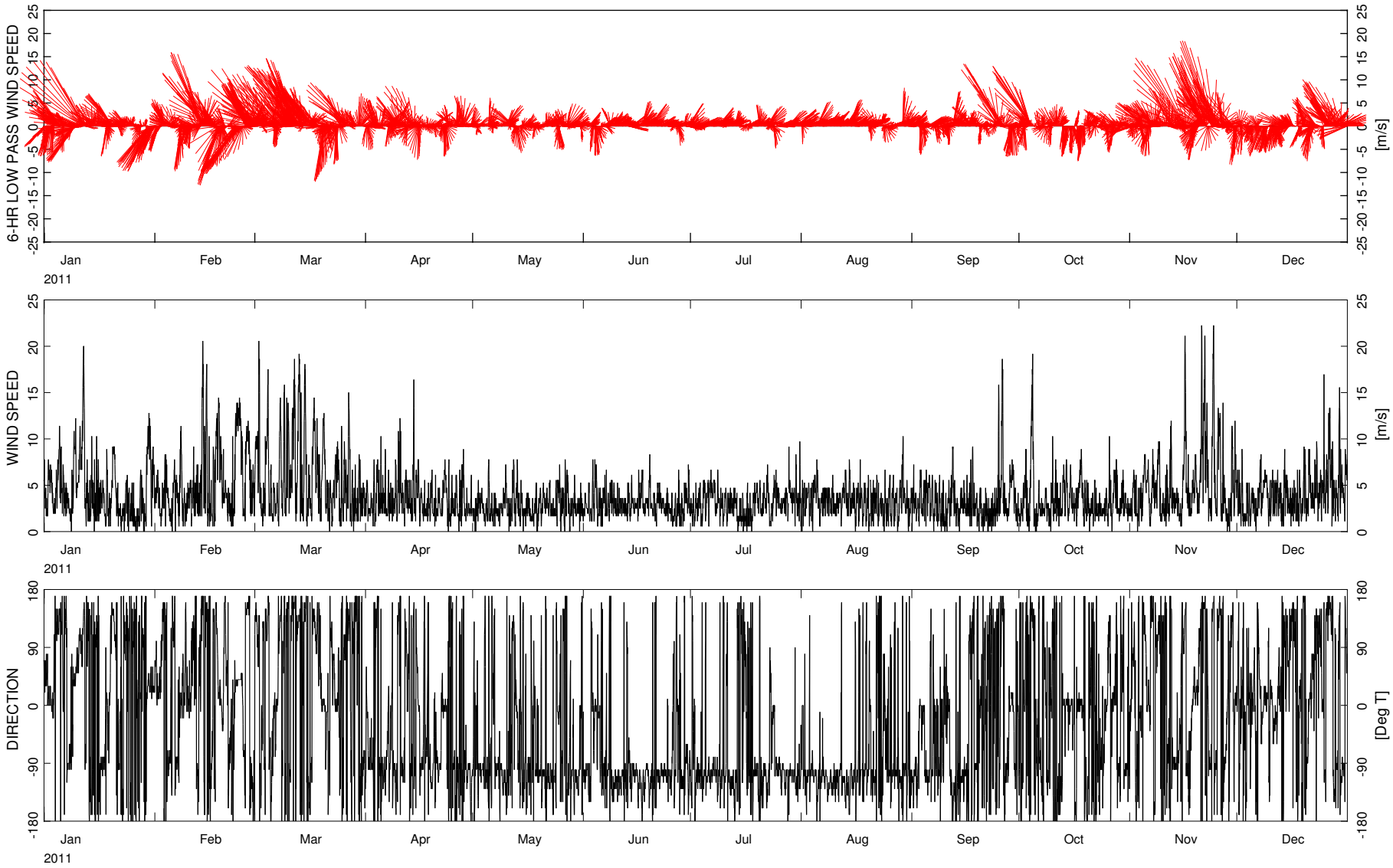
OFFICE: EBA-VANC

DATE: December 11, 2012

STATUS: ISSUED FOR USE

A TETRA TECH COMPANY

Figure A.77



NOTES

- 6-hour low pass hourly wind sticks are shown in the top panel
- Hourly wind speed and direction are shown in the middle and bottom panels

STATUS
ISSUED FOR USE

CLIENT

Kinder Morgan

A TETRA TECH COMPANY

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

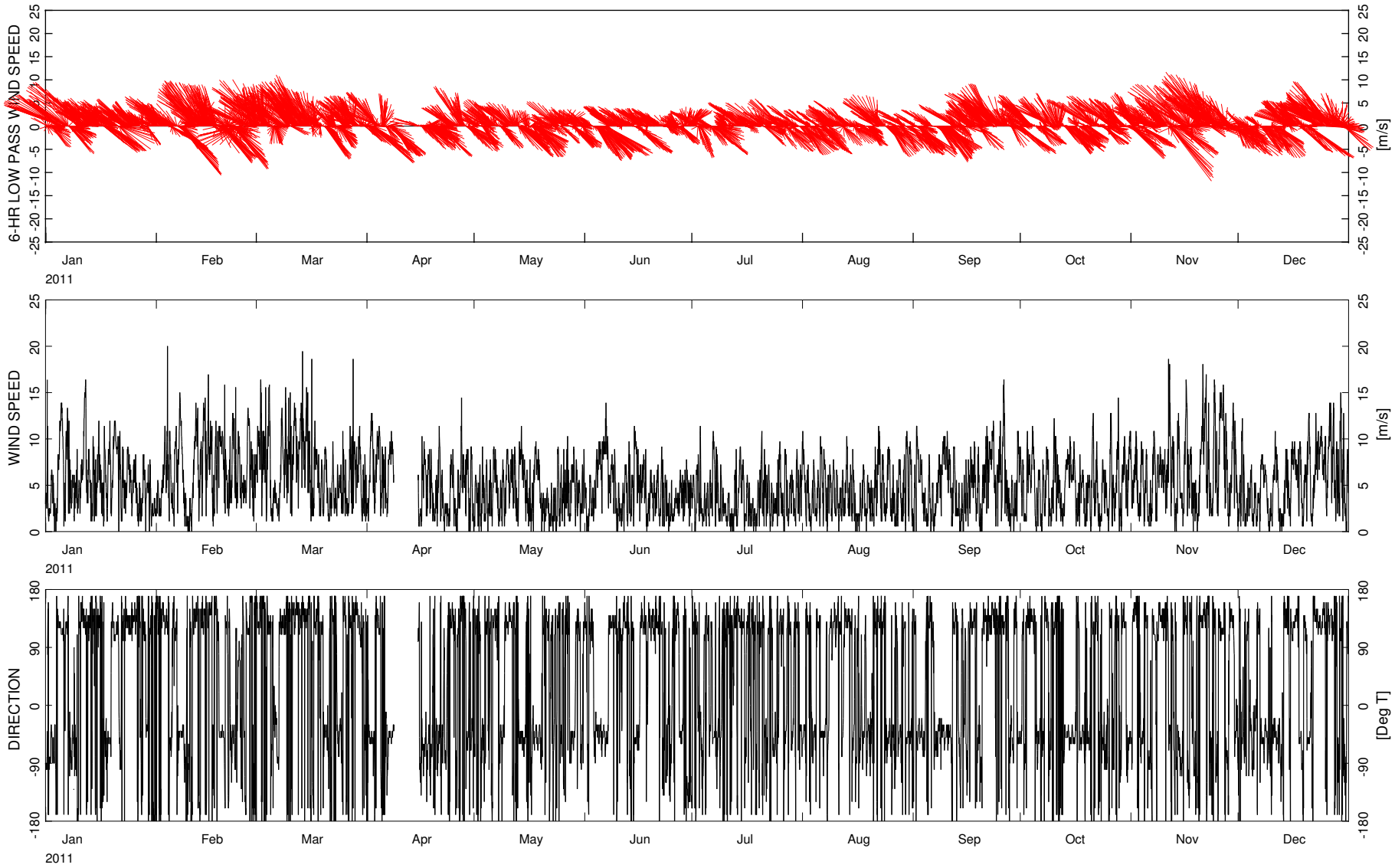
Wind speed and direction at Discovery Island: 2011

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 11, 2012

Figure A.78

Tue Dec 11 12:30:42 2012:V:\V13203022 Trans Mountain\working\DD\01_EC\01_MetData_Scripts\Discovery_Island



NOTES

- 6-hour low pass hourly wind sticks are shown in the top panel
- Hourly wind speed and direction are shown in the middle and bottom panels

STATUS
ISSUED FOR USE

CLIENT

Kinder Morgan

A TETRA TECH COMPANY

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

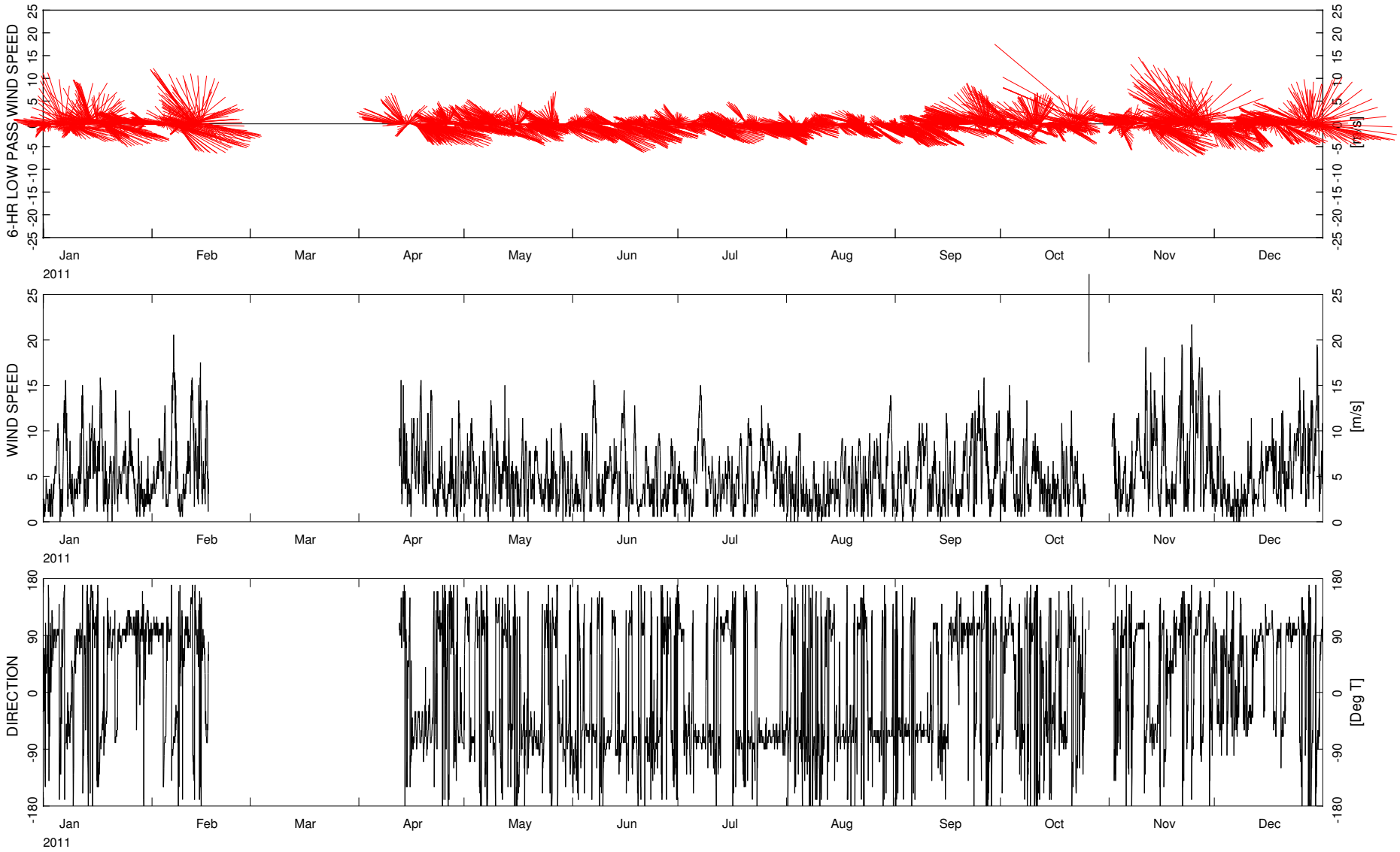
Wind speed and direction at Entrance Island: 2011

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 11, 2012

Figure A.79

Tue Dec 11 12:31:34 2012:V:\V13203022 Trans Mountain\working\DD\01_EC\01_MetData_Scripts\Entrance_Island



NOTES

- 6-hour low pass hourly wind sticks are shown in the top panel
- Hourly wind speed and direction are shown in the middle and bottom panels

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Wind speed and direction at Estevan Point: 2011

STATUS
ISSUED FOR USE

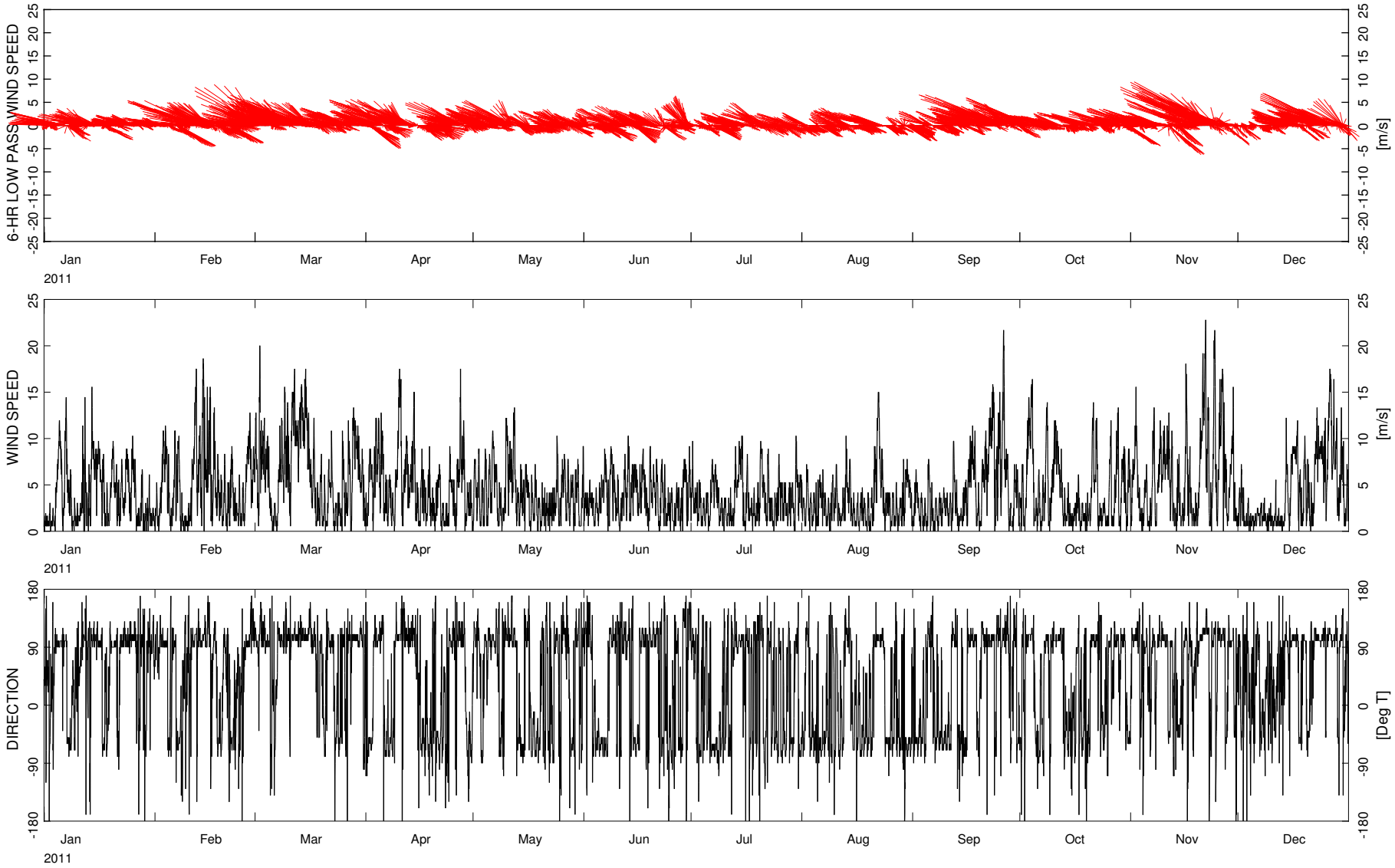
eba
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 11, 2012

Figure A.80

Tue Dec 11 12:33:49 2012:V:\V13203022 Trans Mountain\working\DD\01_EC\01_MetData_Scripts\Estevan_Point



NOTES

- 6-hour low pass hourly wind sticks are shown in the top panel
- Hourly wind speed and direction are shown in the middle and bottom panels

STATUS
ISSUED FOR USE

CLIENT

Kinder Morgan

A TETRA TECH COMPANY

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

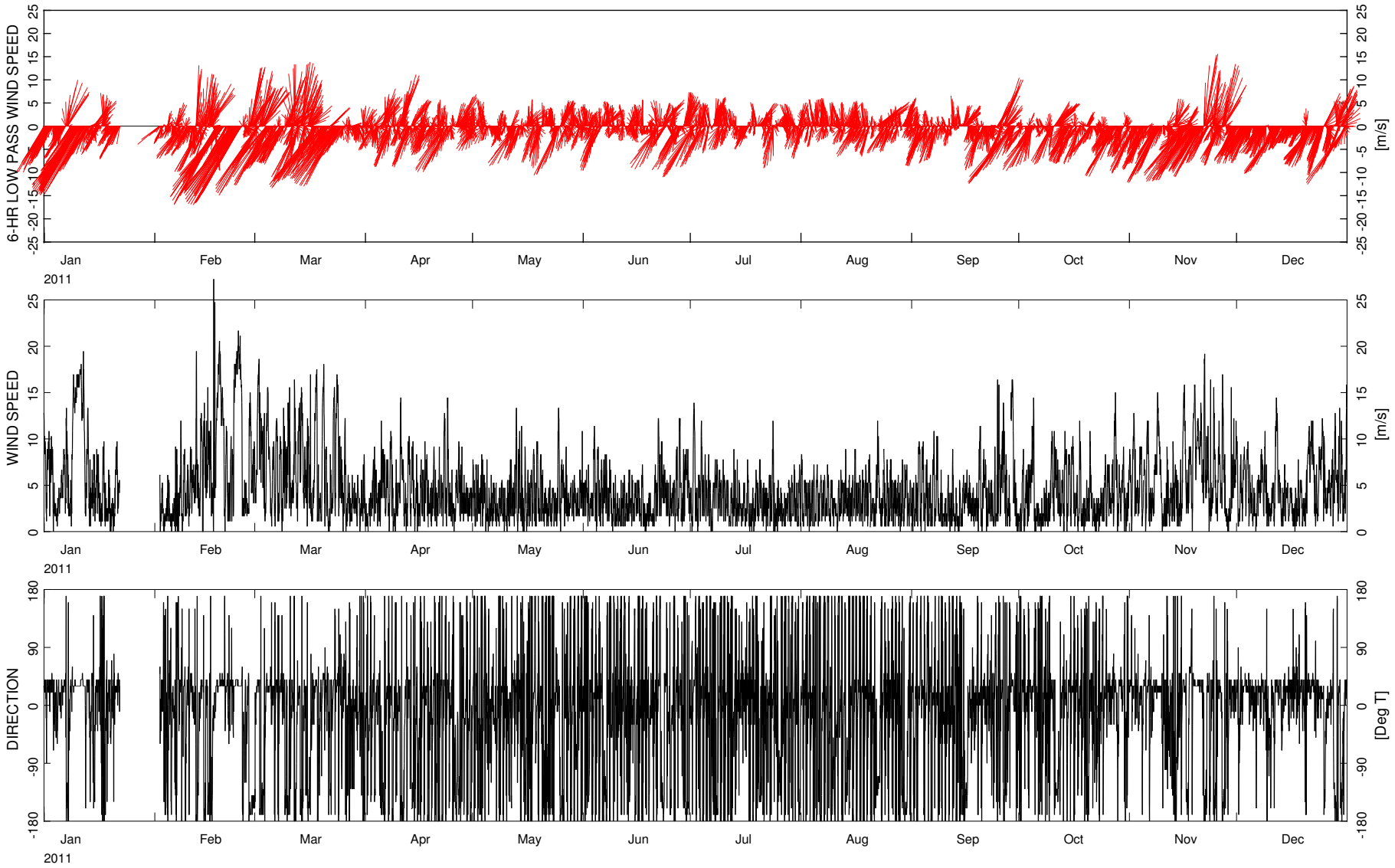
Wind speed and direction at Grief Point: 2011

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 11, 2012

Figure A.81

Tue Dec 11 12:35:00 2012:V:\V13203022 Trans Mountain\working\DD\01_EC\01_MetData_Scripts\Grief_Point



NOTES

- 6-hour low pass hourly wind sticks are shown in the top panel
- Hourly wind speed and direction are shown in the middle and bottom panels

STATUS
ISSUED FOR USE

CLIENT

Kinder Morgan

A TETRA TECH COMPANY

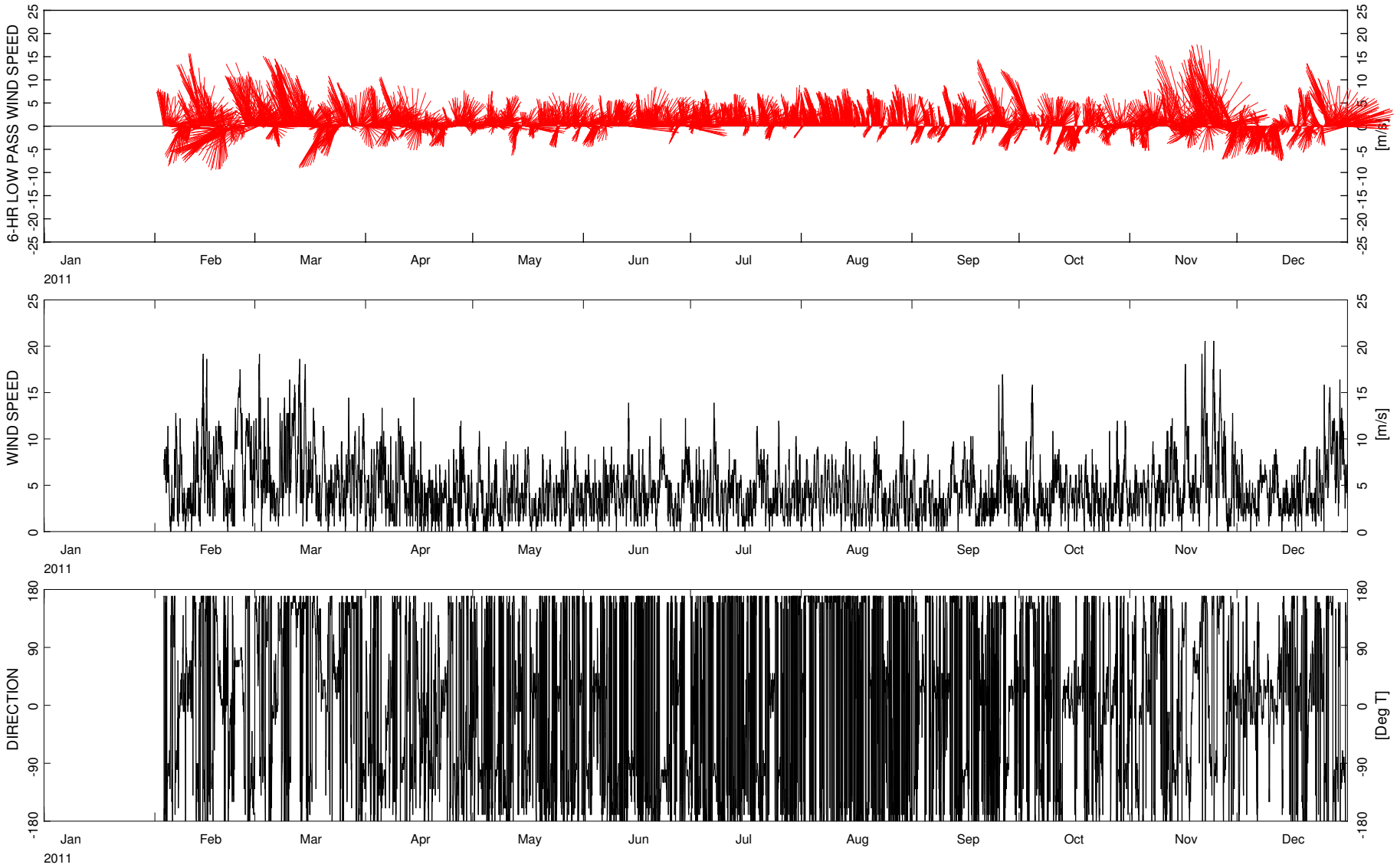
METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Wind speed and direction at Howe Sound-Pam Rocks: 2011

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 11, 2012

Figure A.82



NOTES

- 6-hour low pass hourly wind sticks are shown in the top panel
- Hourly wind speed and direction are shown in the middle and bottom panels

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Wind speed and direction at Kelp Reefs: 2011

STATUS
ISSUED FOR USE

eba
A TETRA TECH COMPANY

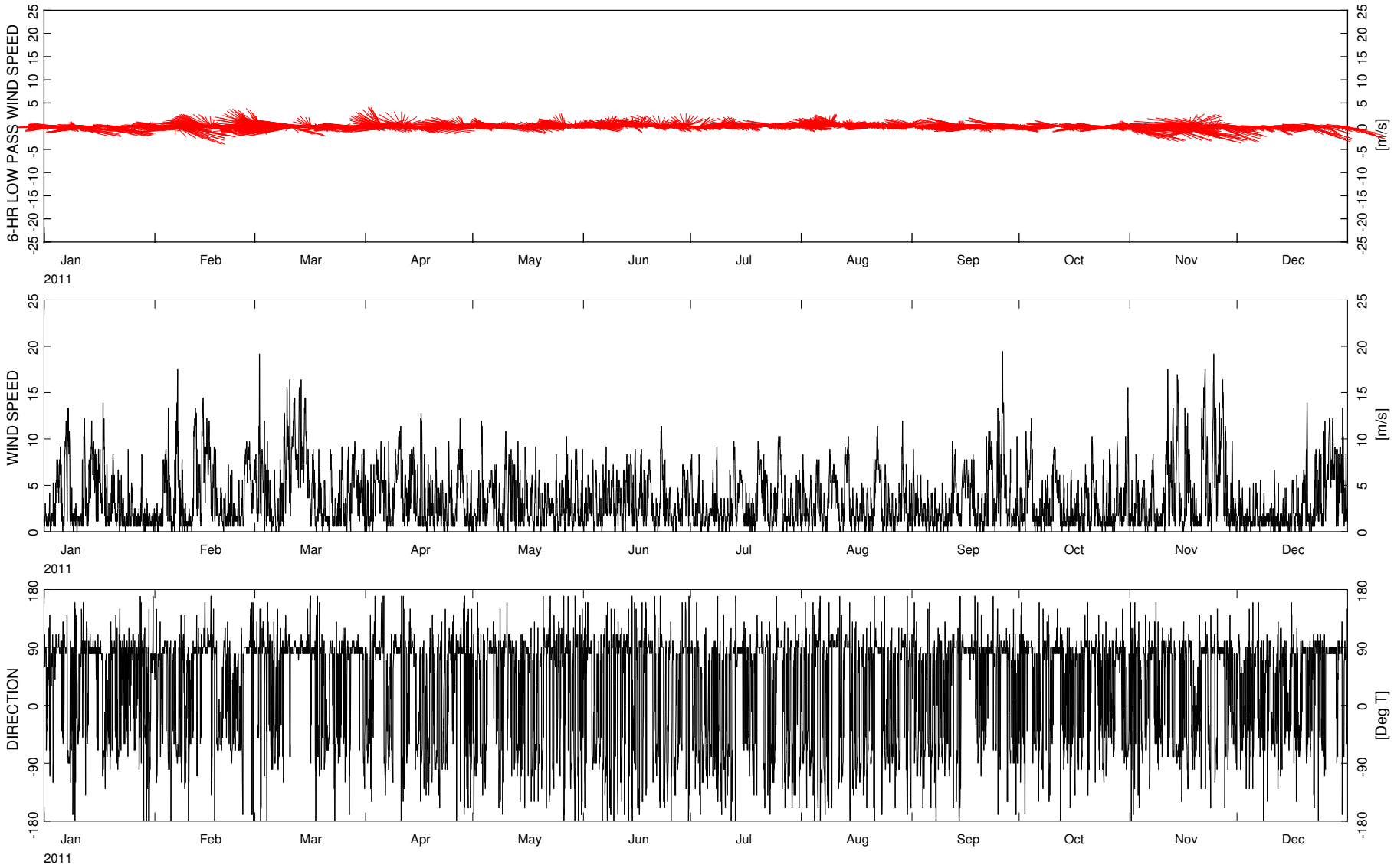
PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 11, 2012

Figure A.83

Tue Dec 11 12:36:46 2012:V:\V13203022 Trans Mountain\working\DD\01_EC\01_MetData_Scripts\Kelp_Reefs



NOTES

- 6-hour low pass hourly wind sticks are shown in the top panel
- Hourly wind speed and direction are shown in the middle and bottom panels

STATUS
ISSUED FOR USE

CLIENT

Kinder Morgan

A TETRA TECH COMPANY

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

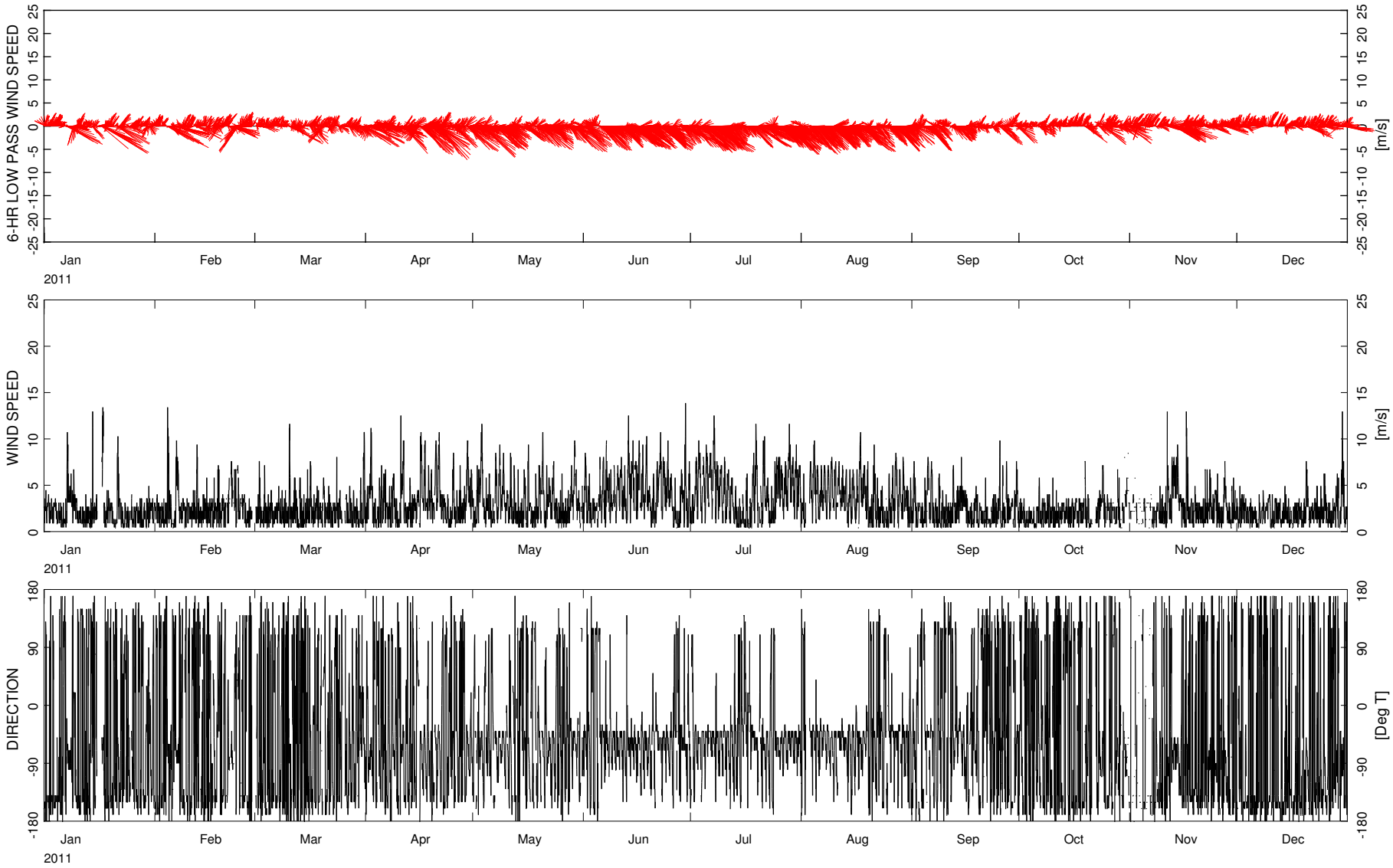
Wind speed and direction at Point Atkinson: 2011

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 11, 2012

Figure A.84

Tue Dec 11 12:37:32 2012:V:\V13203022 Trans Mountain\working\DD\01_EC\01_MetData_Scripts\Point_Atkinson



NOTES

- 6-hour low pass hourly wind sticks are shown in the top panel
- Hourly wind speed and direction are shown in the middle and bottom panels

STATUS
ISSUED FOR USE

CLIENT

Kinder Morgan

A TETRA TECH COMPANY

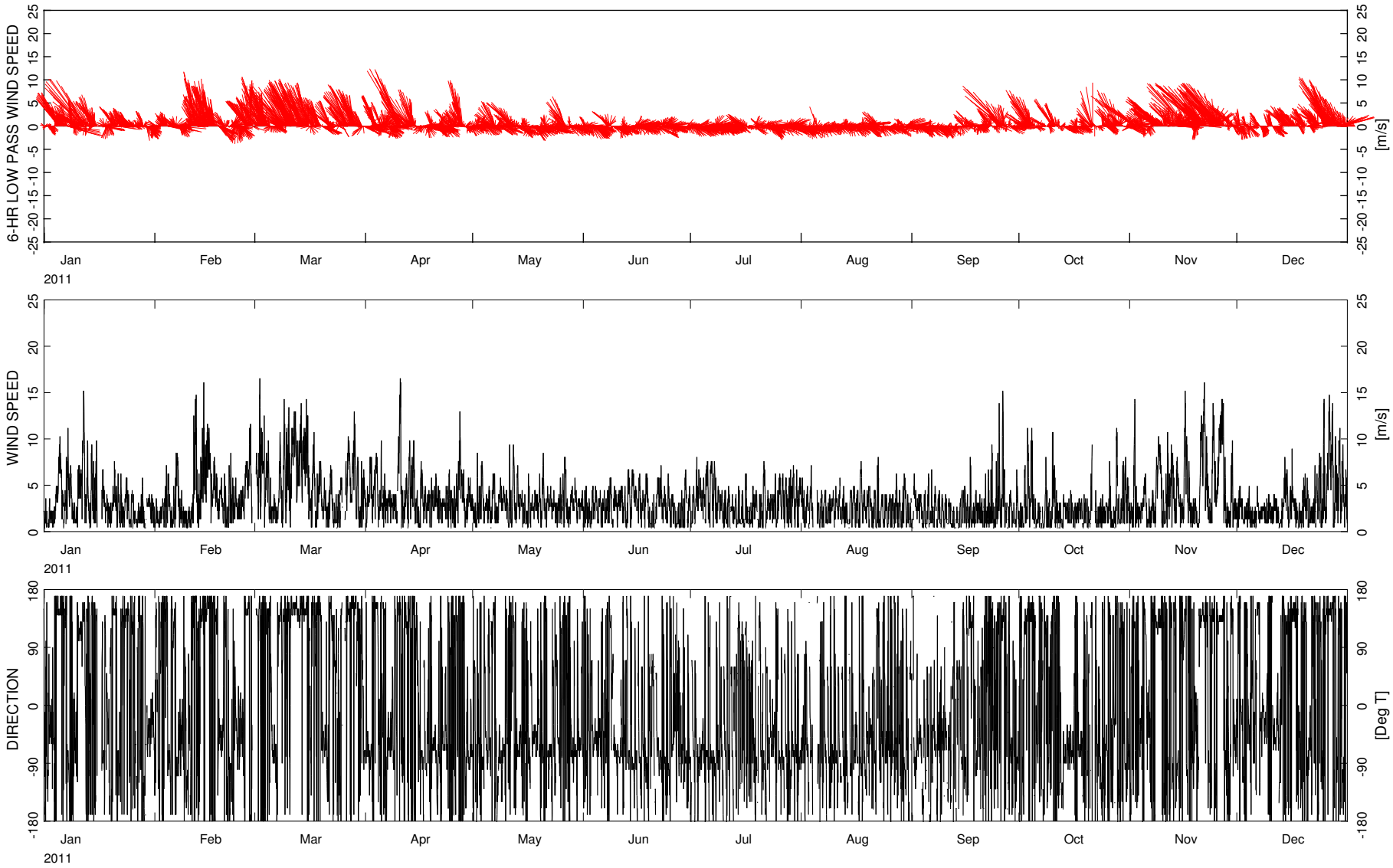
METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Wind speed and direction at Port Angeles: 2011

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 11, 2012

Figure A.85



NOTES

- 6-hour low pass hourly wind sticks are shown in the top panel
- Hourly wind speed and direction are shown in the middle and bottom panels

STATUS
ISSUED FOR USE

CLIENT

Kinder Morgan

A TETRA TECH COMPANY

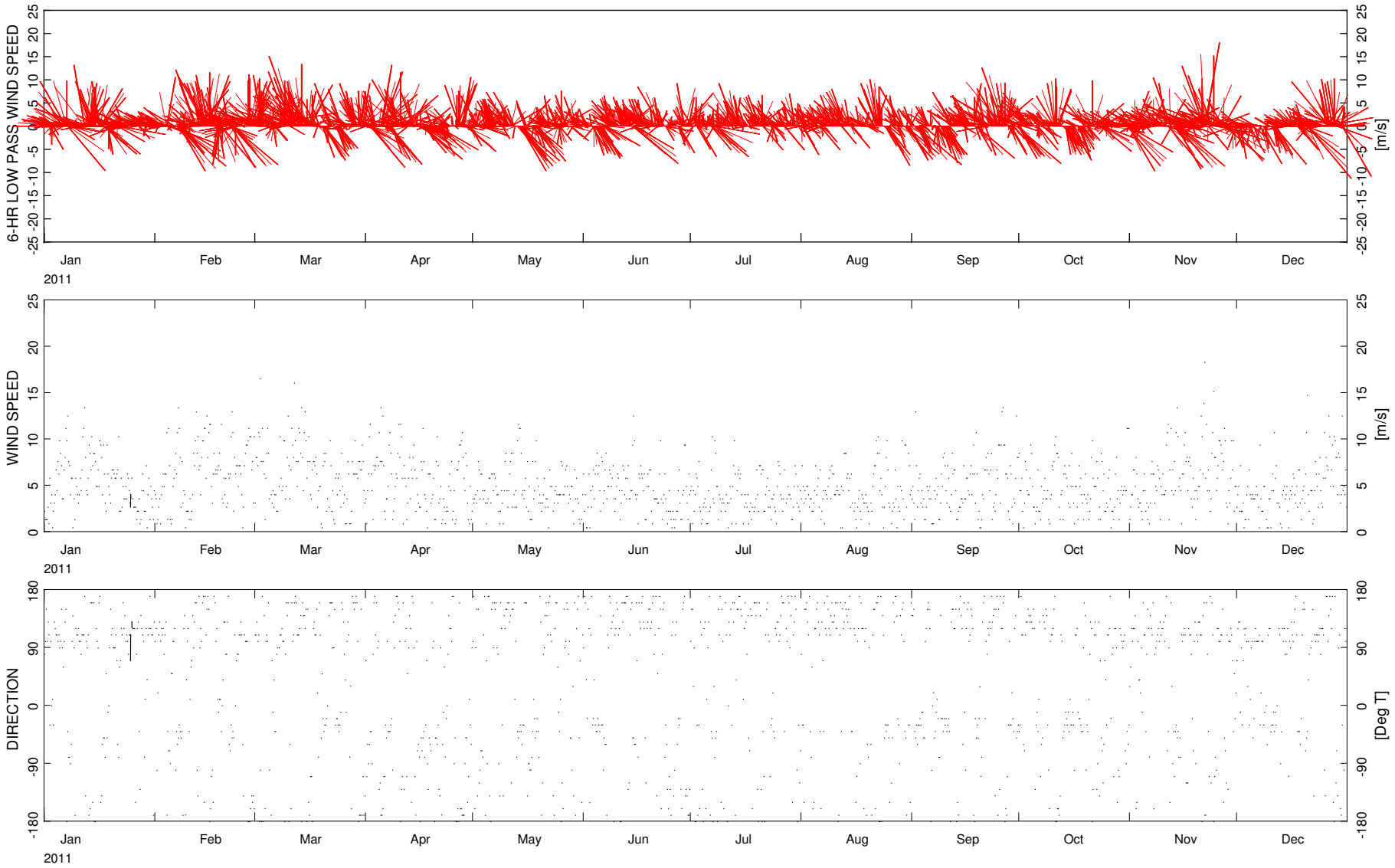
METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Wind speed and direction at Port Townsend: 2011

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 11, 2012

Figure A.86



NOTES

- 6-hour low pass hourly wind sticks are shown in the top panel
- Hourly wind speed and direction are shown in the middle and bottom panels

STATUS
ISSUED FOR USE

CLIENT

Kinder Morgan

A TETRA TECH COMPANY

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

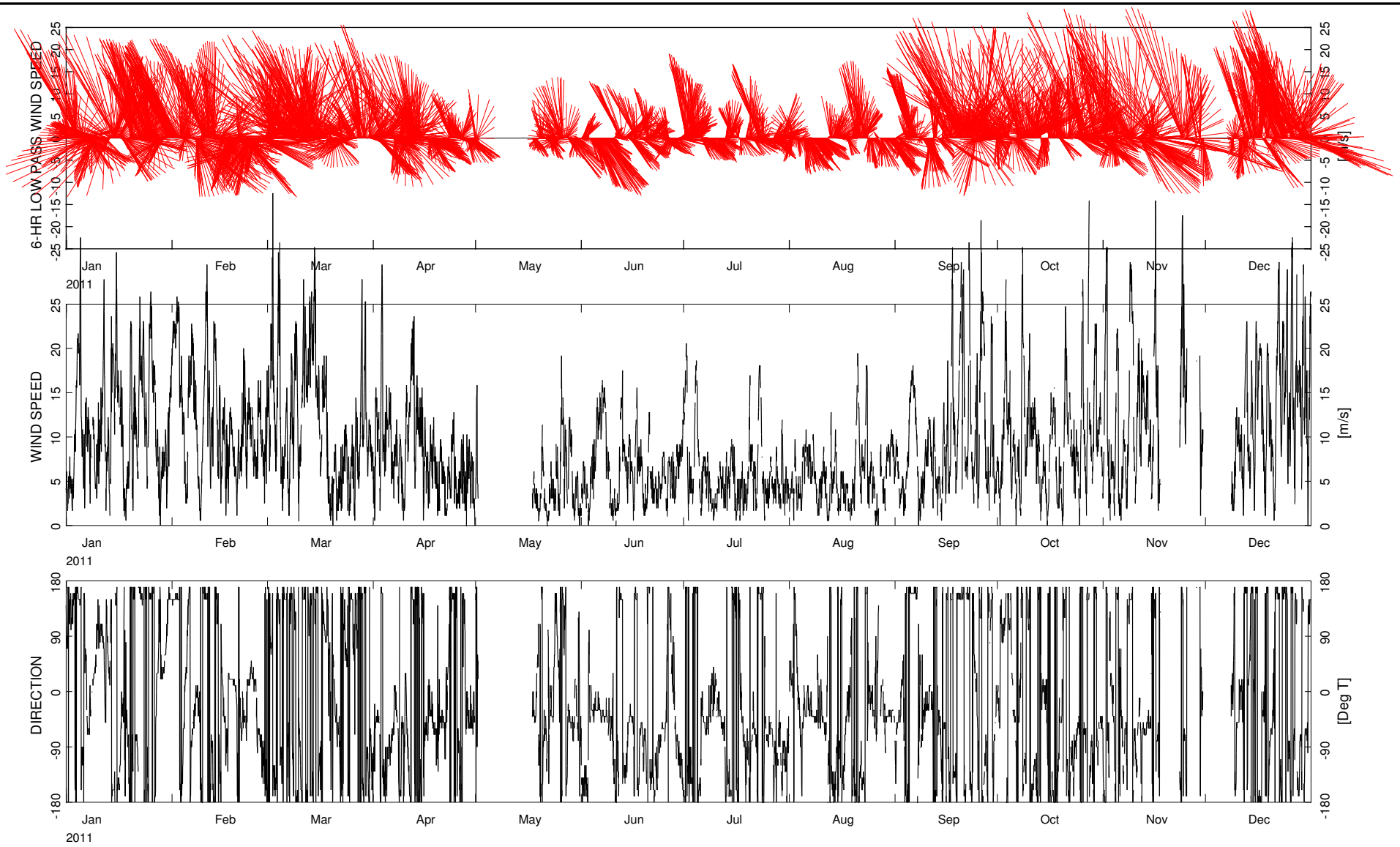
Wind speed and direction at Sand Heads: 2011

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 11, 2012

Figure A.87

Tue Dec 11 12:28:31 2012:V:\V13203022 Trans Mountain\working\DD\02_NOAA_NCDC\01_MetData_Scripts\Sand_Heads



NOTES

- 6-hour low pass hourly wind sticks are shown in the top panel
- Hourly wind speed and direction are shown in the middle and bottom panels

STATUS
ISSUED FOR USE

CLIENT

Kinder Morgan

A TETRA TECH COMPANY

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

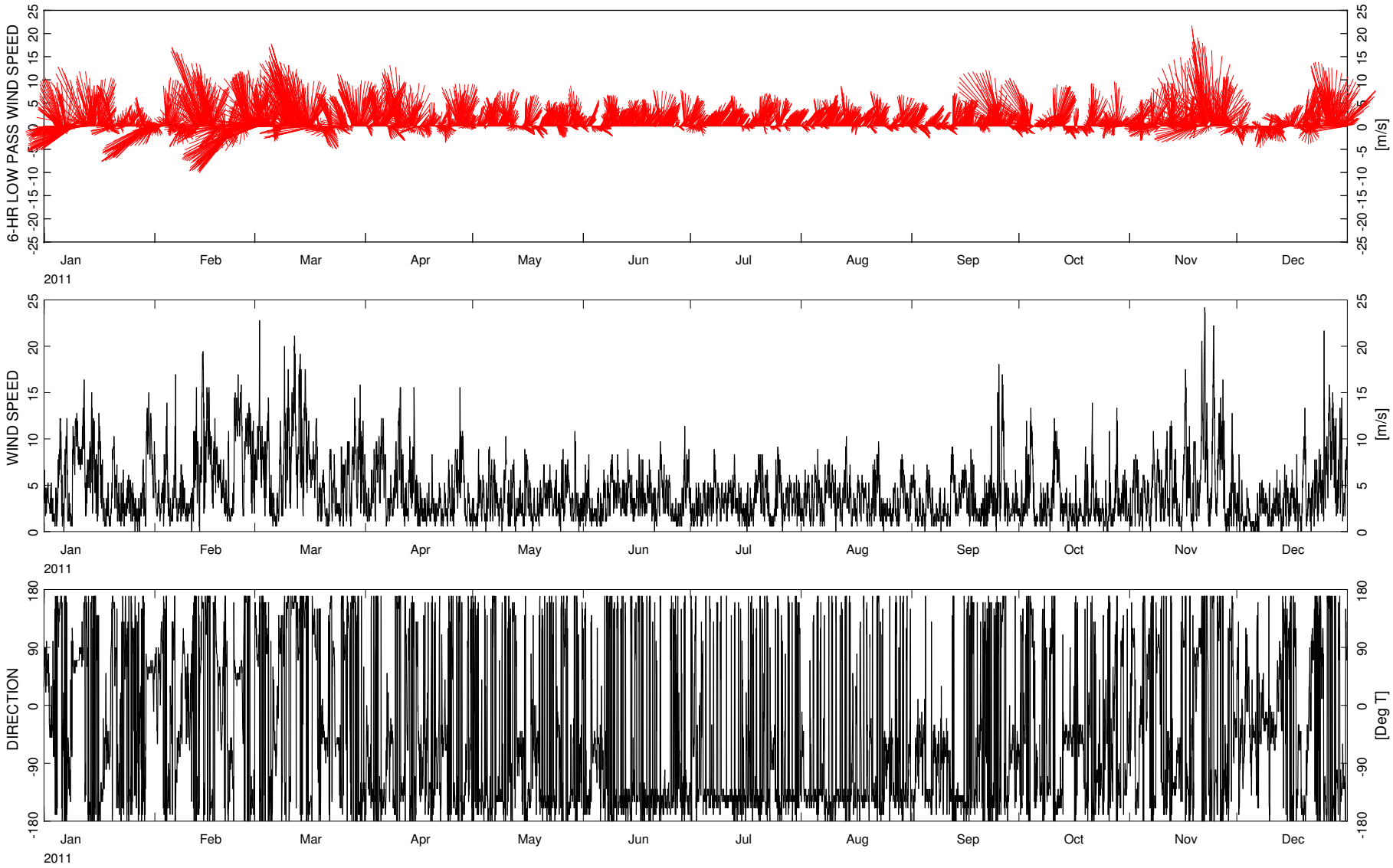
Wind speed and direction at Sartine Island: 2011

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 11, 2012

Figure A.88

Tue Dec 11 12:38:20 2012:V:\V13203022 Trans Mountain\working\DD\01_EC\01_MetData_Scripts\Sartine_Island



NOTES

- 6-hour low pass hourly wind sticks are shown in the top panel
- Hourly wind speed and direction are shown in the middle and bottom panels

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Wind speed and direction at Saturna Island: 2011

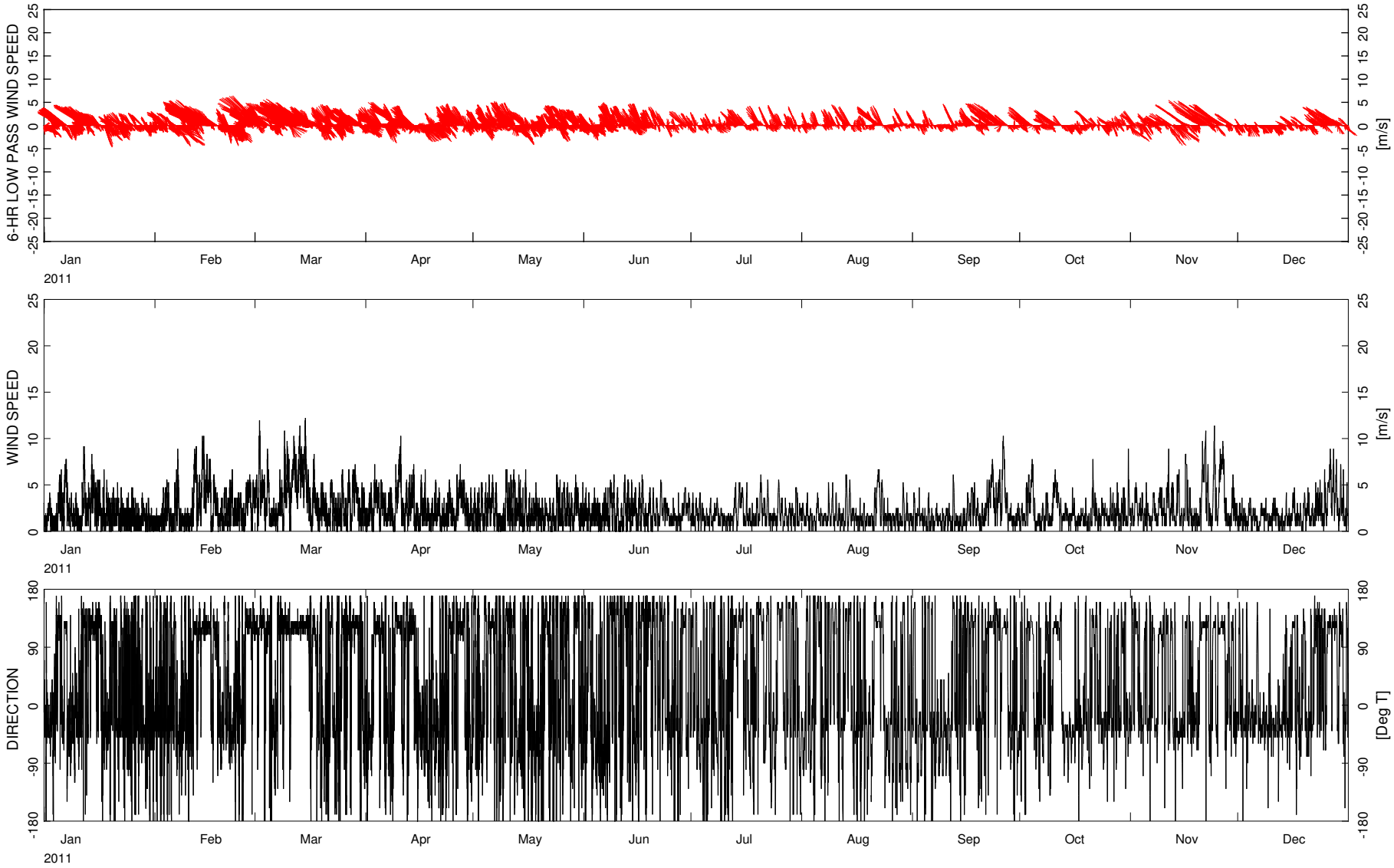
STATUS
ISSUED FOR USE

eba
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 11, 2012

Figure A.89



NOTES

- 6-hour low pass hourly wind sticks are shown in the top panel
- Hourly wind speed and direction are shown in the middle and bottom panels

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Wind speed and direction at Sechelt: 2011

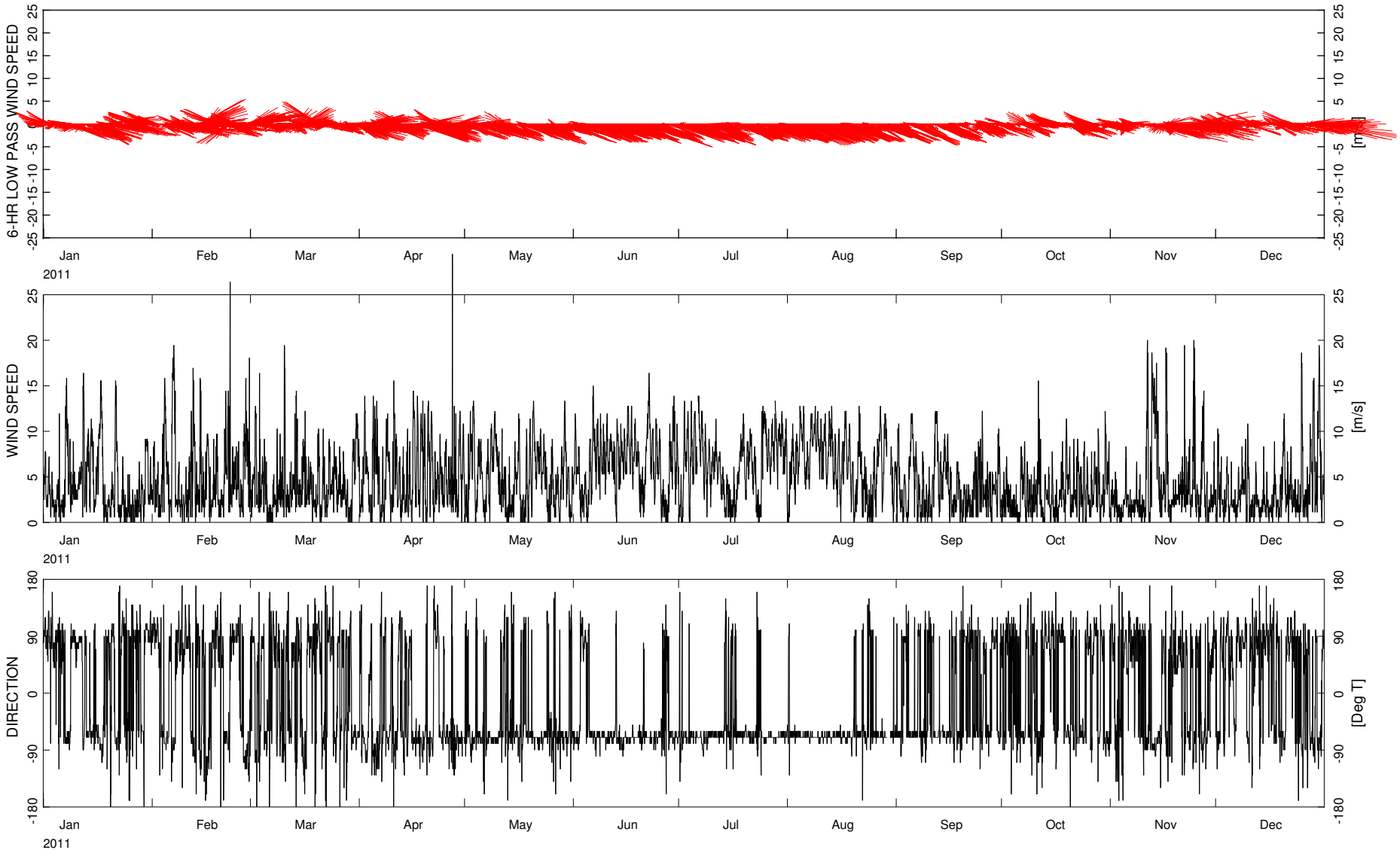
STATUS
ISSUED FOR USE

A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 11, 2012

Figure A.90



NOTES

- 6-hour low pass hourly wind sticks are shown in the top panel
- Hourly wind speed and direction are shown in the middle and bottom panels

STATUS
ISSUED FOR USE

CLIENT

Kinder Morgan

A TETRA TECH COMPANY

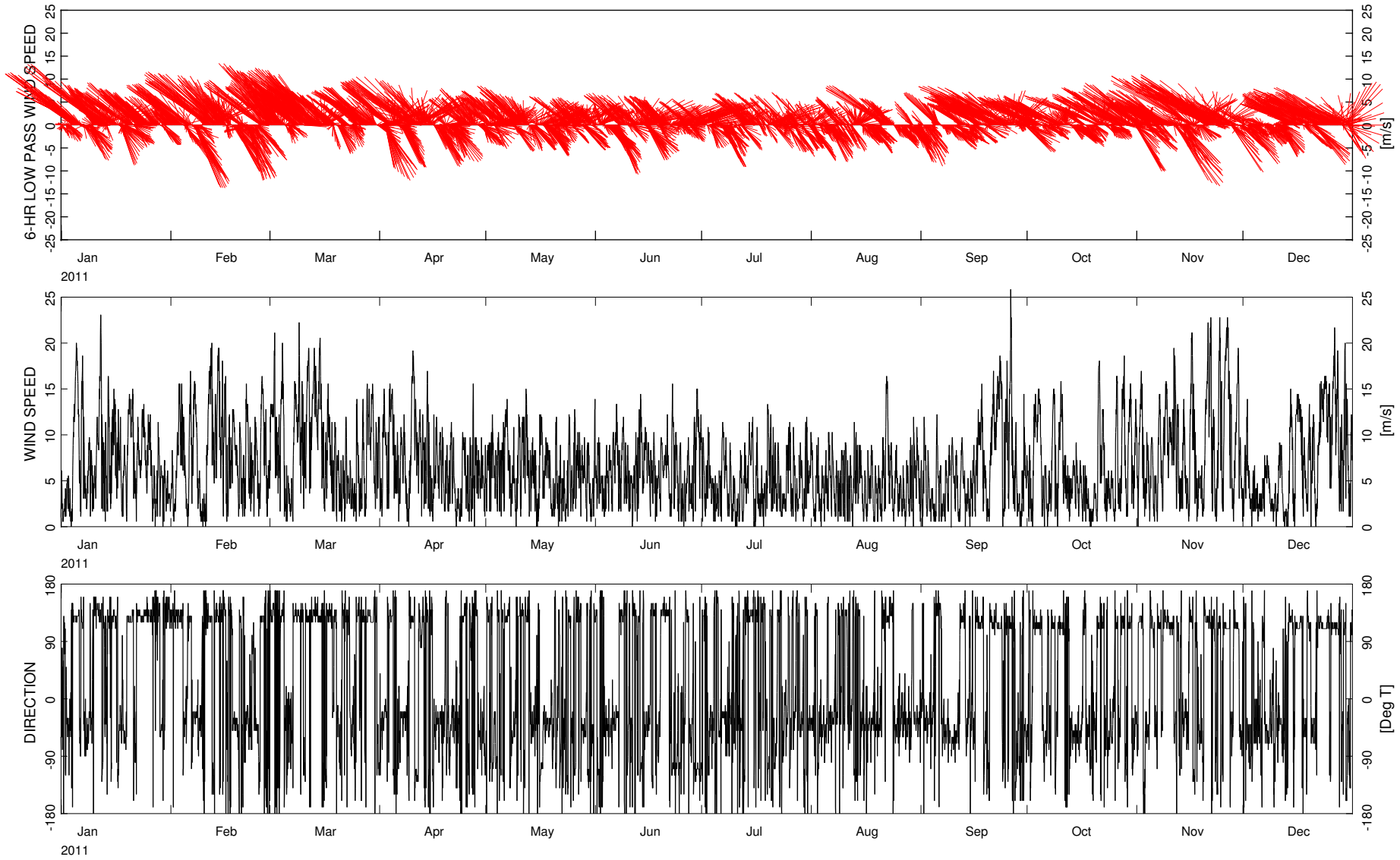
METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Wind speed and direction at Sheringham Point: 2011

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 11, 2012

Figure A.91



NOTES

- 6-hour low pass hourly wind sticks are shown in the top panel
- Hourly wind speed and direction are shown in the middle and bottom panels

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Wind speed and direction at Sisters Island: 2011

STATUS
ISSUED FOR USE

eba
A TETRA TECH COMPANY

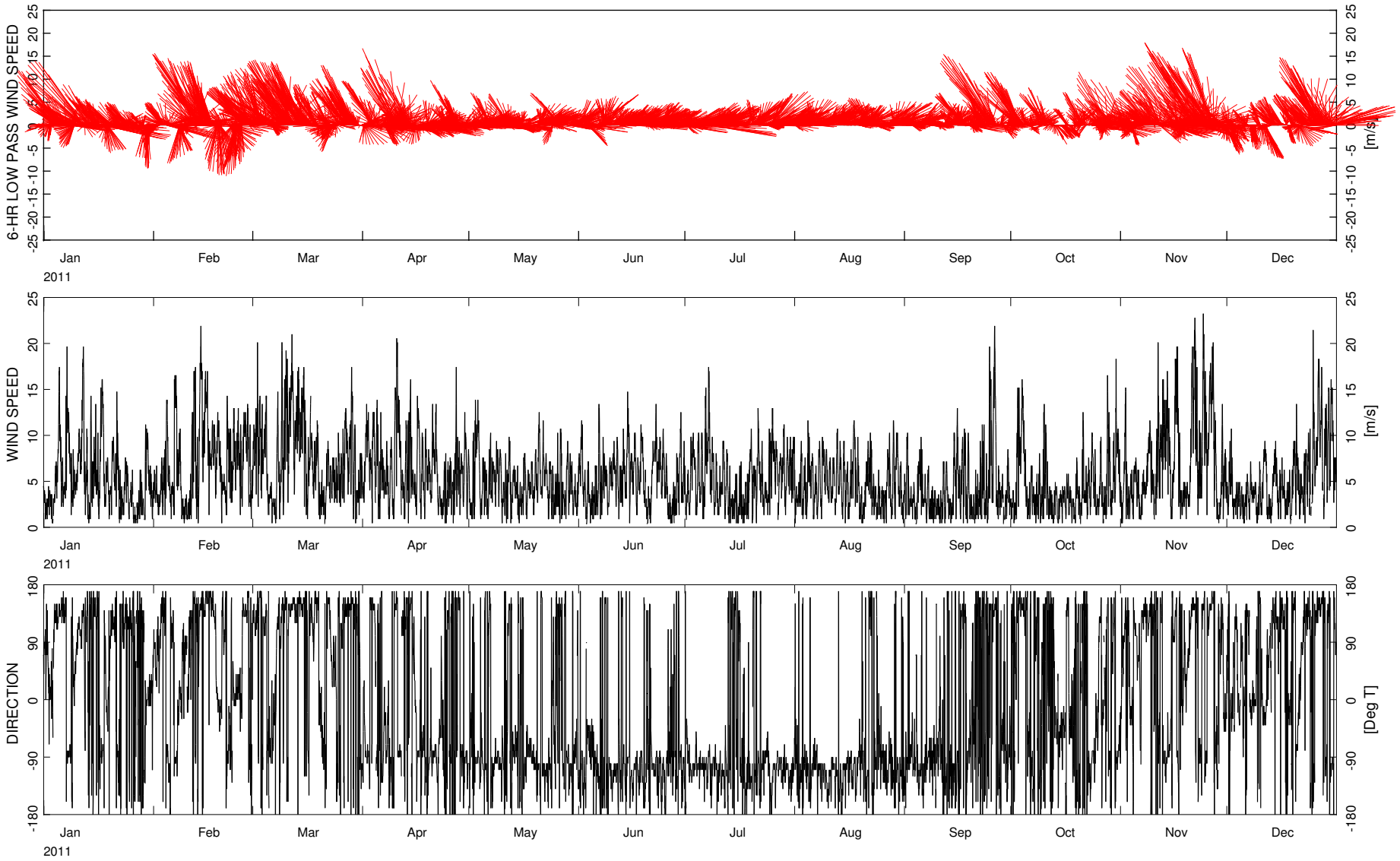
PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE: EBA-VANC

DATE: December 11, 2012

Figure A.92

Tue Dec 11 12:41:33 2012:V:\V13203022 Trans Mountain\working\DD\01_EC\01_MetData_Scripts\Sisters_Island



NOTES

- 6-hour low pass hourly wind sticks are shown in the top panel
- Hourly wind speed and direction are shown in the middle and bottom panels

STATUS
ISSUED FOR USE

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Wind speed and direction at Smith Island: 2011

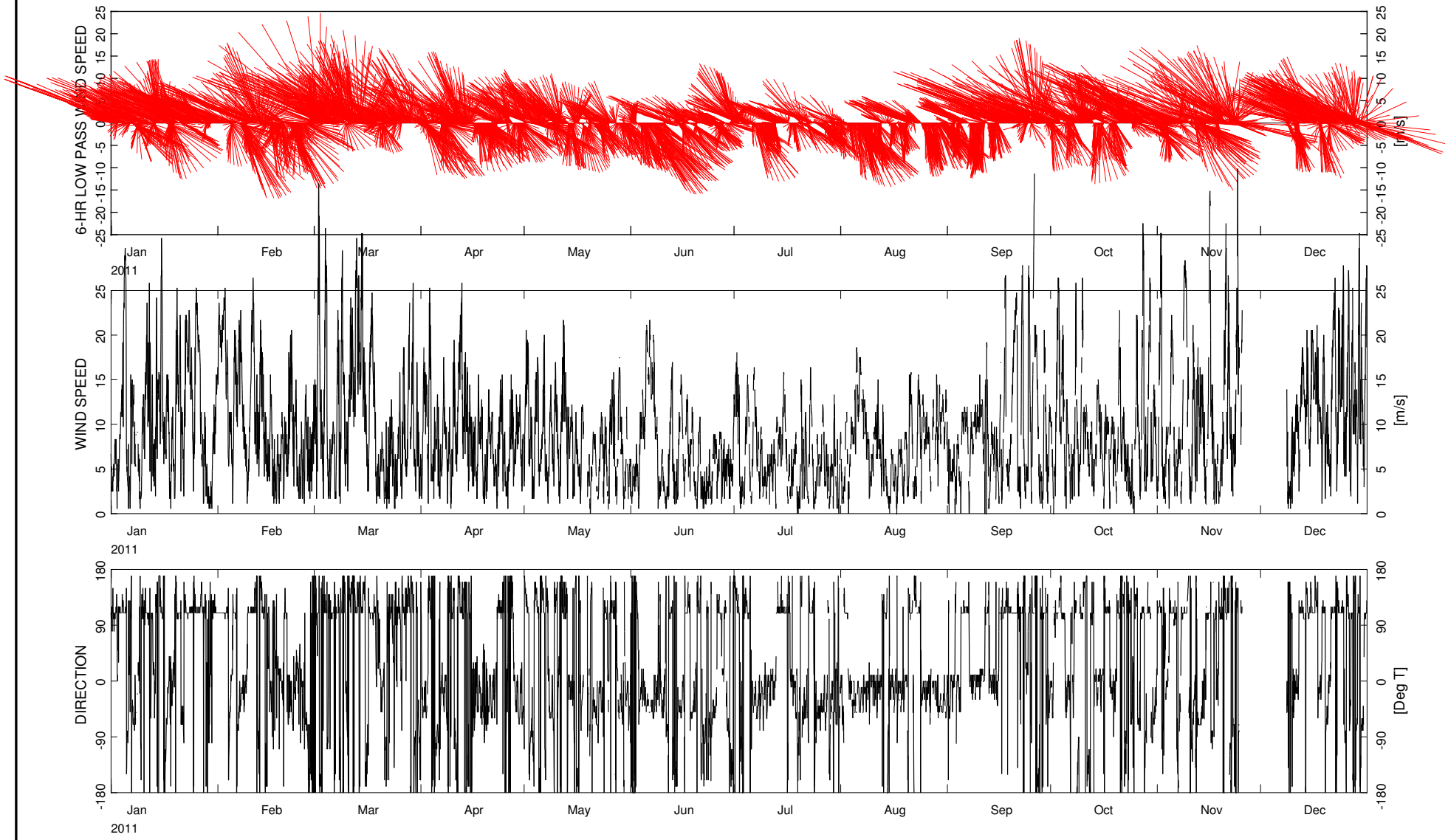
PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 11, 2012

Figure A.93

eba
A TETRA TECH COMPANY

Tue Dec 11 12:31:14 2012:V:\V13203022 Trans Mountain\working\DD\02_NOAA_NCDC\01_MetData_Scripts\Smith_Island



NOTES

- 6-hour low pass hourly wind sticks are shown in the top panel
- Hourly wind speed and direction are shown in the middle and bottom panels

STATUS
ISSUED FOR USE

CLIENT

Kinder Morgan

A TETRA TECH COMPANY

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

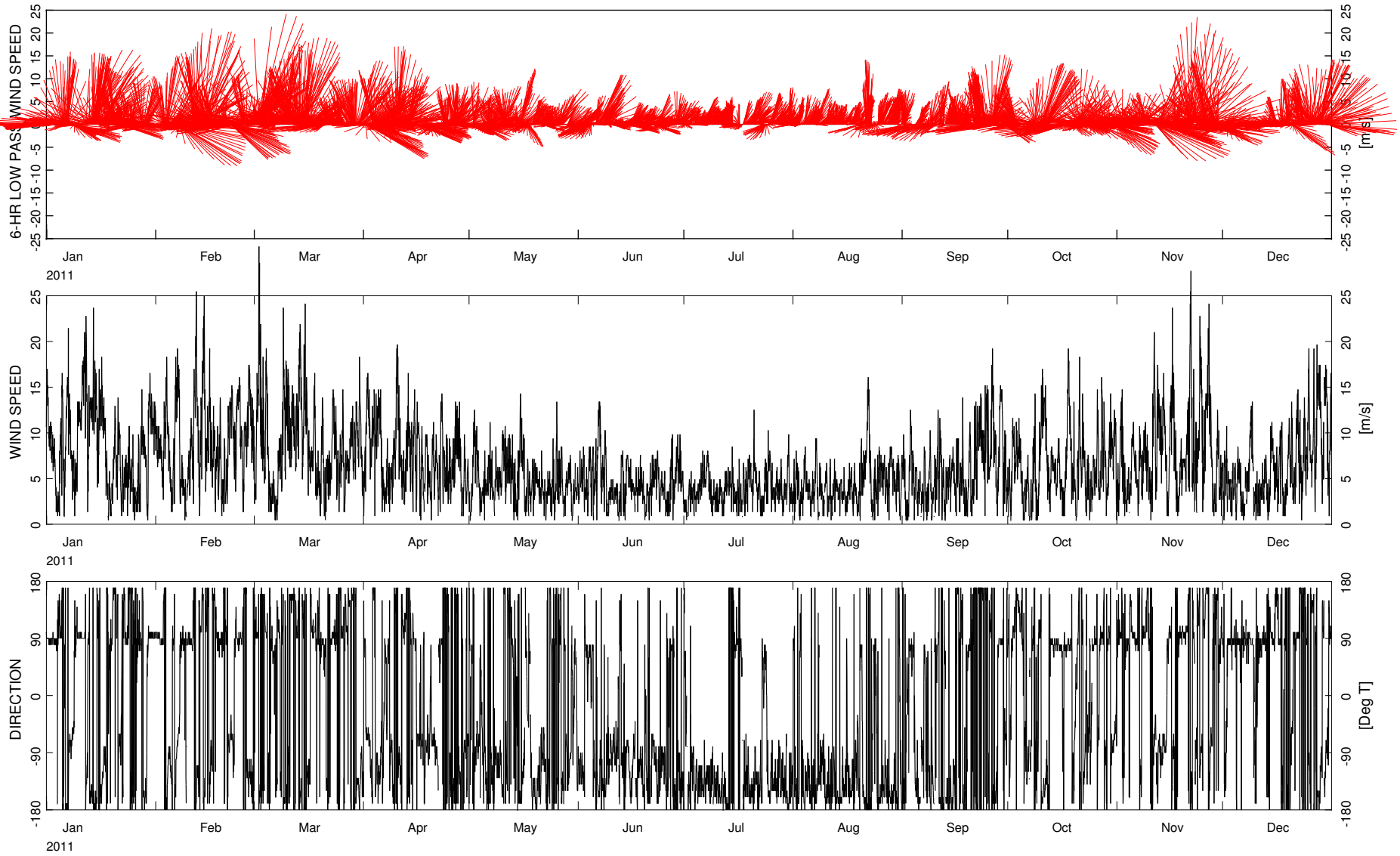
Wind speed and direction at Solander Island: 2011

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 11, 2012

Figure A.94

Tue Dec 11 12:42:24 2012:V:\V13203022 Trans Mountain\working\DD\01_EC\01_MetData_Scripts\Solander_Island



NOTES

- 6-hour low pass hourly wind sticks are shown in the top panel
- Hourly wind speed and direction are shown in the middle and bottom panels

STATUS
ISSUED FOR USE

CLIENT

Kinder Morgan

A TETRA TECH COMPANY

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

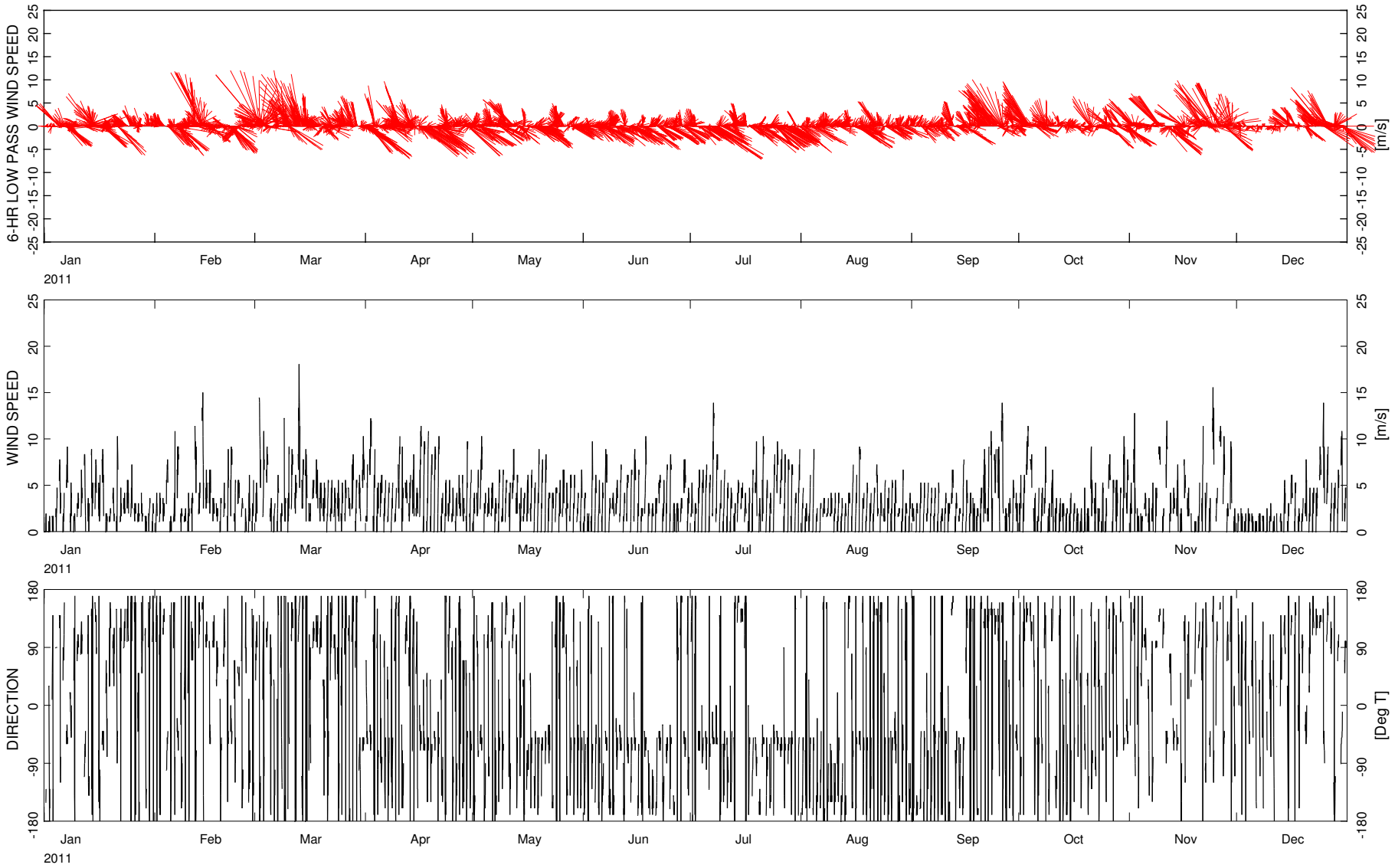
Wind speed and direction at Tatoosh Island: 2011

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 11, 2012

Figure A.95

Tue Dec 11 12:35:31 2012:V:\V13203022 Trans Mountain\working\DD\02_NOAA_NCDC\01_MetData_Scripts\Tatoosh_Island



NOTES

- 6-hour low pass hourly wind sticks are shown in the top panel
- Hourly wind speed and direction are shown in the middle and bottom panels

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Wind speed and direction at Tofino Airport: 2011

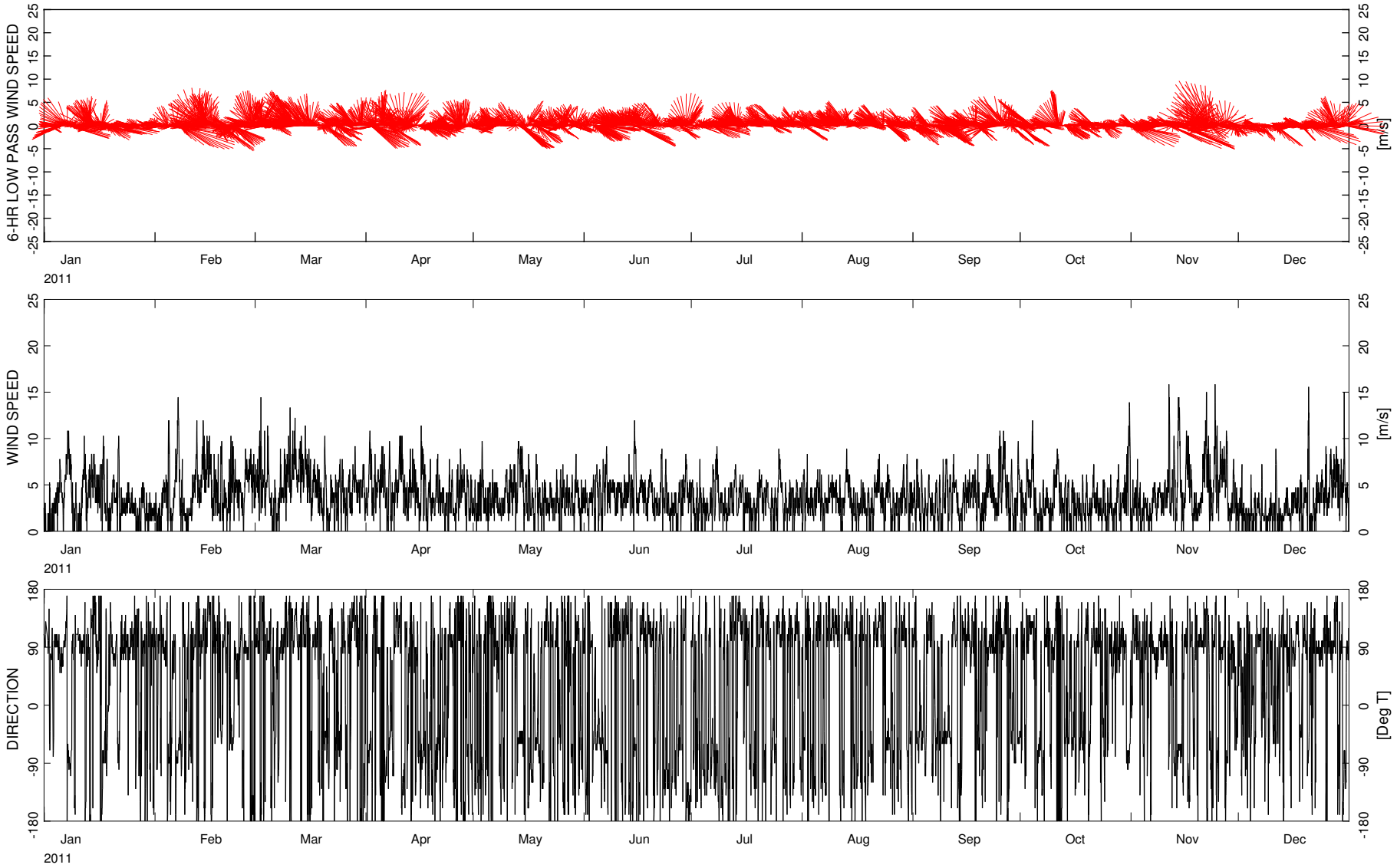
STATUS
ISSUED FOR USE

A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 11, 2012

Figure A.96



NOTES

- 6-hour low pass hourly wind sticks are shown in the top panel
- Hourly wind speed and direction are shown in the middle and bottom panels

STATUS
ISSUED FOR USE

CLIENT

Kinder Morgan

A TETRA TECH COMPANY

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

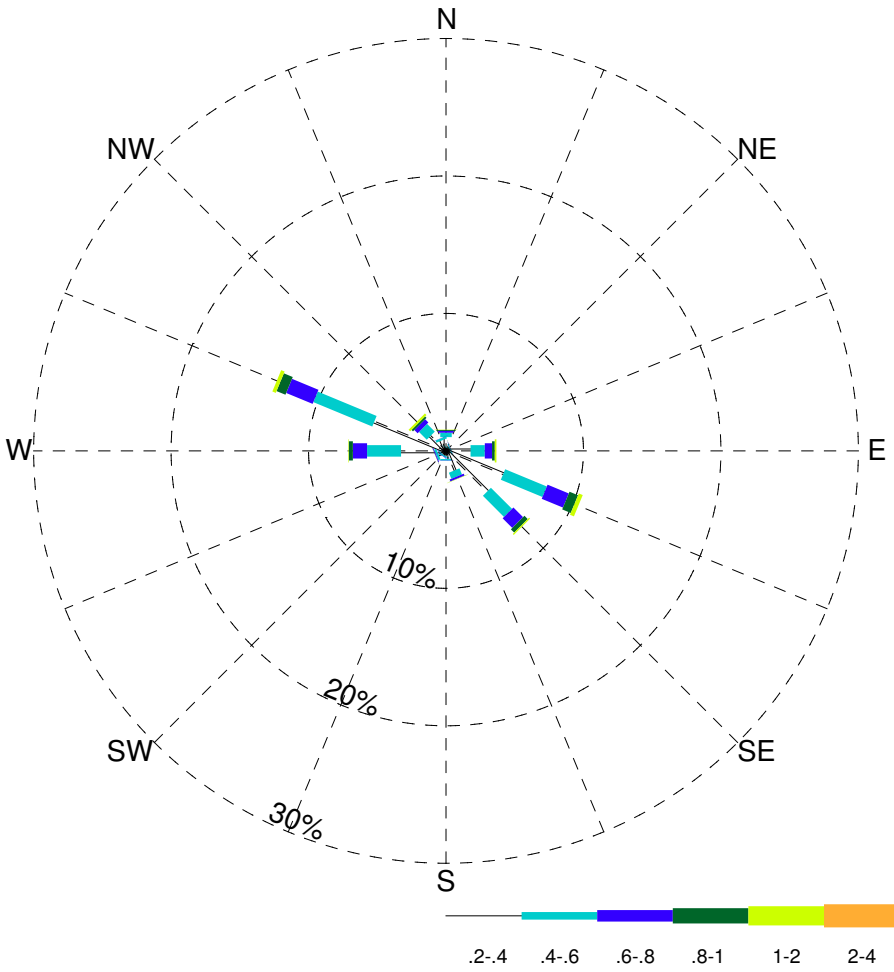
Wind speed and direction at Vancouver Intl Airport: 2011

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 11, 2012

Figure A.97

APPENDIX B
WAVE ROSES



Canadian Buoy C46146
Location:Halibut Bank, SOG
N49° 20' 24.0" W123° 43' 48.0"
Elevation: Sea Level
Sea level: -
Length of Record
Start Date: Mar 13, 1992
End Date: Nov 12, 2012
Comment: -

Wave Height & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-.1 m	.2-.4 m	.4-.6 m	.6-.8 m	.8-1 m	1-2 m	2-4 m	4+ m	Total (%)
ENE	-	0.29	0.06	0.02	0.01	-	-	-	0.38
NE	-	0.18	0.02	-	-	-	-	-	0.19
NNE	-	0.23	0.02	-	-	-	-	-	0.26
N	-	1.00	0.32	0.13	0.07	0.02	-	-	1.54
NNW	-	0.82	0.16	0.01	-	-	-	-	1.00
NW	-	1.57	0.80	0.34	0.15	0.16	-	-	3.02
WNW	-	5.64	4.64	2.08	0.70	0.27	-	-	13.33
W	-	3.27	2.47	1.03	0.29	0.04	-	-	7.11
WSW	-	0.60	0.17	0.06	0.02	-	-	-	0.85
SW	-	0.34	0.05	0.03	-	-	-	-	0.42
SSW	-	0.35	0.07	0.01	-	-	-	-	0.45
S	-	0.60	0.11	0.02	-	-	-	-	0.74
SSE	-	1.55	0.48	0.15	0.01	0.02	-	-	2.21
SE	-	4.21	2.17	0.99	0.34	0.10	-	-	7.81
ESE	-	4.49	3.28	1.67	0.68	0.31	-	-	10.43
E	-	1.79	1.04	0.53	0.20	0.12	-	-	3.67
Calm	46.60	-	-	-	-	-	-	-	46.60
Total (%)	46.60	26.91	15.86	7.08	2.48	1.05	0.02	-	100.00

NOTES

- Measurement of wave direction is absent; as a result, wave direction is assumed the same as wind direction
- The wave direction shown is the direction the waves are coming from

STATUS
ISSUED FOR USE

CLIENT
Kinder Morgan

A TETRA TECH COMPANY

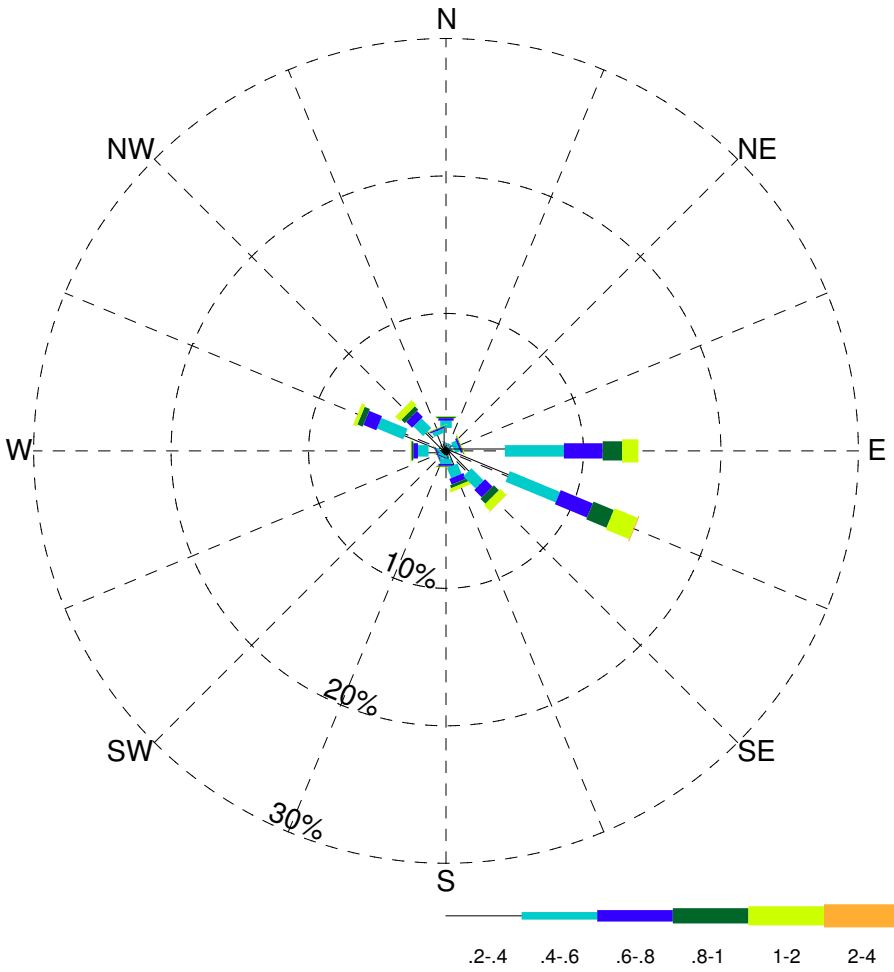
METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Summer Waves: April-September
Halibut Bank, Strait of Georgia

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	AL	JAS	JAS	1

OFFICE: EBA-VANC
DATE: November 14, 2012

Figure B.1



Canadian Buoy C46146
Location:Halibut Bank, SOG
N49° 20' 24.0" W123° 43' 48.0"
Elevation: Sea Level
Sea level: -
Length of Record
Start Date: Mar 13, 1992
End Date: Nov 12, 2012
Comment: -

Wave Height & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-.1 m	.2-.4 m	.4-.6 m	.6-.8 m	.8-1 m	1-2 m	2-4 m	4+ m	Total (%)
ENE	-	0.57	0.37	0.14	0.06	0.07	-	-	1.21
NE	-	0.25	0.10	0.02	-	0.01	-	-	0.39
NNE	-	0.43	0.09	0.02	-	-	-	-	0.55
N	-	1.66	0.53	0.19	0.12	0.04	-	-	2.54
NNW	-	1.27	0.32	0.11	0.04	0.05	-	-	1.79
NW	-	1.94	0.99	0.61	0.36	0.47	0.01	-	4.38
WNW	-	3.20	2.06	1.01	0.41	0.27	0.01	-	6.97
W	-	1.27	0.77	0.34	0.14	0.06	-	-	2.58
WSW	-	0.43	0.18	0.08	0.04	0.01	-	-	0.74
SW	-	0.30	0.12	0.06	0.02	-	-	-	0.50
SSW	-	0.32	0.14	0.06	0.02	0.01	-	-	0.55
S	-	0.56	0.38	0.14	0.07	0.05	-	-	1.21
SSE	-	1.17	0.81	0.45	0.23	0.26	0.01	-	2.93
SE	-	2.20	1.27	0.77	0.51	0.60	0.04	-	5.39
ESE	-	4.86	3.95	2.52	1.60	1.82	0.08	-	14.83
E	-	4.28	4.30	2.82	1.41	1.19	-	-	14.00
Calm	39.44	-	-	-	-	-	-	-	39.44
Total (%)	39.44	24.73	16.38	9.32	5.05	4.89	0.17	-	100.00

NOTES

- Measurement of wave direction is absent; as a result, wave direction is assumed the same as wind direction
- The wave direction shown is the direction the waves are coming from

STATUS
ISSUED FOR USE

CLIENT
Kinder Morgan

A TETRA TECH COMPANY

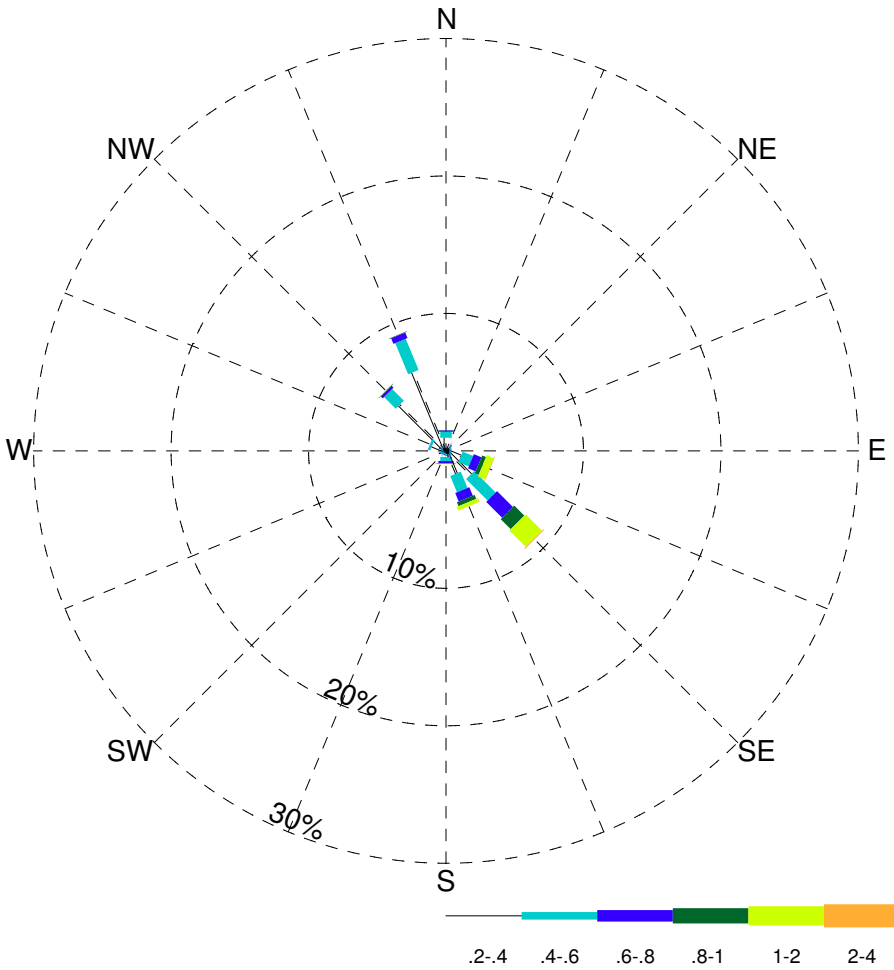
METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Winter Waves: October-March
Halibut Bank, Strait of Georgia

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	AL	JAS	JAS	0

OFFICE: EBA-VANC
DATE: November 14, 2012

Figure B.2



Canadian Buoy C46131
Location:Sentry Shoal, SOG
N49° 54' 36.0" W124° 59' 24.0"
Elevation: Sea Level
Sea level: -
Length of Record
Start Date: Oct 20, 1992
End Date: Nov 9, 2012
Comment: -

Wave Height & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-.1 m	.2-.4 m	.4-.6 m	.6-.8 m	.8-1 m	1-2 m	2-4 m	4+ m	Total (%)
ENE	-	0.10	0.02	0.01	-	-	-	-	0.12
NE	-	0.10	0.02	-	-	-	-	-	0.13
NNE	-	0.20	0.02	-	-	-	-	-	0.22
N	-	0.95	0.44	0.10	0.02	-	-	-	1.51
NNW	-	6.20	2.46	0.44	0.04	-	-	-	9.14
NW	-	4.75	1.20	0.20	0.04	0.03	-	-	6.22
WNW	-	1.08	0.16	0.02	-	-	-	-	1.26
W	-	0.26	0.05	-	-	-	-	-	0.32
WSW	-	0.19	0.03	-	-	-	-	-	0.23
SW	-	0.12	0.03	0.02	-	-	-	-	0.18
SSW	-	0.19	0.09	0.03	-	-	-	-	0.32
S	-	0.45	0.29	0.15	0.04	0.04	-	-	0.97
SSE	-	1.80	1.29	0.67	0.31	0.28	-	-	4.36
SE	-	2.49	2.21	1.63	1.04	1.68	0.07	-	9.11
ESE	-	1.15	0.82	0.60	0.30	0.56	0.04	-	3.46
E	-	0.25	0.09	0.03	0.01	-	-	-	0.39
Calm	62.05	-	-	-	-	-	-	-	62.05
Total (%)	62.05	20.28	9.22	3.90	1.82	2.61	0.12	-	100.00

NOTES

- Measurement of wave direction is absent; as a result, wave direction is assumed the same as wind direction
- The wave direction shown is the direction the waves are coming from

STATUS
ISSUED FOR USE

CLIENT
Kinder Morgan

A TETRA TECH COMPANY

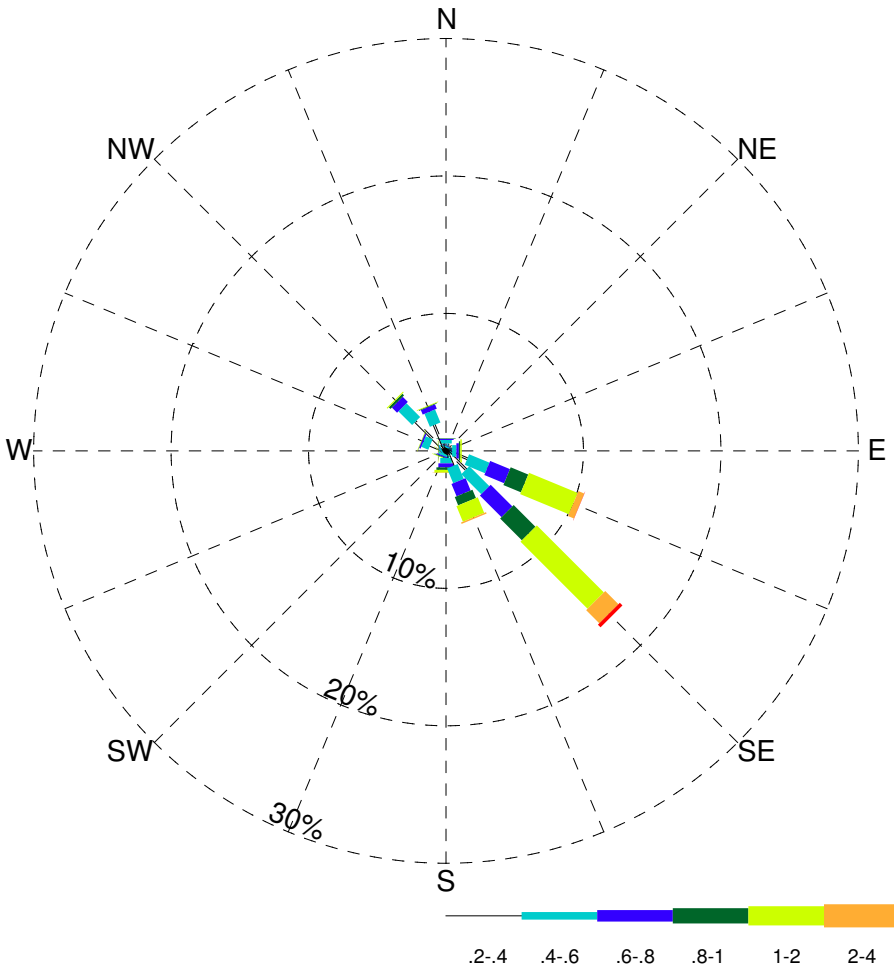
METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Summer Waves: April-September
Sentry Shoal, Strait of Georgia

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	AL	JAS	JAS	0

OFFICE: EBA-VANC
DATE: November 14, 2012

Figure B.3



Canadian Buoy C46131
Location:Sentry Shoal, SOG
N49° 54' 36.0" W124° 59' 24.0"
Elevation: Sea Level
Sea level: -
Length of Record
Start Date: Oct 20, 1992
End Date: Nov 9, 2012
Comment: -

Wave Height & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-.1 m	.2-.4 m	.4-.6 m	.6-.8 m	.8-1 m	1-2 m	2-4 m	4+ m	Total (%)
ENE	-	0.21	0.10	0.05	0.03	0.01	-	-	0.39
NE	-	0.19	0.09	0.05	0.02	-	-	-	0.35
NNE	-	0.22	0.10	0.04	0.02	0.02	-	-	0.40
N	-	0.54	0.25	0.08	0.04	-	-	-	0.91
NNW	-	2.06	1.02	0.35	0.05	0.05	-	-	3.55
NW	-	3.07	1.41	0.53	0.17	0.08	-	-	5.26
WNW	-	1.22	0.55	0.12	0.03	0.03	-	-	1.95
W	-	0.41	0.10	0.03	0.02	0.02	-	-	0.59
WSW	-	0.26	0.07	0.04	0.02	0.02	-	-	0.41
SW	-	0.22	0.07	0.03	0.02	0.03	-	-	0.37
SSW	-	0.25	0.16	0.08	0.05	0.04	-	-	0.58
S	-	0.52	0.39	0.29	0.19	0.20	0.02	-	1.61
SSE	-	1.21	1.17	0.97	0.66	1.23	0.11	-	5.35
SE	-	1.98	2.06	2.22	2.24	6.90	1.35	0.27	17.02
ESE	-	1.65	1.60	1.56	1.38	3.83	0.46	0.02	10.49
E	-	0.45	0.31	0.18	0.10	0.11	-	-	1.15
Calm	49.60	-	-	-	-	-	-	-	49.60
Total (%)	49.60	14.46	9.46	6.62	5.03	12.58	1.96	0.30	100.00

NOTES

- Measurement of wave direction is absent; as a result, wave direction is assumed the same as wind direction
- The wave direction shown is the direction the waves are coming from

STATUS
ISSUED FOR USE

CLIENT
Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

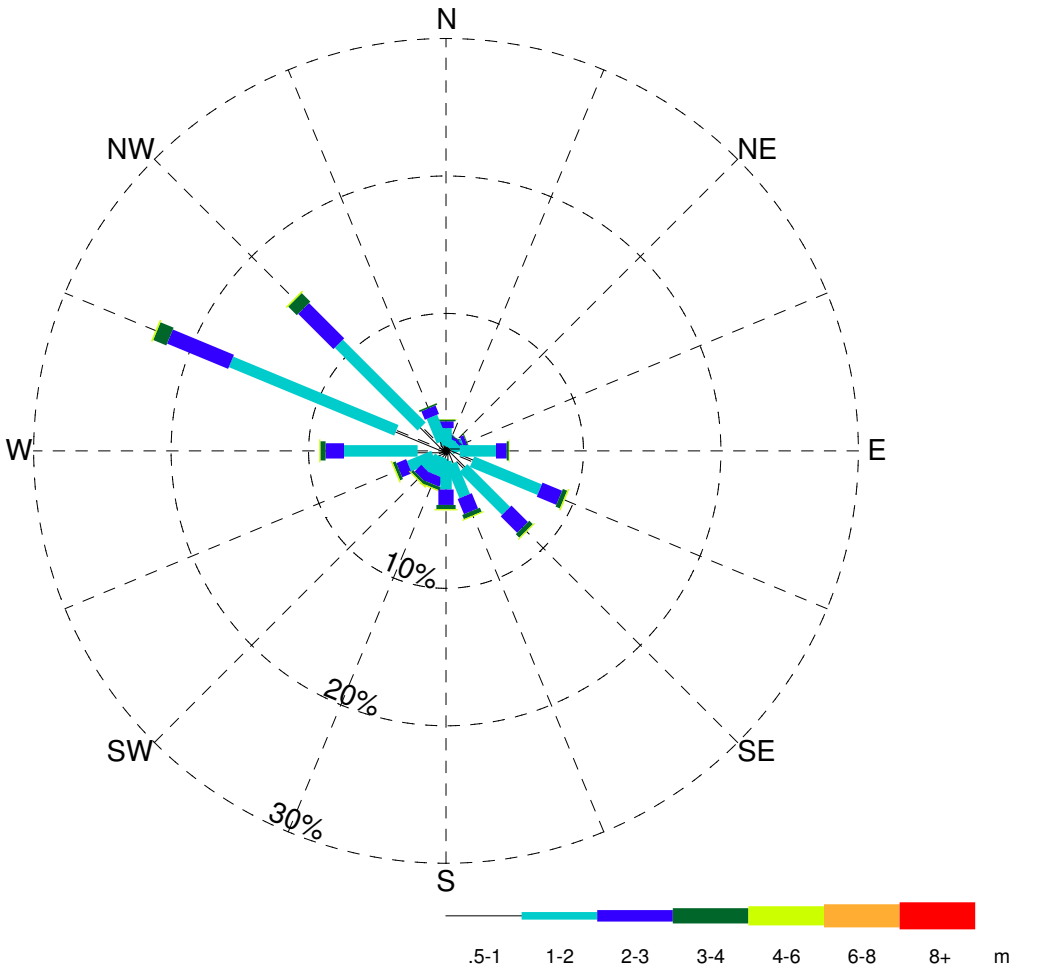
Winter Waves: October-March
Sentry Shoal, Strait of Georgia

eba A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	AL	JAS	JAS	0

OFFICE: EBA-VANC
DATE: November 14, 2012

Figure B.4



Canadian Buoy C46206
Location:La Perouse Bank
N48° 50' 6.0" W125° 59' 52.0"
Elevation: Sea Level
Sea level: -
Length of Record
Start Date: Nov 22, 1988
End Date: Aug 26, 2012
Comment: -

Wave Height & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	**0-.5 m**	**.5-1 m**	**1-2 m**	**2-3 m**	**3-4 m**	**4-6 m**	**6-8 m**	**8+ m**	**Total (%)**
ENE	-	0.40	0.93	0.28	0.07	0.01	-	-	1.68
NE	-	0.30	0.65	0.18	0.04	-	-	-	1.18
NNE	-	0.29	0.63	0.16	0.05	-	-	-	1.14
N	-	0.39	1.26	0.49	0.13	0.04	-	-	2.32
NNW	-	0.75	1.93	0.66	0.12	0.01	-	-	3.48
NW	-	2.51	8.52	3.63	0.89	0.11	-	-	15.65
WNW	-	3.91	13.02	4.81	1.03	0.11	-	-	22.88
W	-	2.07	5.35	1.34	0.38	0.09	-	-	9.23
WSW	-	0.99	1.92	0.76	0.23	0.10	-	-	4.01
SW	-	0.67	1.32	0.68	0.20	0.09	0.01	-	2.98
SSW	-	0.51	1.39	0.70	0.24	0.09	0.01	-	2.94
S	-	0.72	2.09	1.12	0.31	0.09	-	-	4.33
SSE	-	1.02	2.54	1.20	0.33	0.09	-	-	5.18
SE	-	1.78	4.40	1.70	0.36	0.09	-	-	8.33
ESE	-	2.06	5.32	1.54	0.34	0.10	-	-	9.36
E	-	1.00	2.64	0.78	0.15	0.05	-	-	4.62
Calm	0.68	-	-	-	-	-	-	-	0.68
Total (%)	0.68	19.37	53.91	20.05	4.86	1.08	0.05	-	100.00

NOTES

- Measurement of wave direction is absent; as a result, wave direction is assumed the same as wind direction
- The wave direction shown is the direction the waves are coming from

STATUS
ISSUED FOR USE

CLIENT
Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

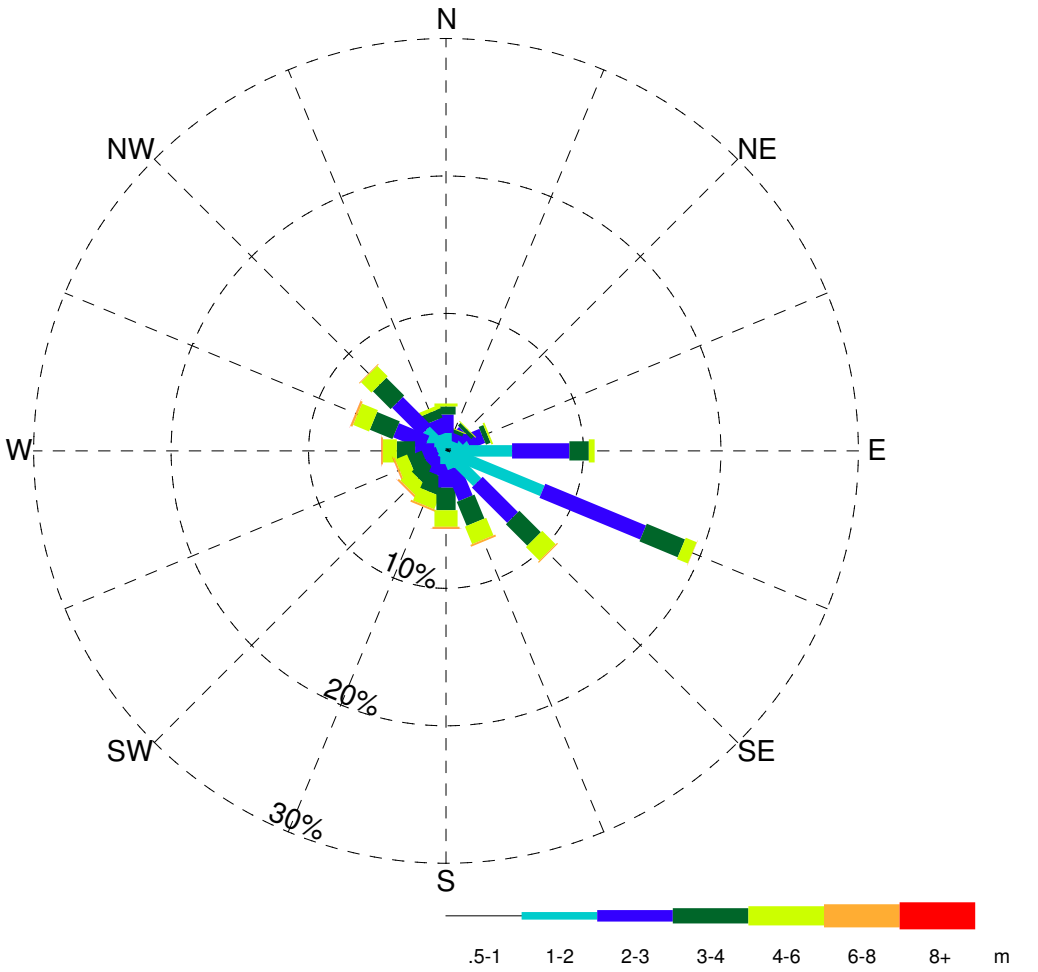
Summer Waves: April-September
La Perouse Bank

A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	AL	JAS	JAS	0

OFFICE: EBA-VANC
DATE: November 14, 2012

Figure B.5



NOAA Buoy C46206
Location:La Perouse Bank
N48° 50' 6.0" W125° 59' 52.0"
Elevation: Sea Level
Sea level: -
Length of Record
Start Date: Nov 22, 1988
End Date: Aug 26, 2012
Comment: -

Wave Height & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-.5 m	.5-1 m	1-2 m	2-3 m	3-4 m	4-6 m	6-8 m	8+ m	Total (%)
ENE	-	0.21	1.49	1.17	0.37	0.14	-	-	3.37
NE	-	0.11	1.07	0.74	0.27	0.07	-	-	2.26
NNE	-	0.07	0.75	0.58	0.26	0.08	-	-	1.74
N	-	0.10	1.21	1.33	0.59	0.21	-	-	3.45
NNW	-	0.13	1.10	1.11	0.68	0.28	-	-	3.30
NW	-	0.17	1.92	2.91	1.83	1.07	0.07	-	7.97
WNW	-	0.10	1.44	2.39	1.78	1.25	0.15	0.01	7.13
W	-	0.06	0.79	1.39	1.33	1.01	0.12	0.01	4.72
WSW	-	0.06	0.52	1.05	1.09	0.94	0.13	0.01	3.80
SW	-	0.02	0.48	1.03	1.30	1.02	0.14	0.01	4.01
SSW	-	0.03	0.54	1.29	1.35	1.04	0.15	-	4.41
S	-	0.05	0.92	1.71	1.64	1.20	0.14	0.01	5.68
SSE	-	0.13	1.23	2.37	1.89	1.38	0.14	-	7.14
SE	-	0.28	2.94	3.63	2.21	1.38	0.09	-	10.54
ESE	-	0.61	6.99	7.93	3.01	0.86	0.03	-	19.42
E	-	0.37	4.44	4.17	1.41	0.43	-	-	10.82
Calm	0.24	-	-	-	-	-	-	-	0.24
Total (%)	0.24	2.50	27.82	34.82	21.00	12.37	1.18	0.07	100.00

NOTES

- Measurement of wave direction is absent; as a result, wave direction is assumed the same as wind direction
- The wave direction shown is the direction the waves are coming from

STATUS
ISSUED FOR USE

CLIENT
Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

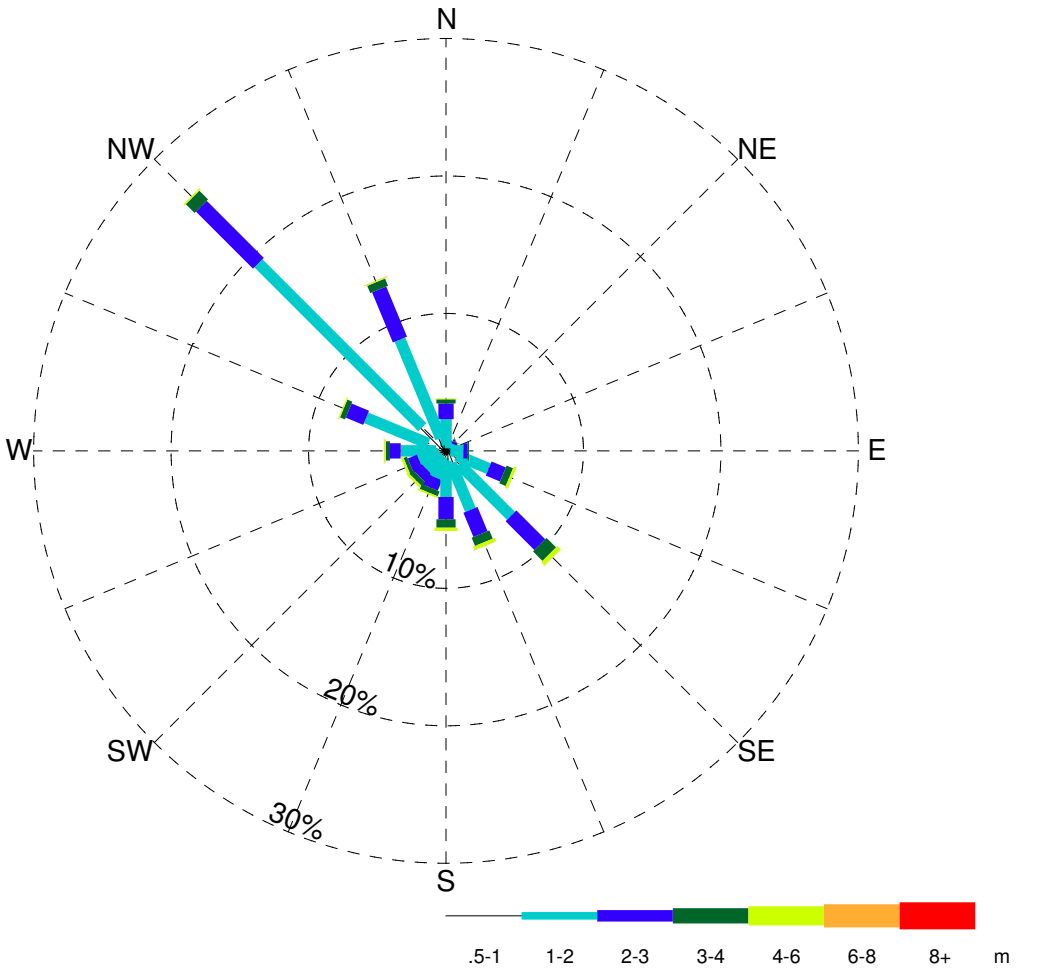
Winter Waves: October-March
La Perouse Bank

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	AL	JAS	JAS	0

OFFICE: EBA-VANC
DATE: November 14, 2012

Figure B.6

A TETRA TECH COMPANY



Canadian Buoy C46132
Location:South Brooks
N49° 43' 48.0" W127° 55' 12.0"
Elevation: Sea Level
Sea level: -
Length of Record
Start Date: May 5, 1994
End Date: Nov 9, 2012
Comment: -

Wave Height & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-.5 m	.5-1 m	1-2 m	2-3 m	3-4 m	4-6 m	6-8 m	8+ m	Total (%)
ENE	-	0.18	0.57	0.15	0.05	0.01	-	-	0.96
NE	-	0.16	0.43	0.15	0.03	-	-	-	0.77
NNE	-	0.14	0.53	0.15	0.03	0.01	-	-	0.87
N	-	0.40	1.90	1.14	0.30	0.06	-	-	3.81
NNW	-	1.01	7.75	3.95	0.58	0.08	0.03	-	13.40
NW	-	2.44	16.86	5.87	0.90	0.12	-	-	26.20
WNW	-	1.41	4.88	1.38	0.39	0.10	-	-	8.16
W	-	0.73	2.57	0.78	0.30	0.11	0.03	-	4.52
WSW	-	0.47	1.59	0.73	0.27	0.17	-	-	3.23
SW	-	0.39	1.54	0.75	0.38	0.18	0.01	-	3.25
SSW	-	0.43	1.65	0.83	0.37	0.14	-	-	3.43
S	-	0.70	2.65	1.62	0.61	0.23	0.01	-	5.83
SSE	-	0.97	3.67	1.91	0.65	0.26	0.01	-	7.48
SE	-	1.36	5.32	2.96	0.98	0.34	0.02	-	10.99
ESE	-	0.82	2.54	1.12	0.51	0.20	0.01	-	5.21
E	-	0.32	0.94	0.32	0.09	0.02	-	-	1.69
Calm	0.19	-	-	-	-	-	-	-	0.19
Total (%)	0.19	11.93	55.41	23.80	6.45	2.07	0.15	-	100.00

NOTES

- Measurement of wave direction is absent; as a result, wave direction is assumed the same as wind direction
- The wave direction shown is the direction the waves are coming from

STATUS
ISSUED FOR USE

CLIENT
Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

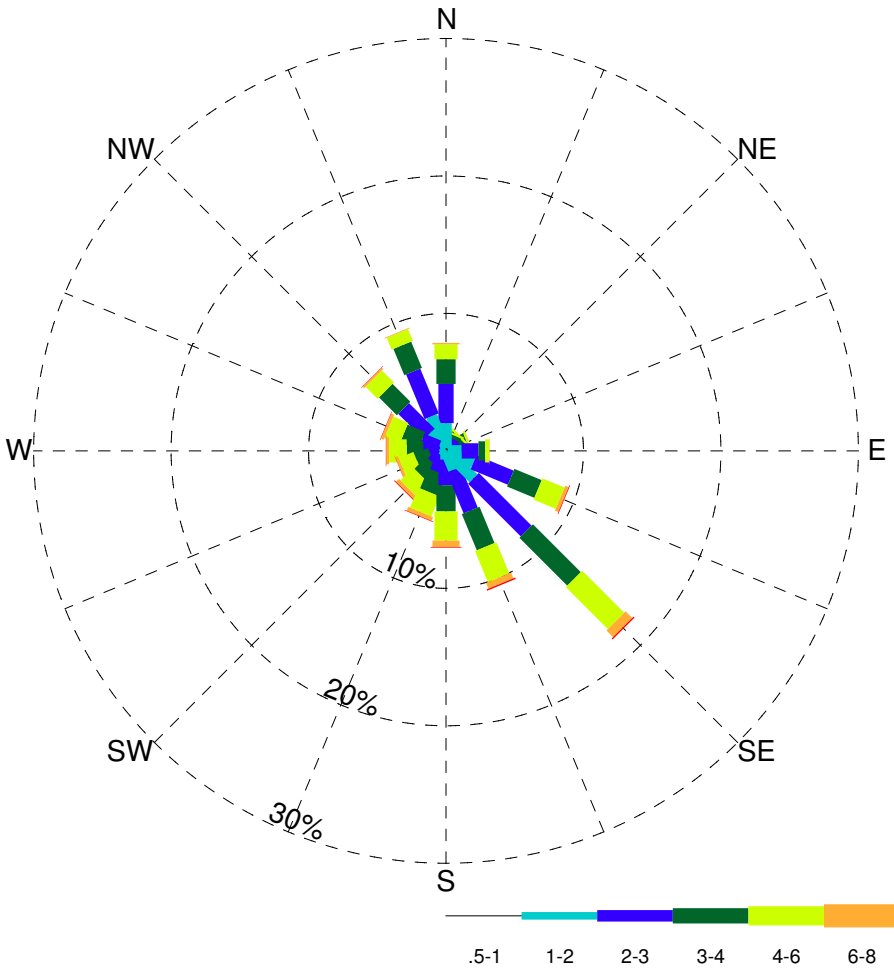
Summer Waves: April-September
South Brooks

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	AL	JAS	JAS	0

OFFICE: EBA-VANC
DATE: November 14, 2012

Figure B.7

A TETRA TECH COMPANY



Canadian Buoy C46132
Location:South Brooks
N49° 43' 48.0" W127° 55' 12.0"
Elevation: Sea Level
Sea level: -
Length of Record
Start Date: May 5, 1994
End Date: Nov 9, 2012
Comment: -

Wave Height & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-.5 m	.5-1 m	1-2 m	2-3 m	3-4 m	4-6 m	6-8 m	8+ m	Total (%)
ENE	-	0.04	0.61	0.70	0.30	0.16	0.01	-	1.82
NE	-	0.04	0.52	0.50	0.29	0.17	-	-	1.52
NNE	-	0.02	0.48	0.48	0.27	0.15	0.02	-	1.42
N	-	0.05	1.96	2.85	1.80	1.08	0.10	-	7.86
NNW	-	0.08	2.65	3.52	2.07	0.93	0.06	-	9.31
NW	-	0.06	1.67	2.63	1.84	1.24	0.14	0.03	7.61
WNW	-	0.05	0.55	1.32	1.40	1.17	0.23	0.04	4.76
W	-	0.04	0.46	1.16	1.21	1.28	0.21	0.03	4.38
WSW	-	0.01	0.29	0.83	1.09	1.16	0.20	0.02	3.61
SW	-	0.02	0.32	0.97	1.24	1.31	0.29	0.06	4.21
SSW	-	0.02	0.40	1.25	1.58	1.57	0.29	0.05	5.15
S	-	0.03	0.61	1.85	1.91	2.12	0.47	0.05	7.04
SSE	-	0.08	1.40	3.21	2.86	2.45	0.44	0.10	10.55
SE	-	0.19	2.63	5.42	4.93	4.31	0.68	0.10	18.27
ESE	-	0.20	1.96	2.94	2.15	1.74	0.27	0.05	9.31
E	-	0.11	1.03	1.22	0.49	0.31	0.02	-	3.17
Calm	0.01	-	-	-	-	-	-	-	0.01
Total (%)	0.01	1.05	17.54	30.84	25.42	21.14	3.45	0.54	100.00

NOTES

- Measurement of wave direction is absent; as a result, wave direction is assumed the same as wind direction
- The wave direction shown is the direction the waves are coming from

STATUS
ISSUED FOR USE

CLIENT
Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

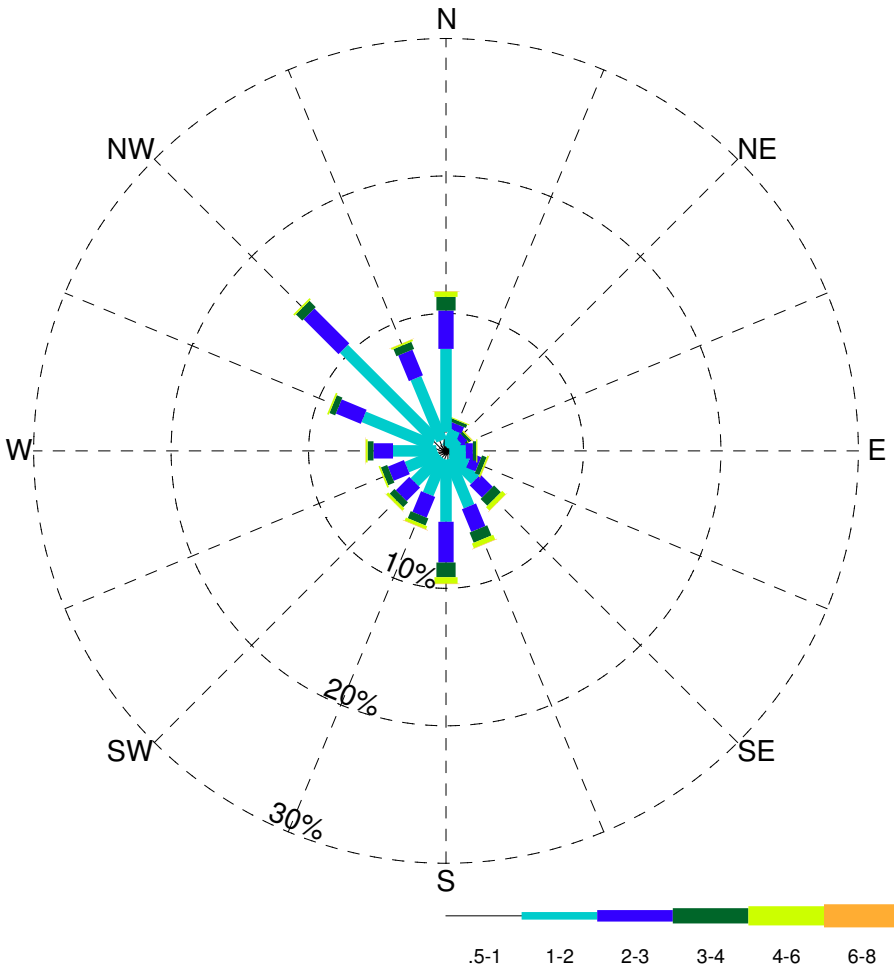
Winter Waves: October-March
South Brooks

A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	AL	JAS	JAS	0

OFFICE: EBA-VANC
DATE: November 14, 2012

Figure B.8



Canadian Buoy C46207
Location:East Dellwood
N50° 51' 36.0" W129° 54' 36.0"
Elevation: Sea Level
Sea level: -
Length of Record
Start Date: Oct 18, 1989
End Date: Nov 9, 2012
Comment: -

Wave Height & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-.5 m	.5-1 m	1-2 m	2-3 m	3-4 m	4-6 m	6-8 m	8+ m	Total (%)
ENE	-	0.18	0.92	0.41	0.18	0.08	-	-	1.78
NE	-	0.21	0.97	0.46	0.20	0.08	0.02	-	1.93
NNE	-	0.30	1.30	0.49	0.26	0.07	-	-	2.43
N	-	1.38	6.04	2.79	0.99	0.39	0.03	-	11.62
NNW	-	0.83	4.89	2.02	0.56	0.14	0.02	-	8.46
NW	-	1.17	9.34	3.59	0.65	0.13	-	-	14.88
WNW	-	1.06	5.42	1.96	0.45	0.13	-	-	9.03
W	-	0.71	3.14	1.42	0.43	0.14	0.02	-	5.86
WSW	-	0.58	2.50	1.27	0.49	0.13	-	-	4.97
SW	-	0.54	2.68	1.39	0.50	0.22	0.02	-	5.34
SSW	-	0.59	2.81	1.63	0.56	0.24	0.04	-	5.88
S	-	0.65	4.51	2.96	1.07	0.47	0.03	-	9.69
SSE	-	0.61	3.76	1.78	0.81	0.37	0.03	-	7.35
SE	-	0.59	2.40	1.26	0.70	0.35	0.02	-	5.32
ESE	-	0.37	1.45	0.73	0.36	0.12	0.02	-	3.05
E	-	0.24	1.20	0.51	0.24	0.09	-	-	2.29
Calm	0.10	-	-	-	-	-	-	-	0.10
Total (%)	0.10	10.01	53.34	24.68	8.45	3.14	0.27	0.01	100.00

NOTES

- Measurement of wave direction is absent; as a result, wave direction is assumed the same as wind direction
- The wave direction shown is the direction the waves are coming from

STATUS
ISSUED FOR USE

CLIENT
Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

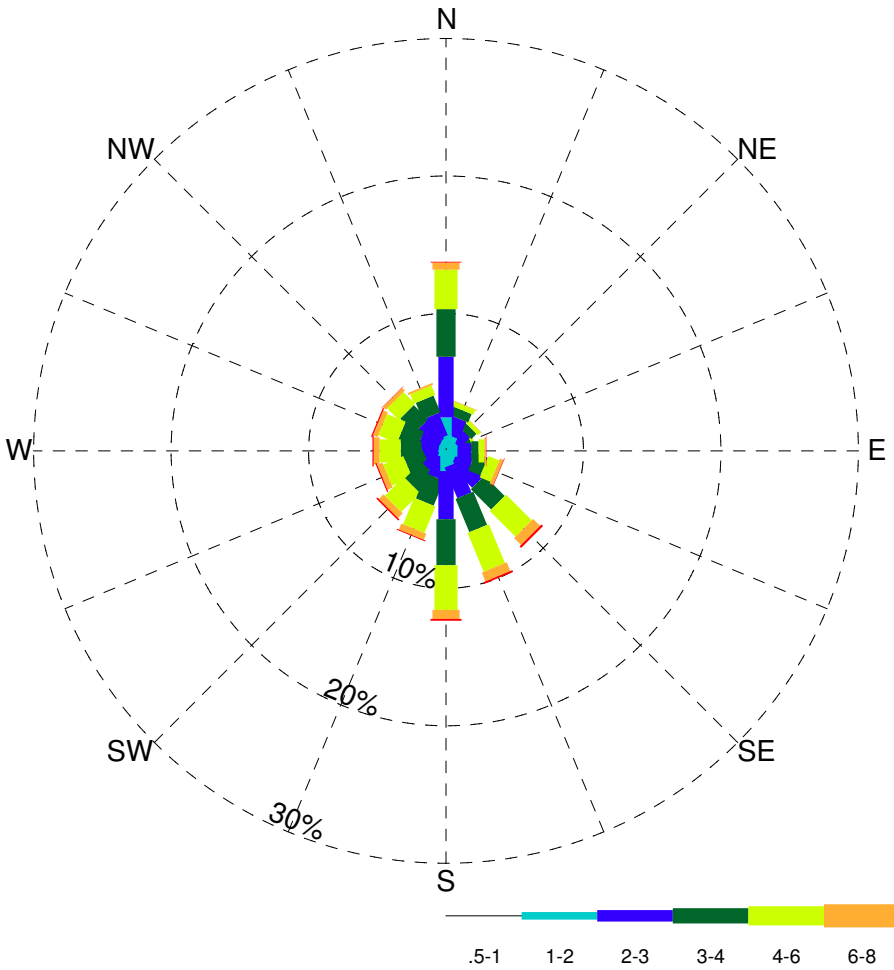
Summer Waves: April-September
East Dellwood

A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	AL	JAS	JAS	0

OFFICE: EBA-VANC
DATE: November 14, 2012

Figure B.9



Canadian Buoy C46207
Location:East Dellwood
N50° 51' 36.0" W129° 54' 36.0"
Elevation: Sea Level
Sea level: -
Length of Record
Start Date: Oct 18, 1989
End Date: Nov 9, 2012
Comment: -

Wave Height & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-.5 m	.5-1 m	1-2 m	2-3 m	3-4 m	4-6 m	6-8 m	8+ m	Total (%)
ENE	-	0.05	0.68	0.79	0.40	0.21	0.03	-	2.15
NE	-	0.05	0.81	1.05	0.53	0.31	0.03	-	2.79
NNE	-	0.04	1.11	1.37	0.66	0.37	0.05	-	3.61
N	-	0.07	2.37	4.41	3.46	2.87	0.52	0.06	13.76
NNW	-	0.03	0.97	1.76	1.31	0.73	0.14	-	4.95
NW	-	0.02	0.72	1.80	1.48	1.20	0.28	0.03	5.53
WNW	-	0.02	0.55	1.46	1.50	1.46	0.35	0.09	5.44
W	-	0.01	0.48	1.27	1.52	1.54	0.42	0.09	5.35
WSW	-	0.01	0.43	1.09	1.48	1.59	0.41	0.09	5.11
SW	-	0.02	0.44	1.37	1.68	1.93	0.47	0.12	6.05
SSW	-	0.03	0.52	1.52	1.97	2.09	0.48	0.08	6.67
S	-	0.10	1.39	3.49	3.34	3.25	0.66	0.14	12.36
SSE	-	0.07	1.02	2.41	2.62	3.06	0.69	0.14	10.01
SE	-	0.04	1.00	2.21	2.09	2.64	0.71	0.16	8.86
ESE	-	0.05	0.73	1.27	0.96	0.84	0.27	0.04	4.16
E	-	0.06	0.79	0.99	0.53	0.42	0.12	0.03	2.93
Calm	0.28	-	-	-	-	-	-	-	0.28
Total (%)	0.28	0.68	14.00	28.25	25.56	24.52	5.62	1.10	100.00

NOTES

- Measurement of wave direction is absent; as a result, wave direction is assumed the same as wind direction
- The wave direction shown is the direction the waves are coming from

STATUS
ISSUED FOR USE

CLIENT
Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

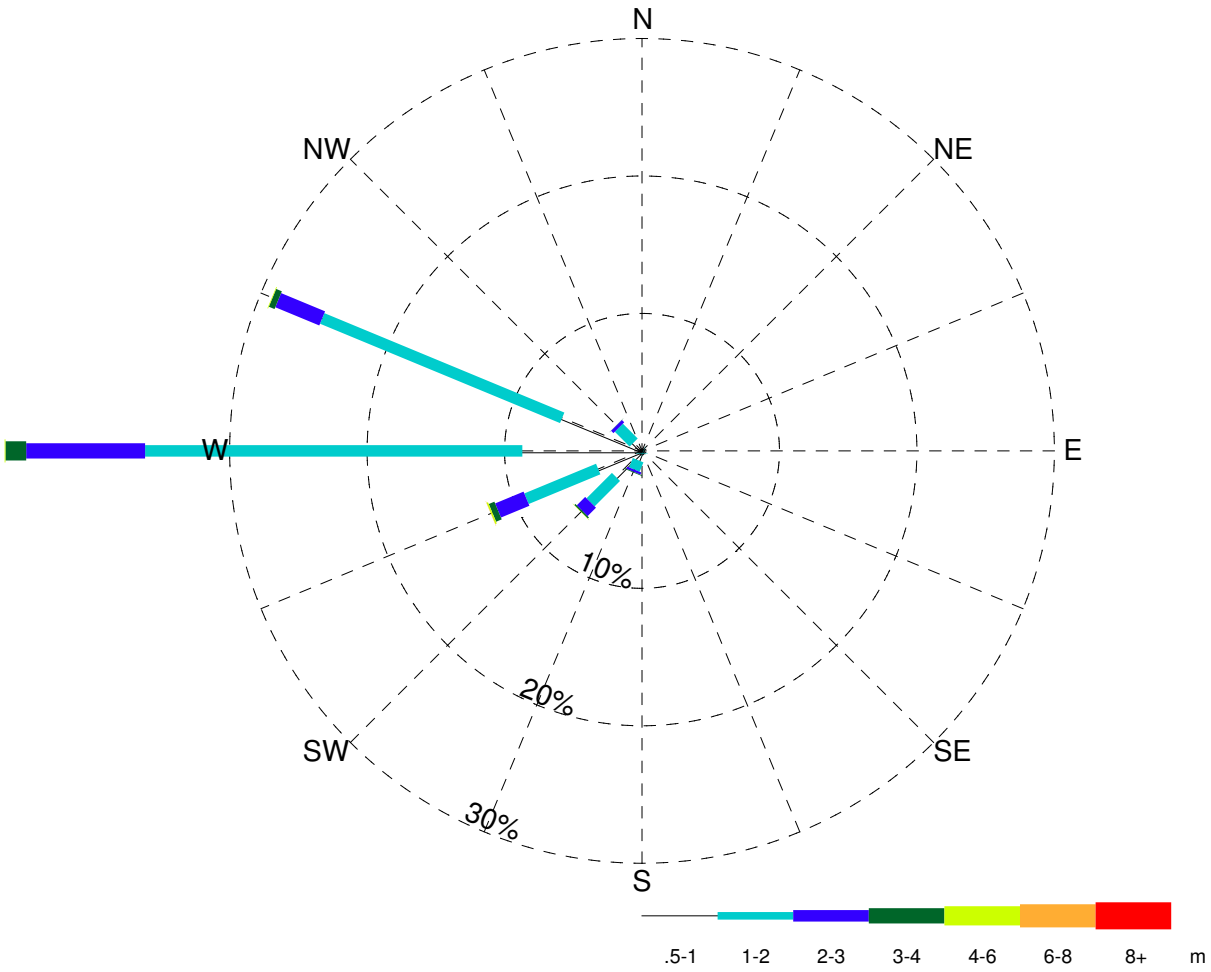
Winter Waves: October-March
East Dellwood

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	AL	JAS	JAS	0

OFFICE: EBA-VANC
DATE: November 14, 2012

A TETRA TECH COMPANY

Figure B.10



NOAA Buoy 46087
Location:Neah Bay
N48° 29' 37.0" W124° 43' 39.0"
Elevation: Sea Level
Sea level: -
Length of Record
Start Date: July 9, 2004
End Date: Sep 30, 2012
Comment: -

Wave Height & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-.5 m	.5-1 m	1-2 m	2-3 m	3-4 m	4-6 m	6-8 m	8+ m	Total (%)
ENE	-	-	-	-	-	-	-	-	-
NE	-	-	-	-	-	-	-	-	-
NNE	-	0.01	-	-	-	-	-	-	0.01
N	-	0.01	-	-	-	-	-	-	0.01
NNW	-	0.03	-	-	-	-	-	-	0.03
NW	-	0.86	1.52	0.24	0.01	-	-	-	2.64
WNW	-	6.28	18.90	3.46	0.45	0.05	-	-	29.15
W	-	8.70	27.45	8.65	1.51	0.06	-	-	46.37
WSW	-	3.45	5.65	2.24	0.44	0.11	0.02	-	11.91
SW	-	2.68	2.61	0.86	0.11	0.03	-	-	6.30
SSW	-	0.73	0.74	0.17	0.05	-	-	-	1.70
S	-	0.15	0.04	-	-	-	-	-	0.19
SSE	-	0.06	-	-	-	-	-	-	0.06
SE	-	0.03	-	-	-	-	-	-	0.03
ESE	-	0.10	0.02	-	-	-	-	-	0.12
E	-	0.03	-	-	-	-	-	-	0.03
Calm	1.44	-	-	-	-	-	-	-	1.44
Total (%)	1.44	23.13	56.94	15.63	2.58	0.26	0.03	-	100.00

NOTES

- Wave direction is measured at the buoy
- The wave direction shown is the direction the waves are coming from

STATUS
ISSUED FOR USE

CLIENT
Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

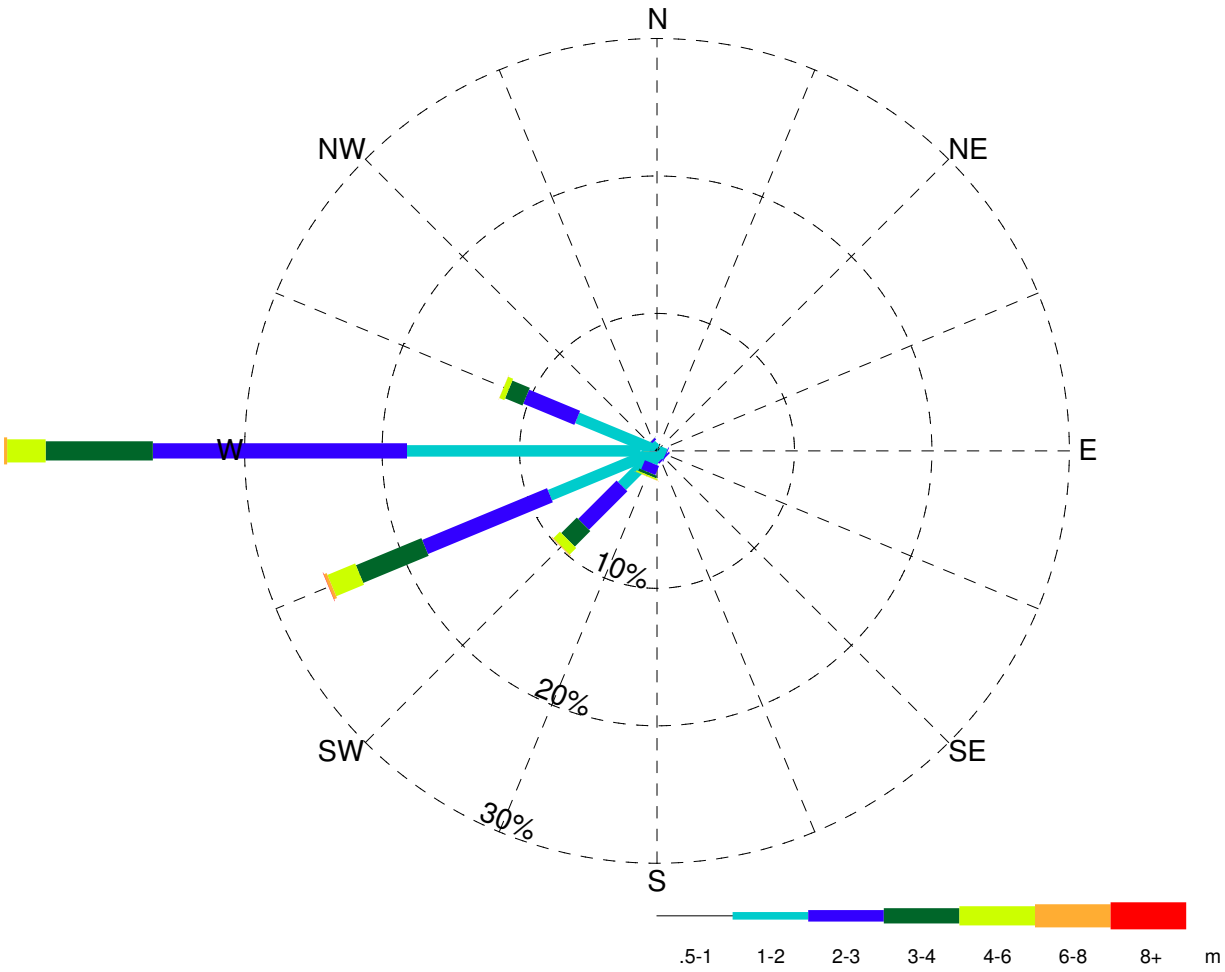
Summer Waves: April-September
Neah Bay, Juan de Fuca Strait

A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	AL	JAS	JAS	0

OFFICE: EBA-VANC
DATE: November 14, 2012

Figure B.11



NOAA Buoy 46087
Location:Neah Bay
N48° 29' 37.0" W124° 43' 39.0"
Elevation: Sea Level
Sea level: -
Length of Record
Start Date: July 9, 2004
End Date: Sep 30, 2012
Comment: -

Wave Height & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-.5 m	.5-1 m	1-2 m	2-3 m	3-4 m	4-6 m	6-8 m	8+ m	Total (%)
ENE	-	0.01	0.01	-	-	-	-	-	0.03
NE	-	-	-	-	-	-	-	-	-
NNE	-	-	-	-	-	-	-	-	-
N	-	-	-	-	-	-	-	-	-
NNW	-	-	-	-	-	-	-	-	-
NW	-	0.14	0.50	0.16	0.02	-	-	-	0.82
WNW	-	0.45	5.83	4.02	1.37	0.39	0.01	-	12.08
W	-	1.20	16.99	18.49	7.80	2.80	0.23	-	47.51
WSW	-	0.53	7.90	9.84	5.15	2.18	0.22	0.03	25.86
SW	-	0.29	3.31	3.95	1.60	0.67	0.06	-	9.89
SSW	-	0.06	0.90	0.72	0.20	0.11	0.02	-	2.00
S	-	-	0.04	0.01	-	-	0.02	-	0.08
SSE	-	0.02	-	-	-	-	-	-	0.03
SE	-	0.06	0.60	0.13	-	-	-	-	0.78
ESE	-	0.11	0.56	0.06	-	-	-	-	0.72
E	-	0.03	0.06	-	-	-	-	-	0.09
Calm	0.09	-	-	-	-	-	-	-	0.09
Total (%)	0.09	2.91	36.70	37.38	16.15	6.16	0.56	0.04	100.00

NOTES

- Wave direction is measured at the buoy
- The wave direction shown is the direction the waves are coming from

CLIENT
Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Winter Waves: October-March
Neah Bay, Juan de Fuca Strait

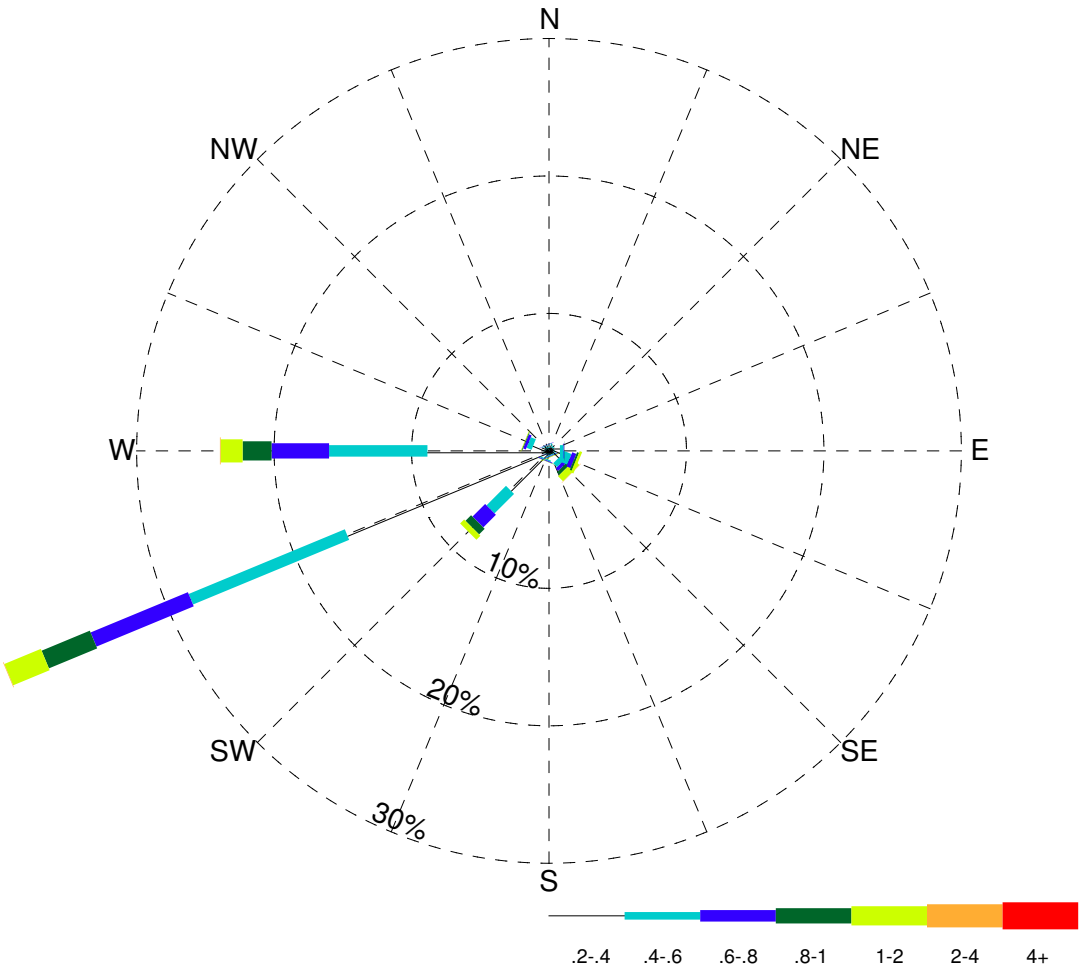
STATUS
ISSUED FOR USE

eba
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	AL	JAS	JAS	0

OFFICE: EBA-VANC
DATE: November 14, 2012

Figure B.12



NOAA Buoy 46088
Location:Juan de Fuca Strait
N48° 20' 8.0" W123° 9' 31.0"
Elevation: Sea Level
Sea level: -
Length of Record
Start Date: July 1, 2004
End Date: Sep 30, 2012
Comment: -

Wave Height & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-.1 m	.2-.4 m	.4-.6 m	.6-.8 m	.8-1 m	1-2 m	2-4 m	4+ m	Total (%)
ENE	-	0.32	0.06	-	-	-	-	-	0.38
NE	-	0.06	0.02	-	-	-	-	-	0.08
NNE	-	0.09	0.02	-	-	-	-	-	0.10
N	-	0.23	0.03	-	-	-	-	-	0.27
NNW	-	0.42	0.03	0.02	-	-	-	-	0.47
NW	-	0.21	0.02	-	-	-	-	-	0.24
WNW	-	1.21	0.40	0.21	0.06	0.04	-	-	1.91
W	-	8.85	7.15	4.19	2.10	1.60	0.05	-	23.94
WSW	-	15.91	12.30	7.66	3.80	2.88	0.04	-	42.59
SW	-	4.01	2.01	1.30	0.58	0.41	-	-	8.31
SSW	-	0.60	0.09	0.06	0.02	0.01	-	-	0.79
S	-	0.21	0.03	0.01	-	-	-	-	0.26
SSE	-	0.31	0.06	0.04	0.02	0.04	-	-	0.48
SE	-	0.85	0.40	0.26	0.26	0.51	0.03	-	2.31
ESE	-	0.96	0.64	0.32	0.15	0.19	-	-	2.27
E	-	0.80	0.27	0.05	0.01	-	-	-	1.12
Calm	14.48	-	-	-	-	-	-	-	14.48
Total (%)	14.48	35.04	23.53	14.12	7.01	5.68	0.13	-	100.00

NOTES

- Wave direction is measured at the buoy
- The wave direction shown is the direction the waves are coming from

CLIENT
Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Summer Waves: April-September
New Dungeness, Juan de Fuca Strait

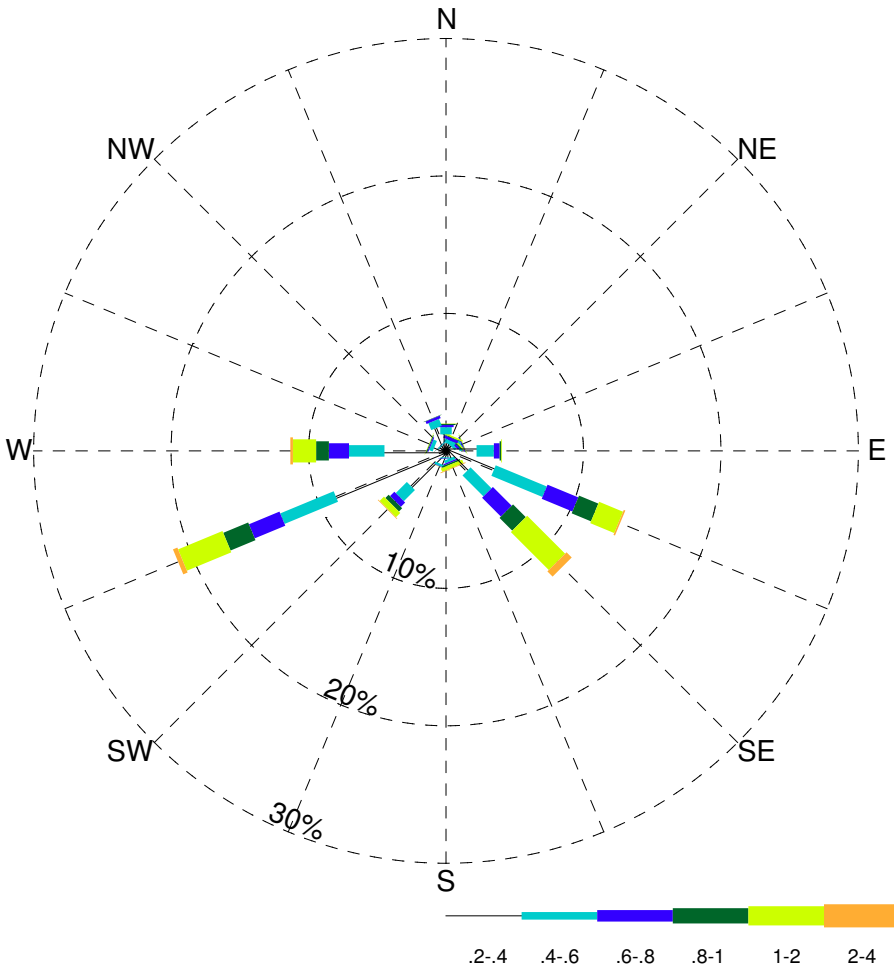
STATUS
ISSUED FOR USE

eba
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	AL	JAS	JAS	0

OFFICE: EBA-VANC
DATE: November 14, 2012

Figure B.13



NOAA Buoy 46088
Location:Juan de Fuca Strait
N48° 20' 8.0" W123° 9' 31.0"
Elevation: Sea Level
Sea level: -
Length of Record
Start Date: July 1, 2004
End Date: Sep 30, 2012
Comment: -

Wave Height & Direction Frequency Distribution Table

	Percent Occurrence (%)								
Direction	0-.1 m	.2-.4 m	.4-.6 m	.6-.8 m	.8-1 m	1-2 m	2-4 m	4+ m	Total (%)
ENE	-	0.91	0.30	0.08	0.04	0.03	-	-	1.35
NE	-	0.48	0.20	0.17	0.09	0.10	-	-	1.04
NNE	-	0.54	0.28	0.21	0.04	0.10	-	-	1.18
N	-	1.20	0.53	0.15	0.09	0.03	-	-	1.99
NNW	-	1.80	0.54	0.20	0.03	-	-	-	2.57
NW	-	0.47	0.07	0.01	0.01	-	-	-	0.56
WNW	-	0.88	0.28	0.09	0.06	0.03	-	-	1.35
W	-	4.48	2.58	1.47	0.93	1.69	0.19	-	11.32
WSW	-	8.67	4.21	2.41	1.97	3.50	0.34	-	21.10
SW	-	3.61	1.15	0.45	0.34	0.44	0.05	-	6.04
SSW	-	1.02	0.17	0.04	-	0.03	-	-	1.26
S	-	0.47	0.07	0.03	-	-	-	-	0.58
SSE	-	0.61	0.22	0.10	0.12	0.26	0.06	-	1.36
SE	-	2.11	2.16	1.93	1.31	3.91	0.53	-	11.95
ESE	-	3.74	4.02	2.42	1.52	1.89	0.12	-	13.71
E	-	2.22	1.26	0.42	0.12	0.06	-	-	4.07
Calm	18.56	-	-	-	-	-	-	-	18.56
Total (%)	18.56	33.22	18.03	10.17	6.67	12.05	1.30	-	100.00

NOTES

- Wave direction is measured at the buoy
- The wave direction shown is the direction the waves are coming from

STATUS
ISSUED FOR USE

CLIENT
Kinder Morgan

A TETRA TECH COMPANY

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Winter Waves: October-March
New Dungeness, Juan de Fuca Strait

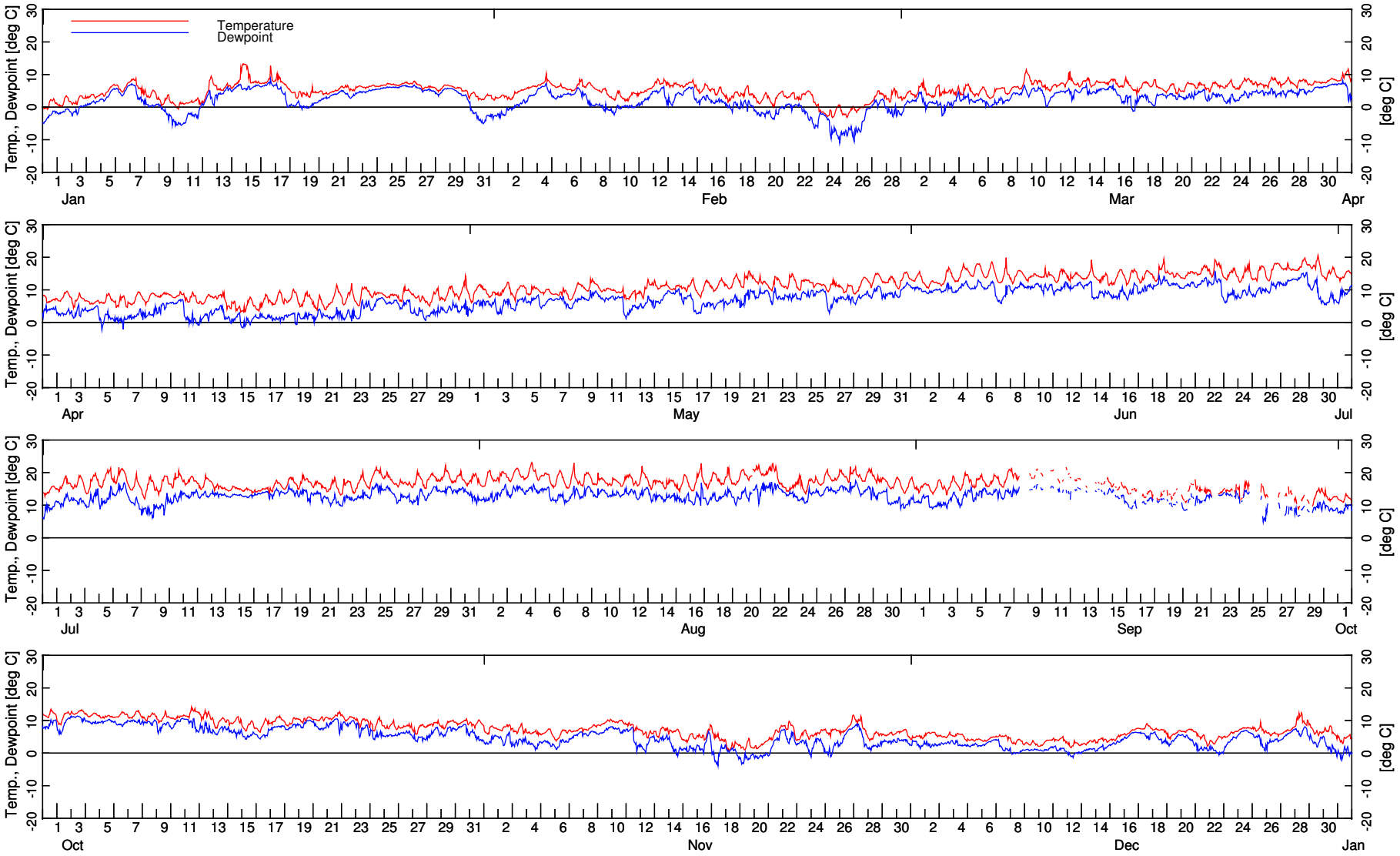
PROJECT NO.	DWN	CHK	APVD	REV
V13203022	AL	JAS	JAS	0

OFFICE: EBA-VANC
DATE: November 14, 2012

Figure B.14

APPENDIX C

2011 TIME SERIES PLOTS OF TEMPERATURE, DEWPOINT AND VISIBILITY



NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Hourly surface air temperature and dew point
Ballenas Islands: 2011

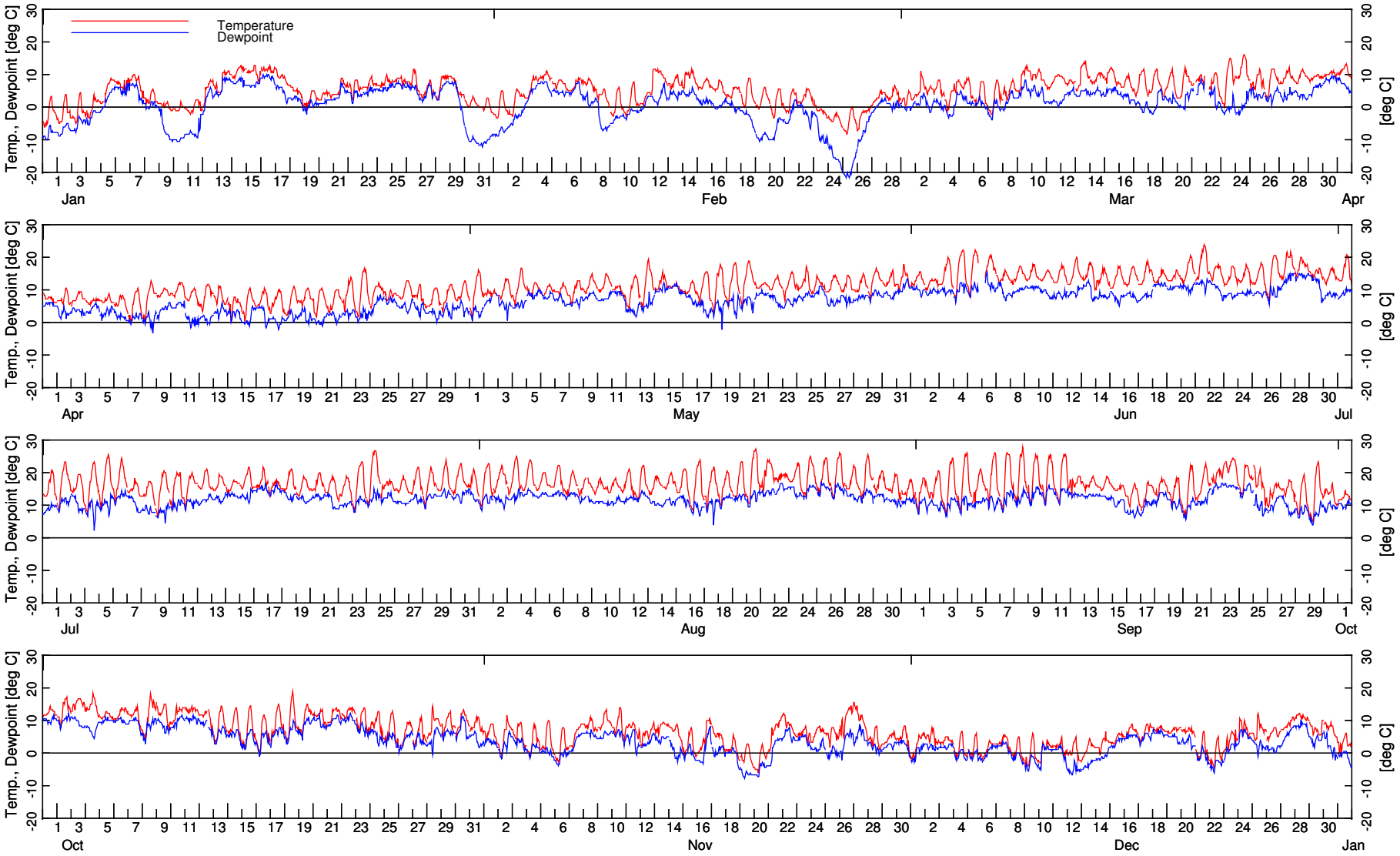
STATUS
ISSUED FOR USE

eba
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 07, 2012

Figure C.1



NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Hourly surface air temperature and dew point
Bellingham Intl: 2011

STATUS
ISSUED FOR USE

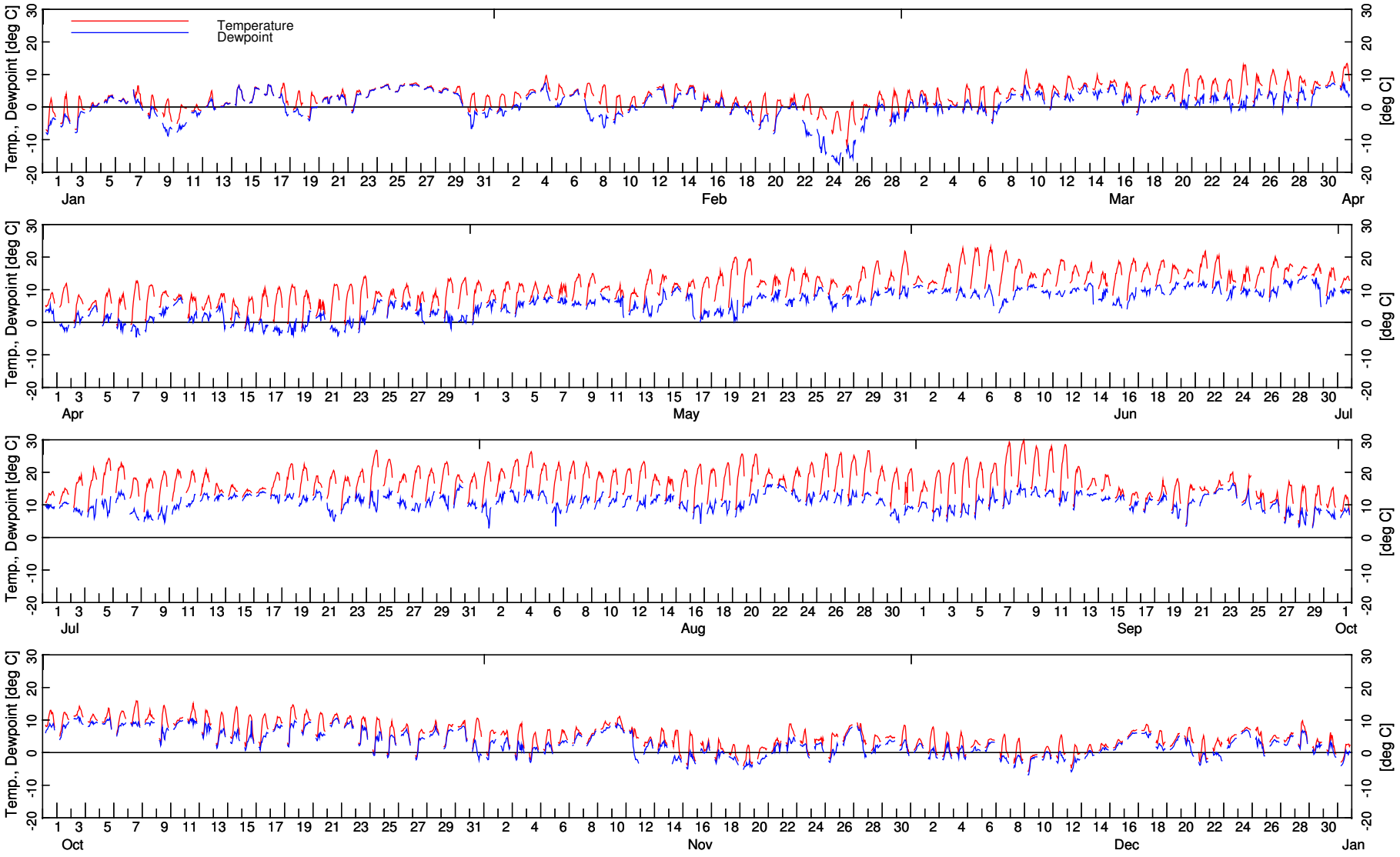
eba
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 07, 2012

Figure C.2

Fri Dec 07 19:34:13 2012:V:\V13203022 Trans Mountain\working\DD\02_NOAA_NCDC\01_MetData_Scripts\Bellingham_Intl



NOTES

STATUS
ISSUED FOR USE

CLIENT

Kinder Morgan

eba
A TETRA TECH COMPANY

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

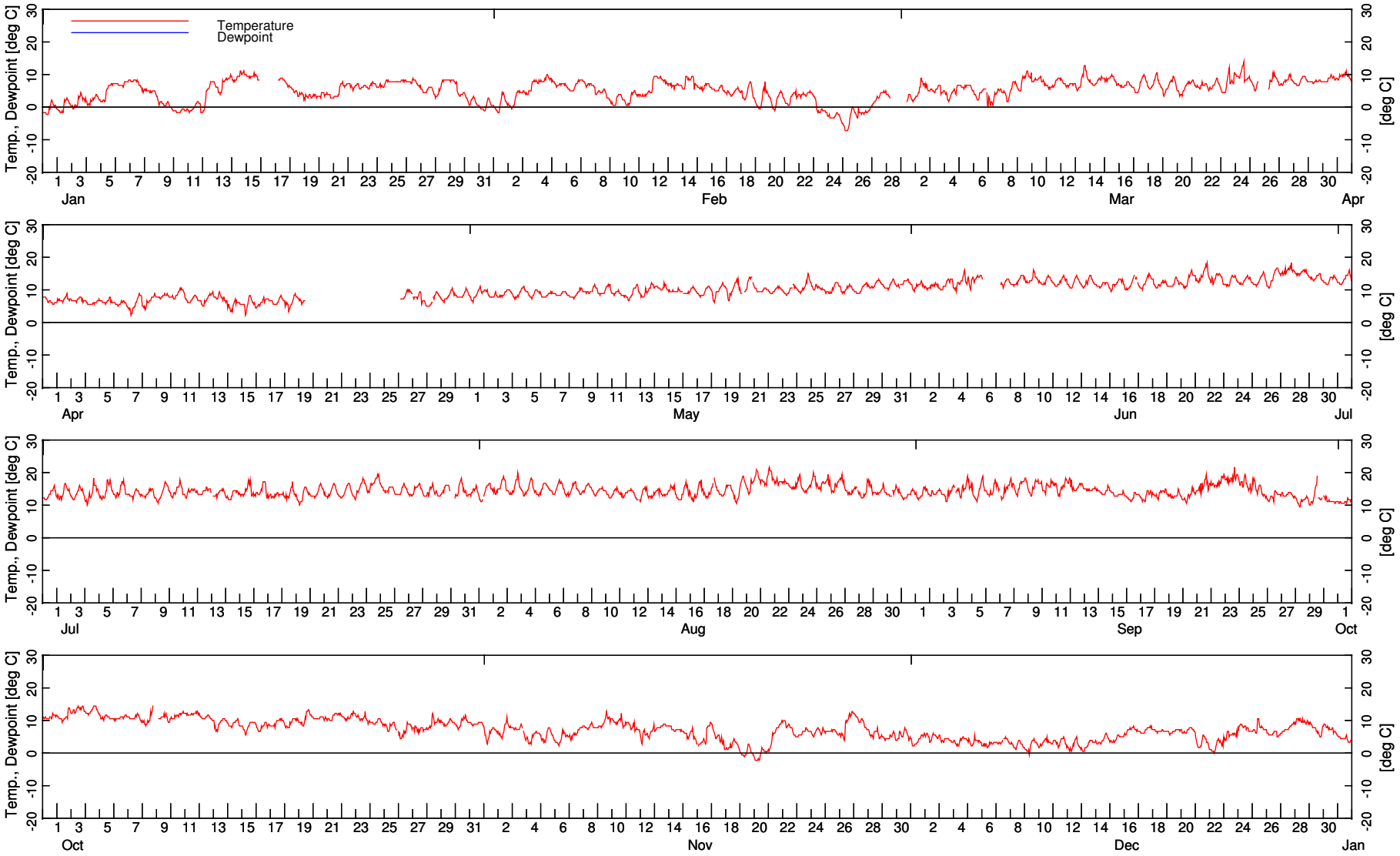
Hourly surface air temperature and dew point
Campbell River Airport: 2011

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 07, 2012

Figure C.3

Fri Dec 07 19:27:48 2012:V:\V13203022 Trans Mountain\working\DD\01_EC\01_MetData_Scripts\Campbell_River_Airport



NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Hourly surface air temperature and dew point
Cherry Point: 2011

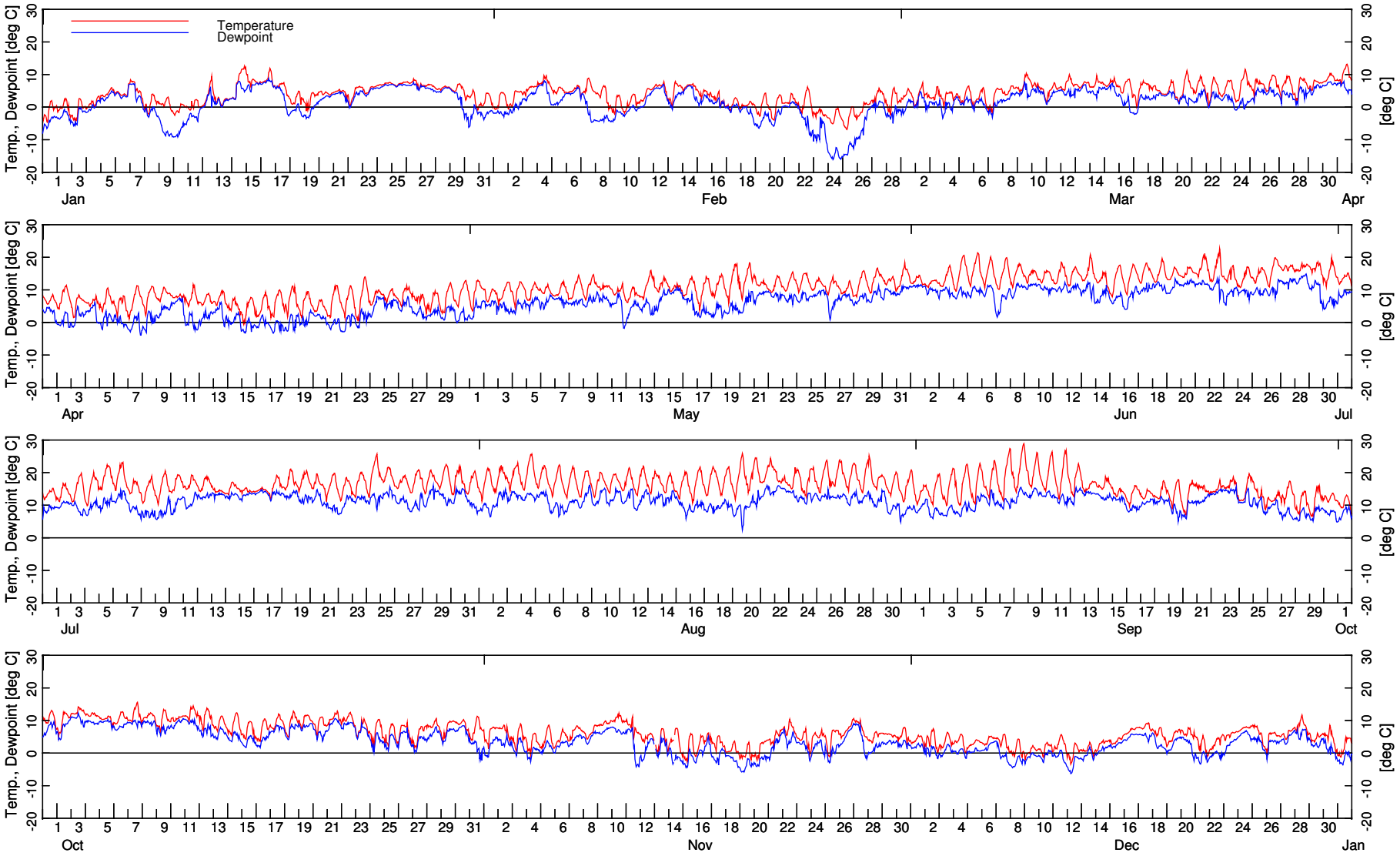
STATUS
ISSUED FOR USE

eba
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 07, 2012

Figure C.4



NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Hourly surface air temperature and dew point
Comox Airport: 2011

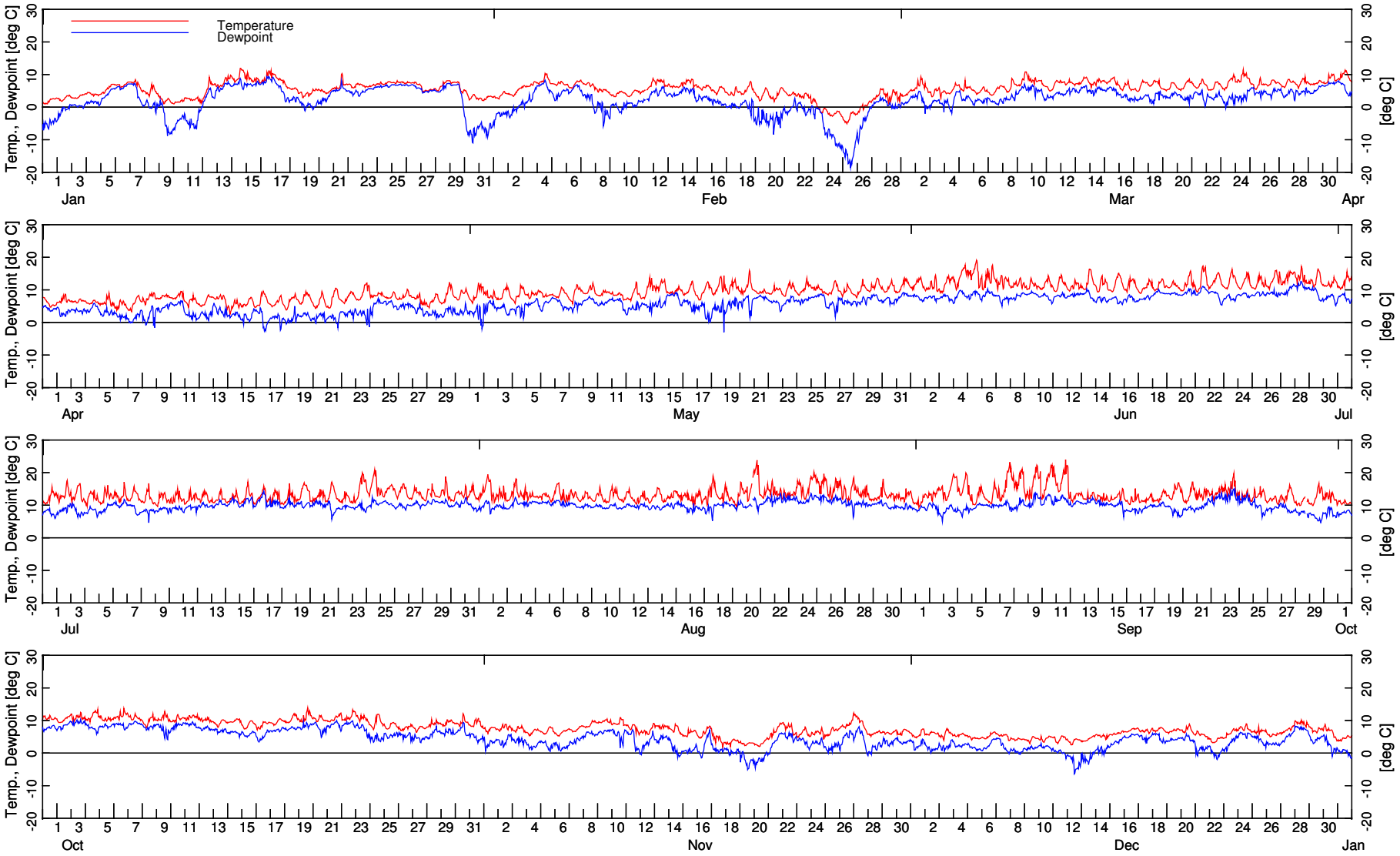
STATUS
ISSUED FOR USE

A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 07, 2012

Figure C.5



NOTES ISSUED FO

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Hourly surface air temperature and dew point
Discovery Island: 2011

STATUS
ISSUED FOR USE

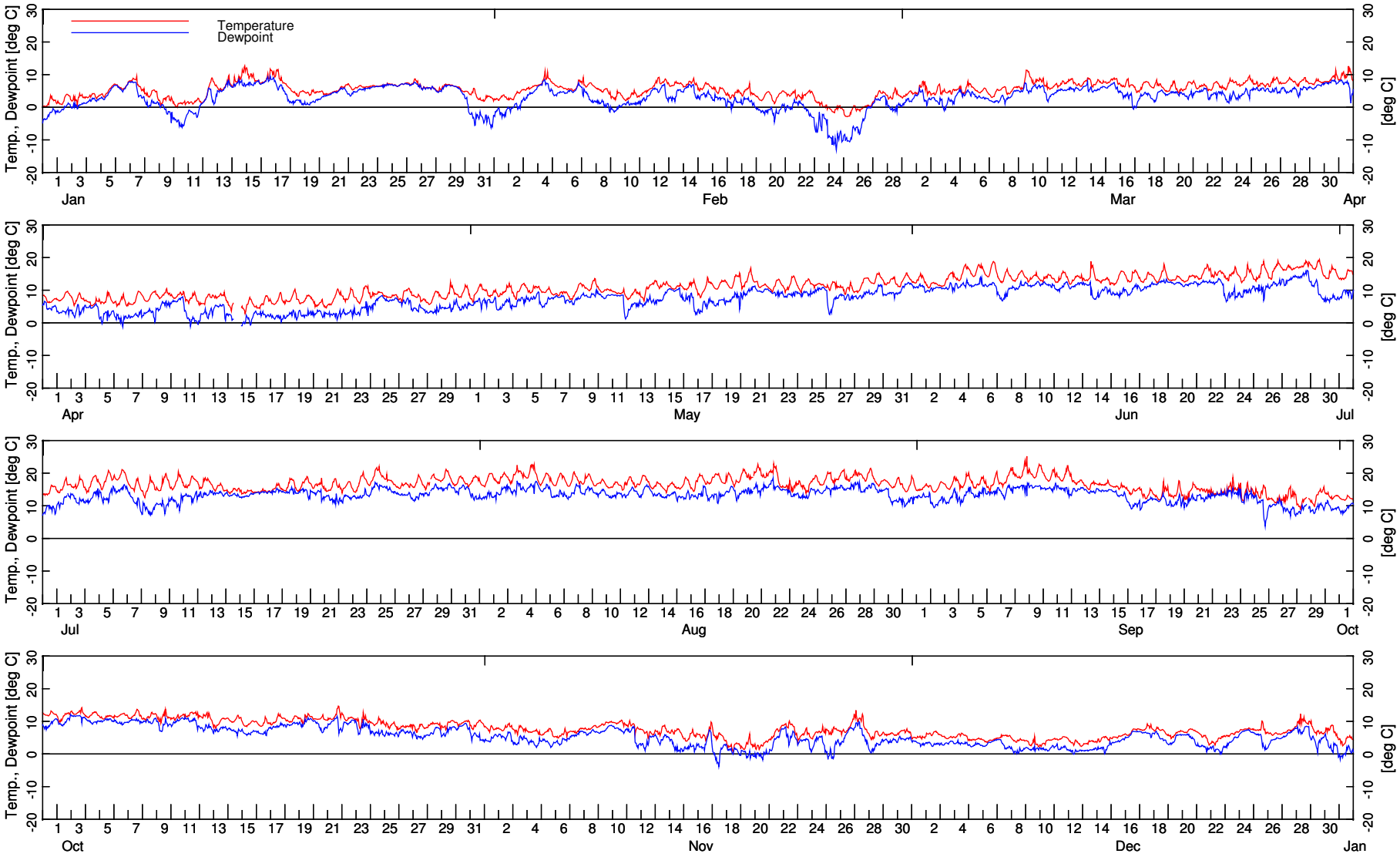
eba
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 07, 2012

Figure C.6

Fri Dec 07 19:36:50 2012:V:\V13203022 Trans Mountain\working\DD\01_EC\01_MetData_Scripts\Discovery_Island



NOTES

STATUS
ISSUED FOR USE

CLIENT

Kinder Morgan

eba
A TETRA TECH COMPANY

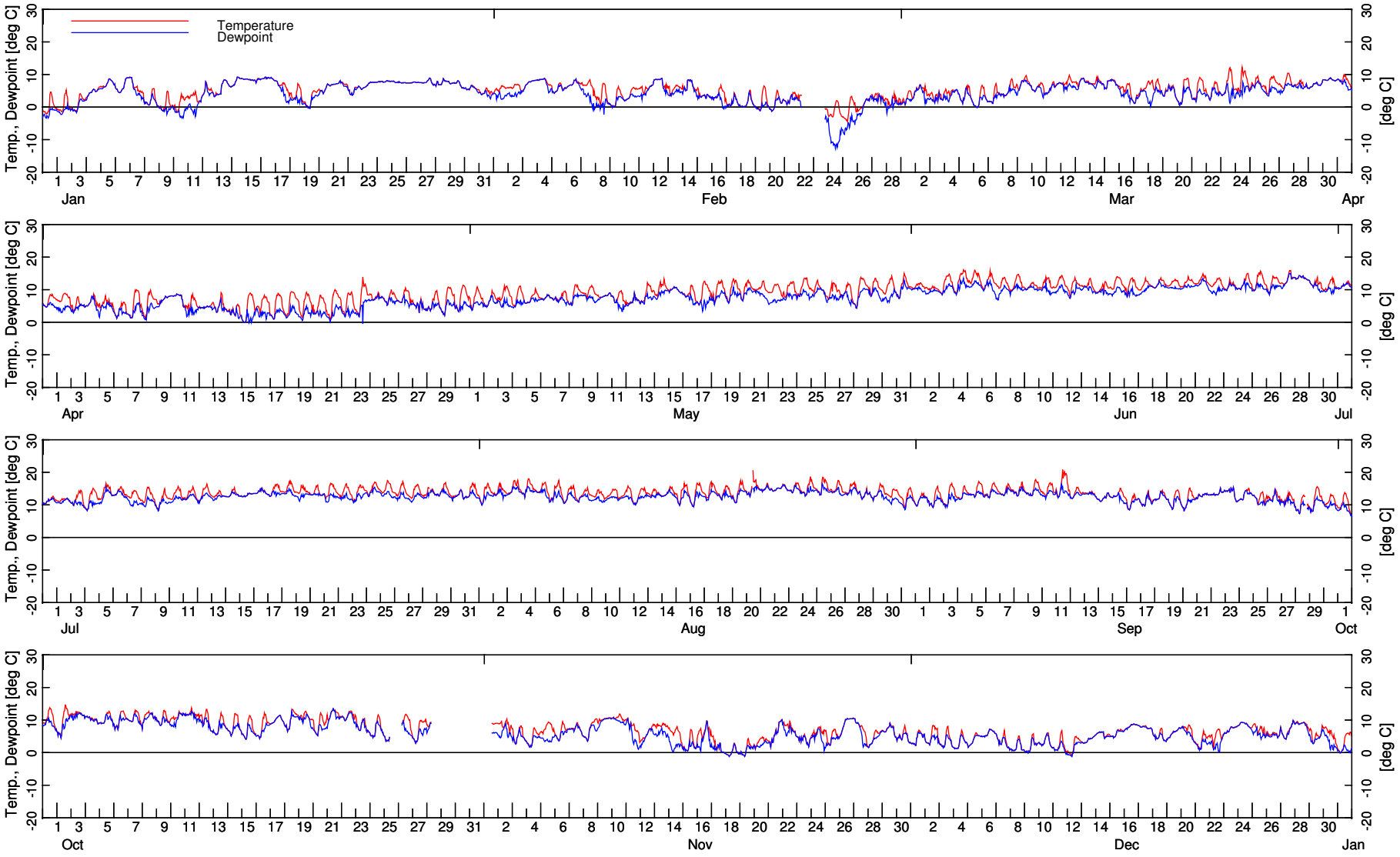
METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Hourly surface air temperature and dew point
Entrance Island: 2011

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 07, 2012

Figure C.7



NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Hourly surface air temperature and dew point
Estevan Point: 2011

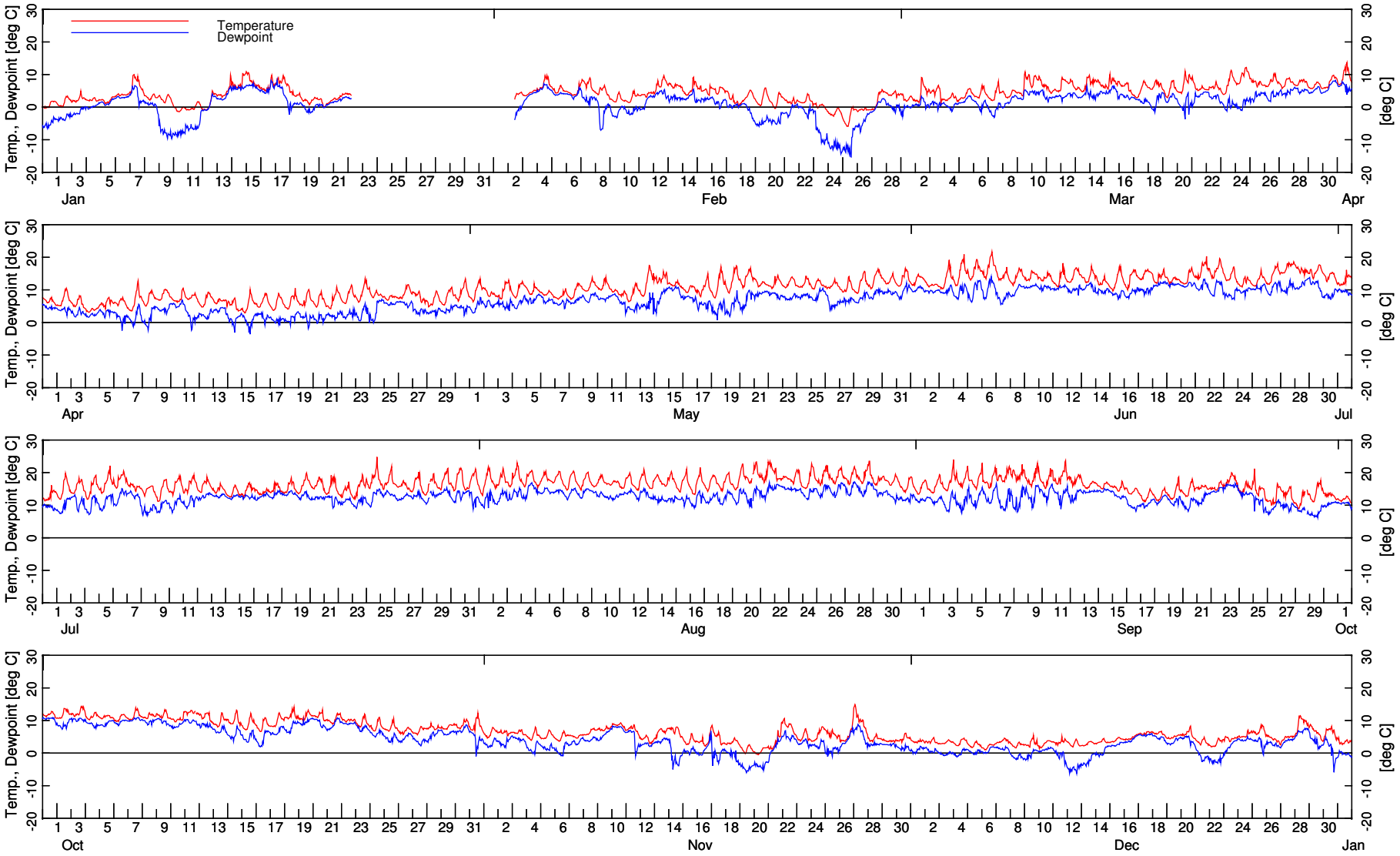
STATUS
ISSUED FOR USE

A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 07, 2012

Figure C.8



NOTES

STATUS
ISSUED FOR USE

CLIENT

Kinder Morgan

A TETRA TECH COMPANY

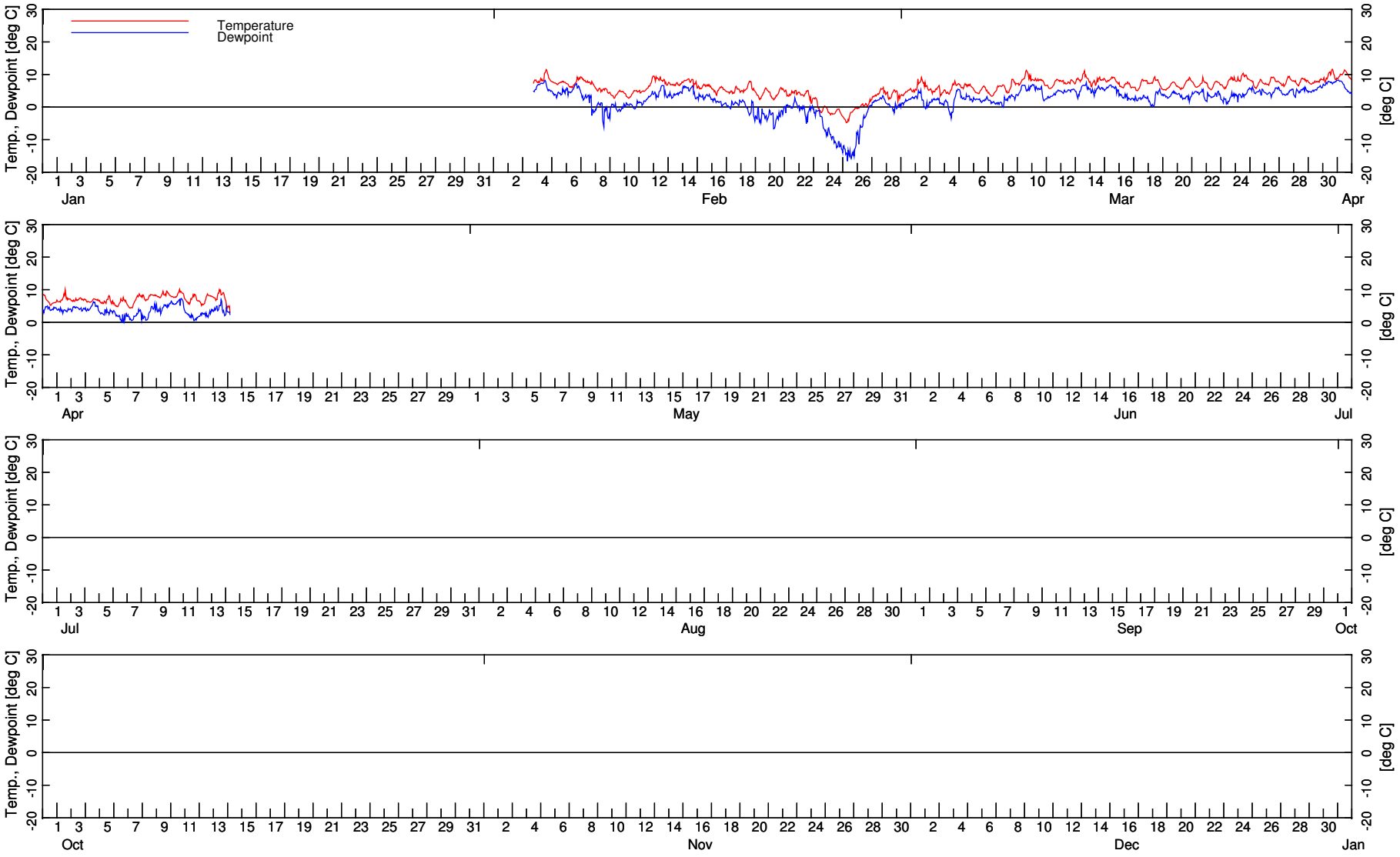
METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Hourly surface air temperature and dew point
Howe Sound-Pam Rocks: 2011

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 07, 2012

Figure C.9



NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Hourly surface air temperature and dew point
Kelp Reefs: 2011

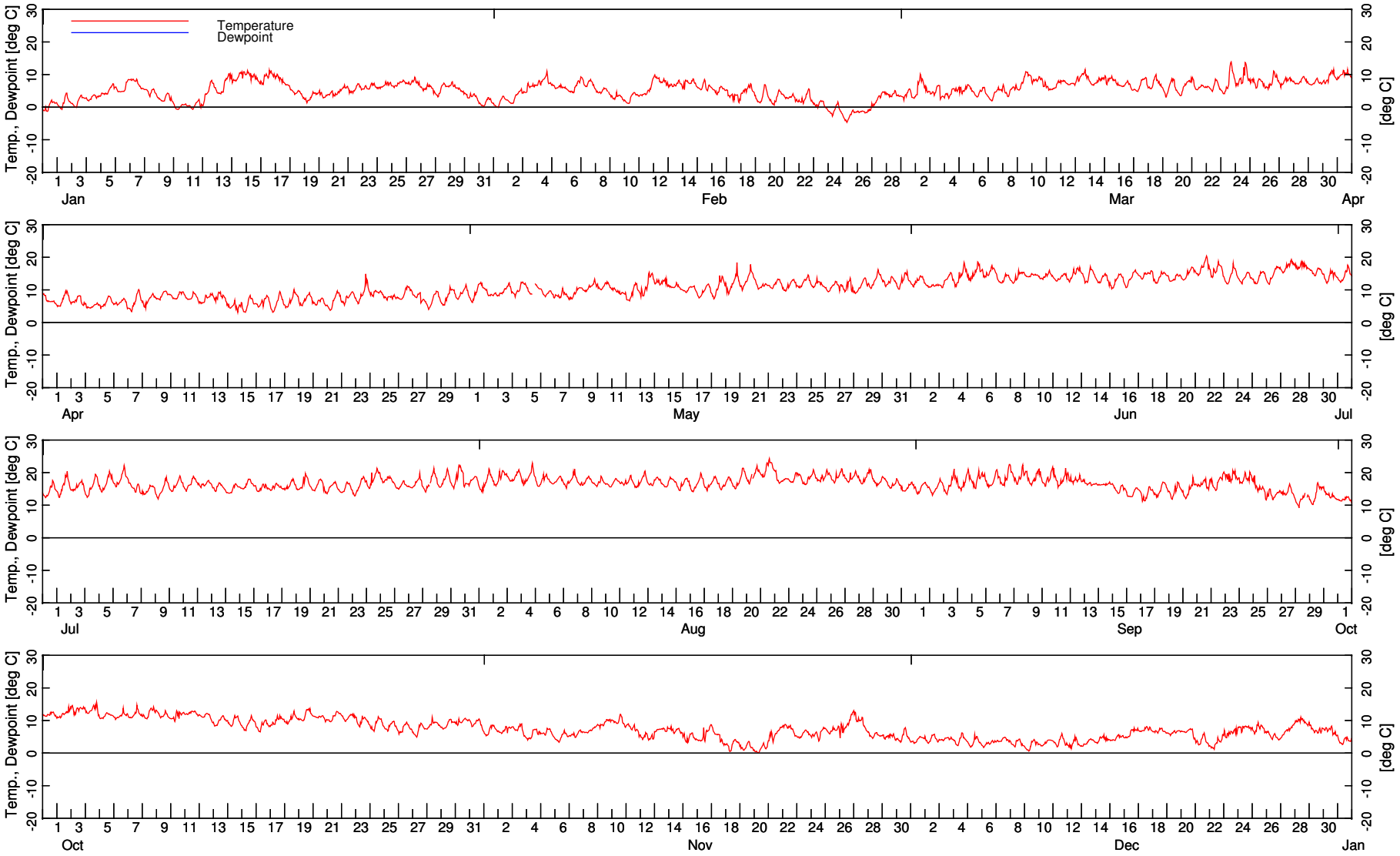
STATUS
ISSUED FOR USE

A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 07, 2012

Figure C.10



NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Hourly surface air temperature and dew point
Point Atkinson: 2011

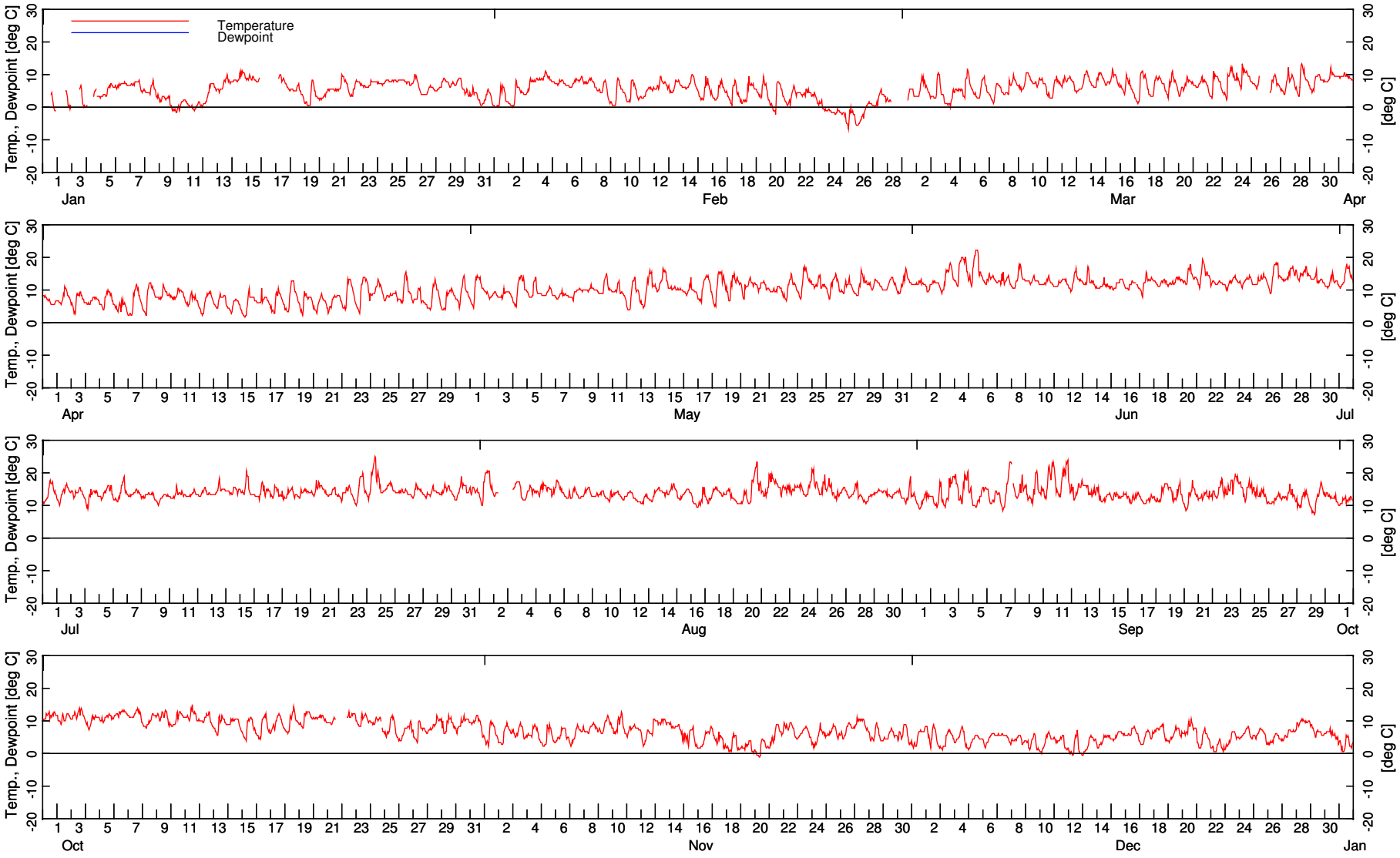
STATUS
ISSUED FOR USE

A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 07, 2012

Figure C.11



NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Hourly surface air temperature and dew point
Port Angeles: 2011

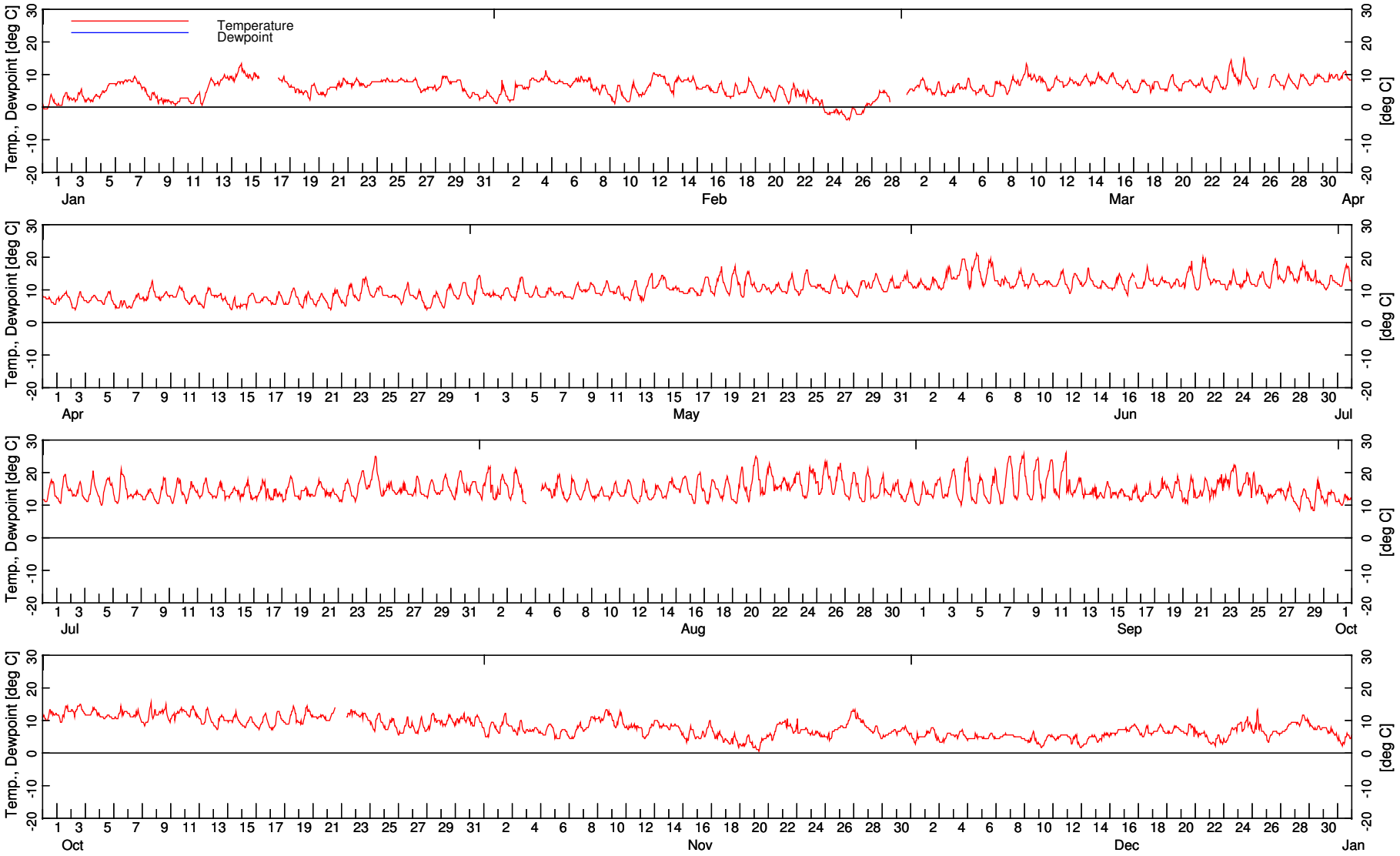
STATUS
ISSUED FOR USE

A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 07, 2012

Figure C.12



NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Hourly surface air temperature and dew point
Port Townsend: 2011

STATUS
ISSUED FOR USE

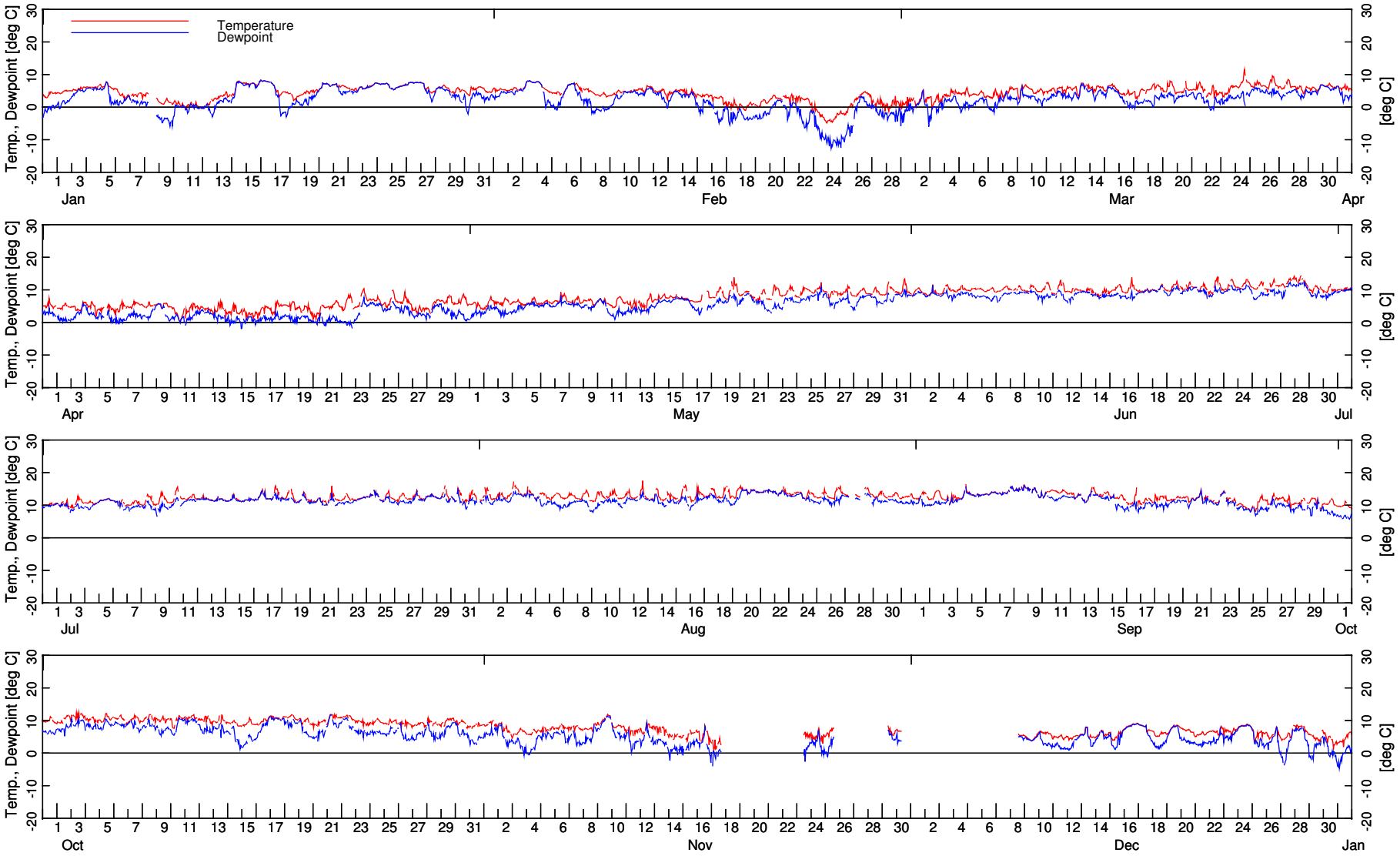
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 07, 2012

Figure C.13

Fri Dec 07 19:22:10 2012:V:\V13203022 Trans Mountain\working\DD\02_NOAA_NCDC\01_MetData_Scripts\Port_Townsend



NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Hourly surface air temperature and dew point
Sartine Island: 2011

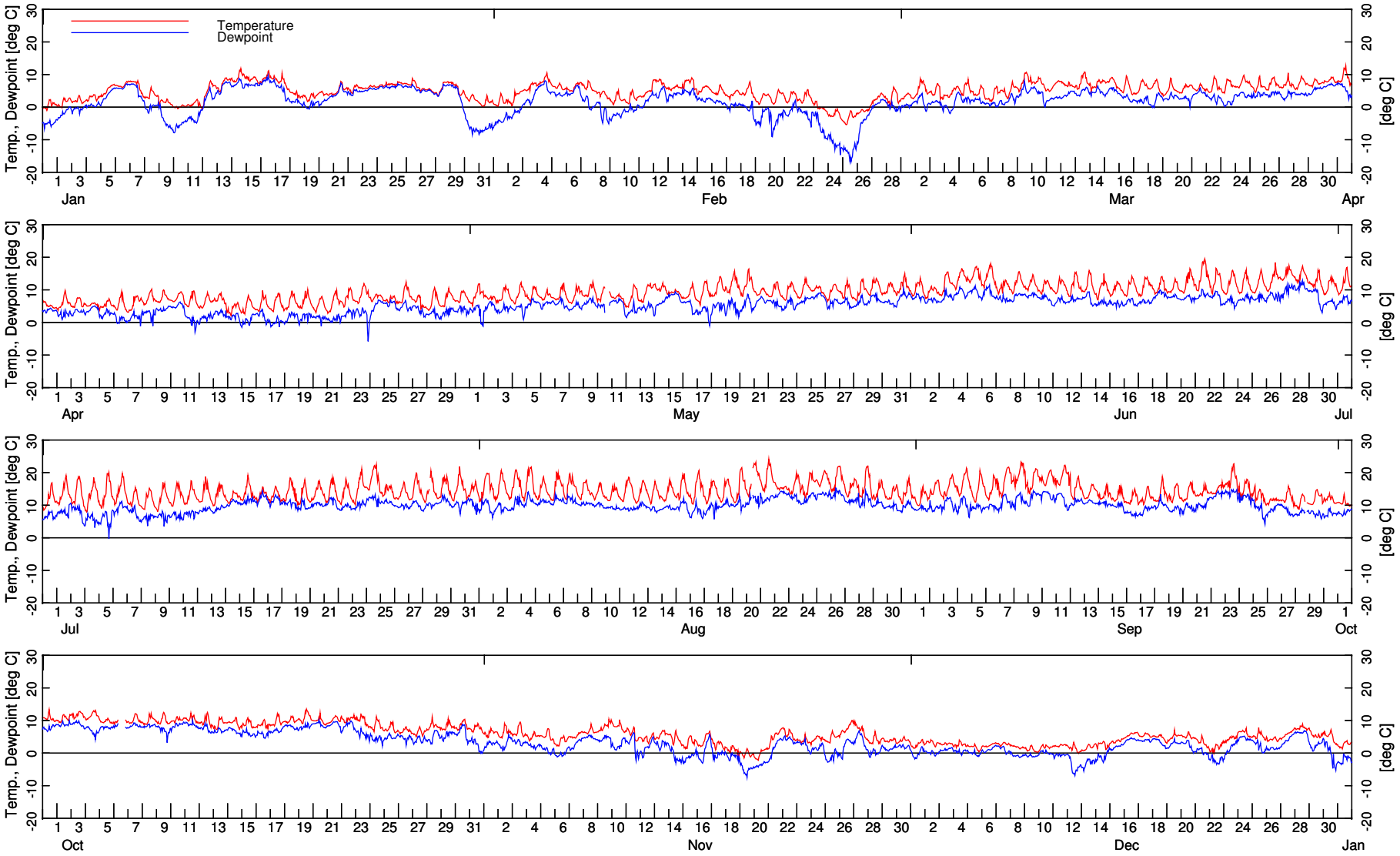
STATUS
ISSUED FOR USE

A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 07, 2012

Figure C.14



NOTES

STATUS
ISSUED FOR USE

CLIENT

Kinder Morgan

A TETRA TECH COMPANY

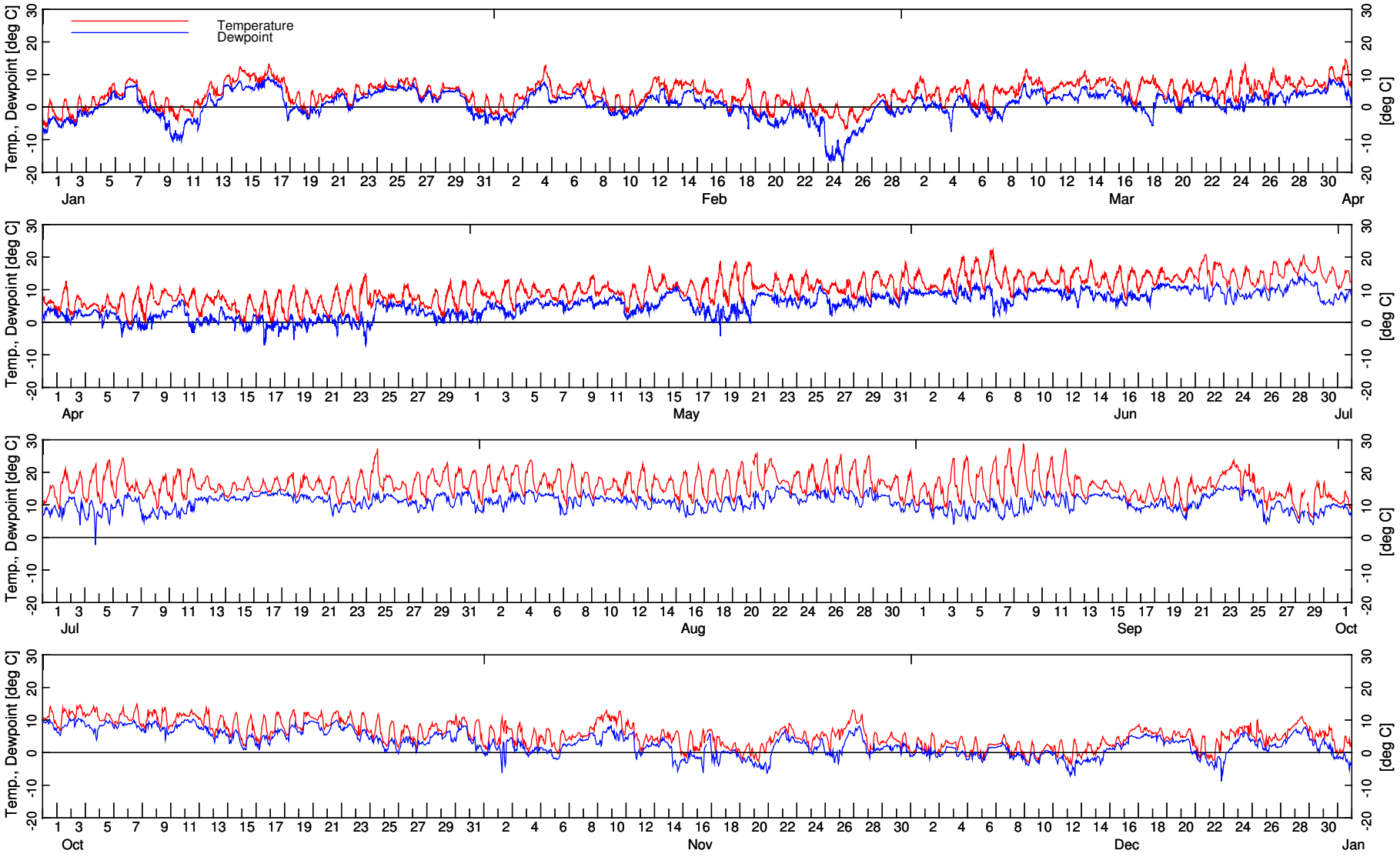
METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Hourly surface air temperature and dew point
Saturna Island: 2011

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 07, 2012

Figure C.15



NOTES

STATUS
ISSUED FOR USE

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

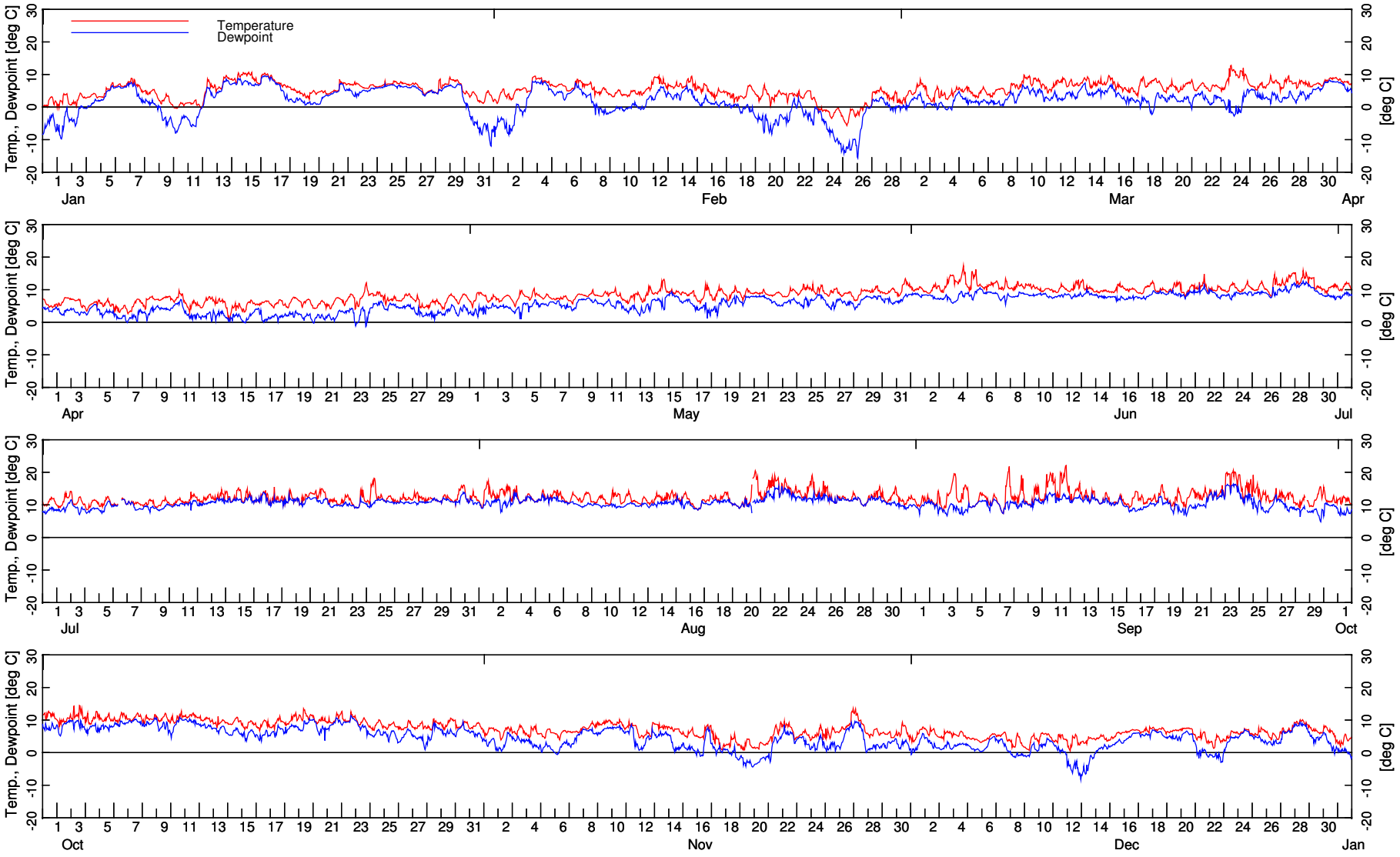
Hourly surface air temperature and dew point
Sechelt: 2011

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 07, 2012

Figure C.16

A TETRA TECH COMPANY



NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Hourly surface air temperature and dew point
Sheringham Point: 2011

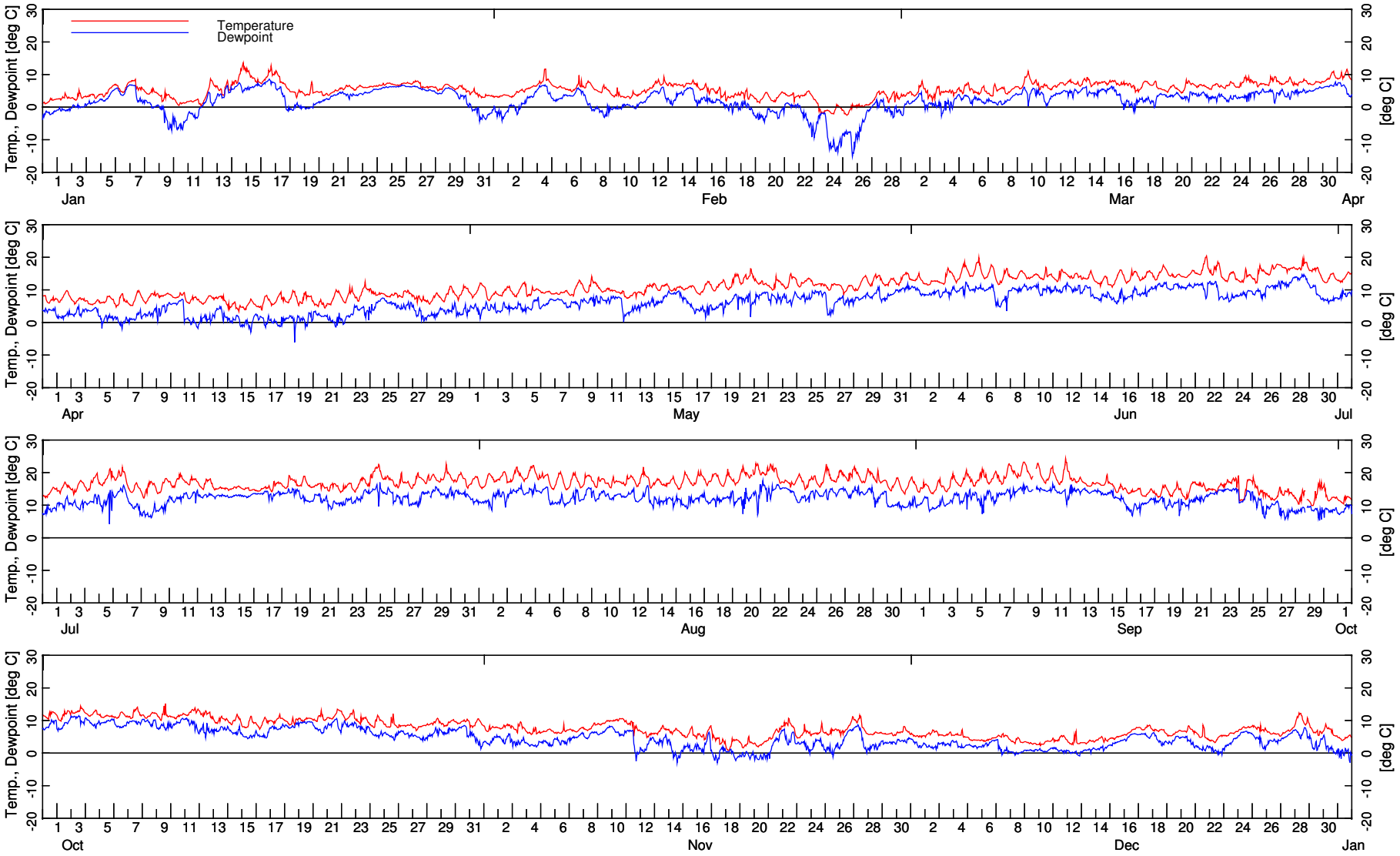
STATUS
ISSUED FOR USE

eba
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 07, 2012

Figure C.17



NOTES

STATUS
ISSUED FOR USE

CLIENT

Kinder Morgan

eba
A TETRA TECH COMPANY

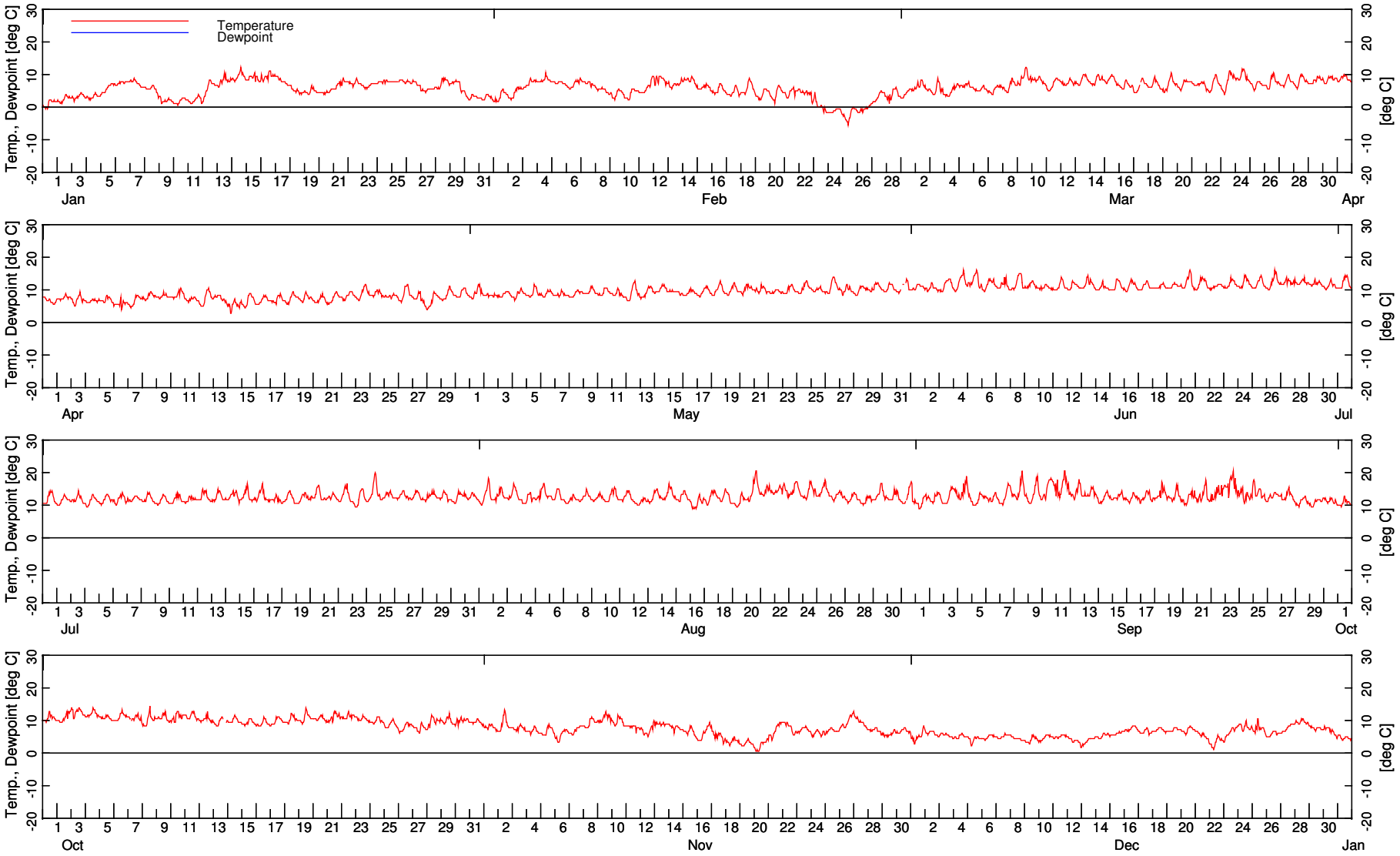
METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Hourly surface air temperature and dew point
Sisters Island: 2011

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 07, 2012

Figure C.18



NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Hourly surface air temperature and dew point
Smith Island: 2011

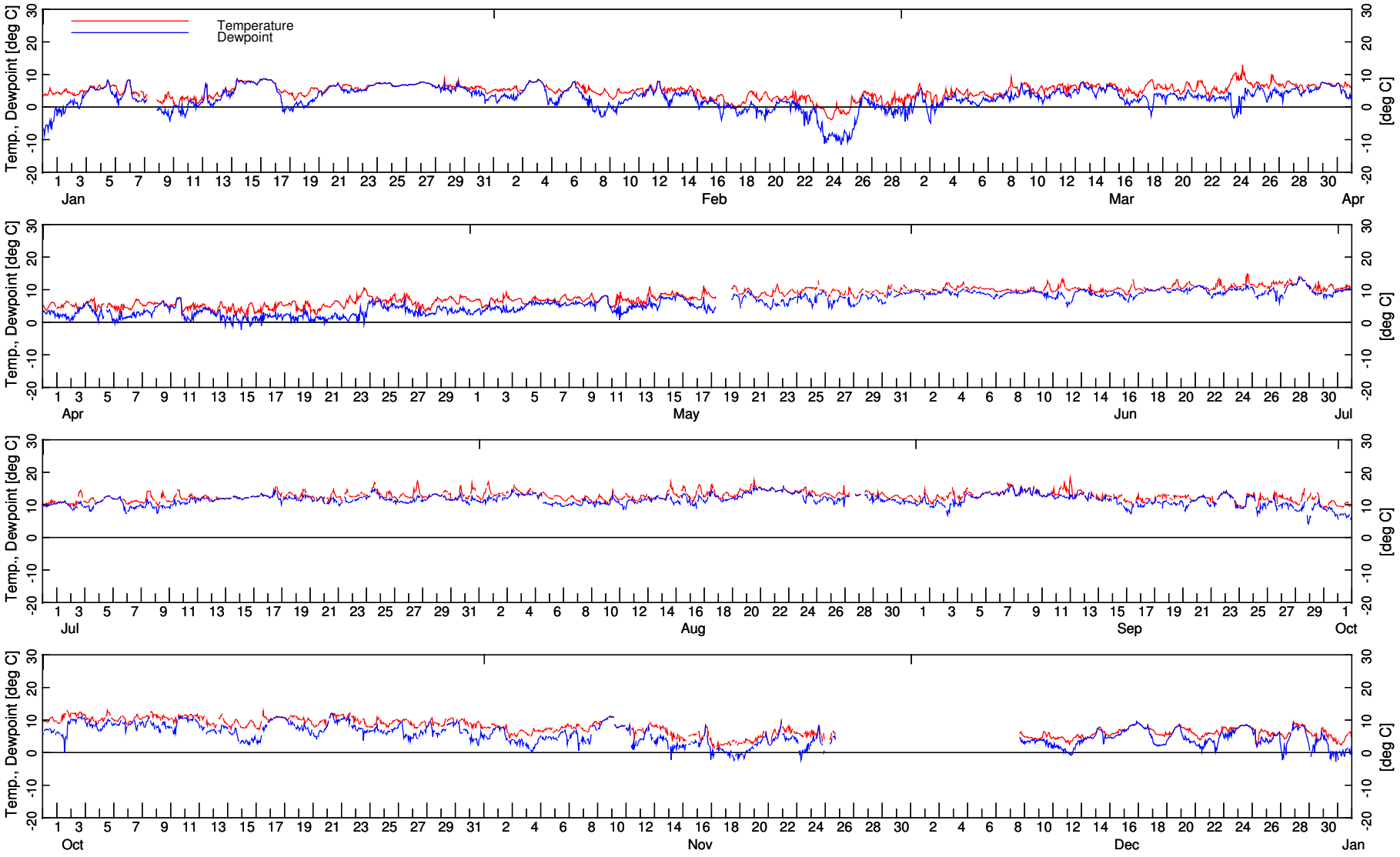
STATUS
ISSUED FOR USE

A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 07, 2012

Figure C.19



NOTES

STATUS
ISSUED FOR USE

CLIENT

Kinder Morgan

A TETRA TECH COMPANY

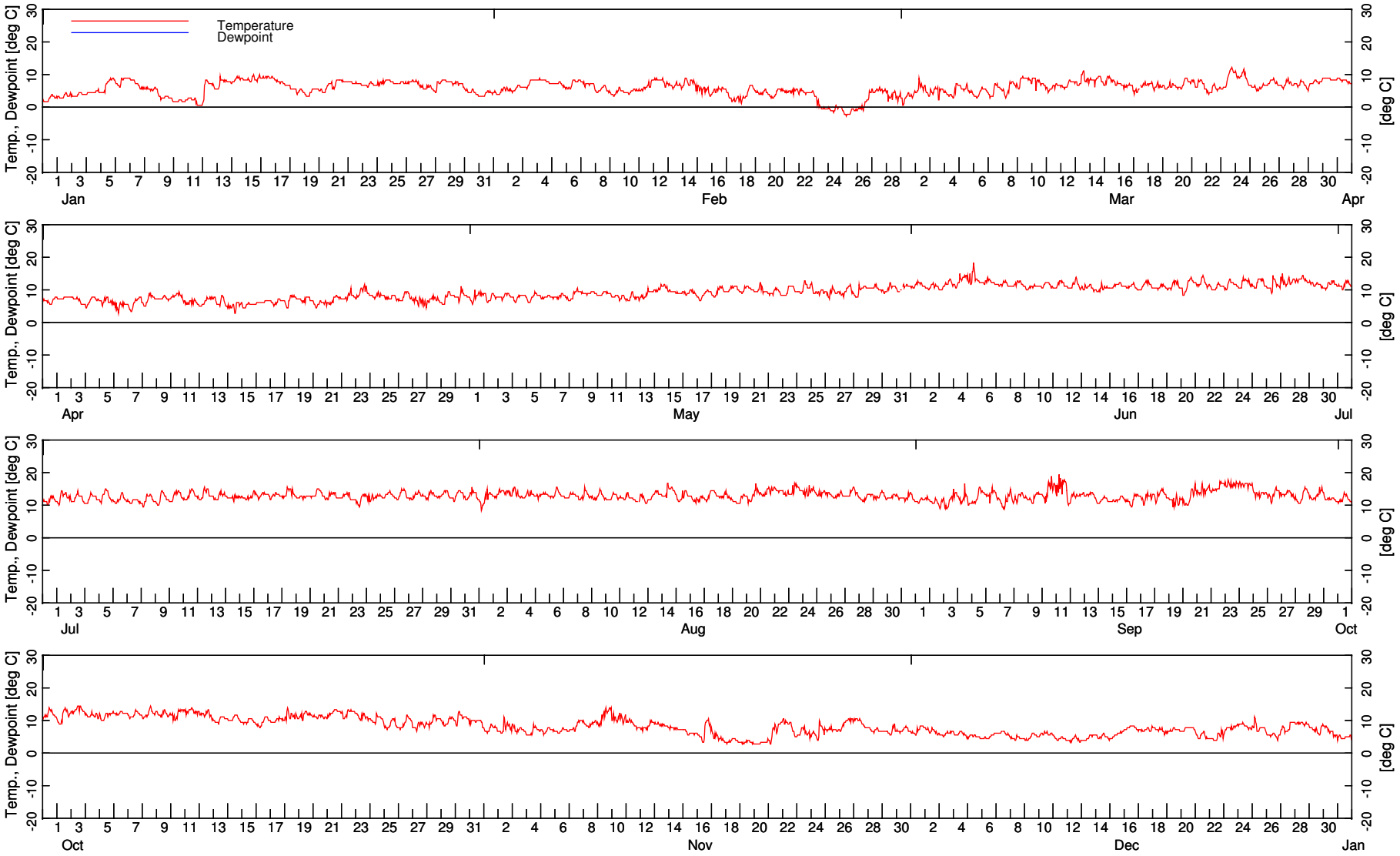
METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Hourly surface air temperature and dew point
Solander Island: 2011

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 07, 2012

Figure C.20



NOTES

STATUS
ISSUED FOR USE

CLIENT

Kinder Morgan

A TETRA TECH COMPANY

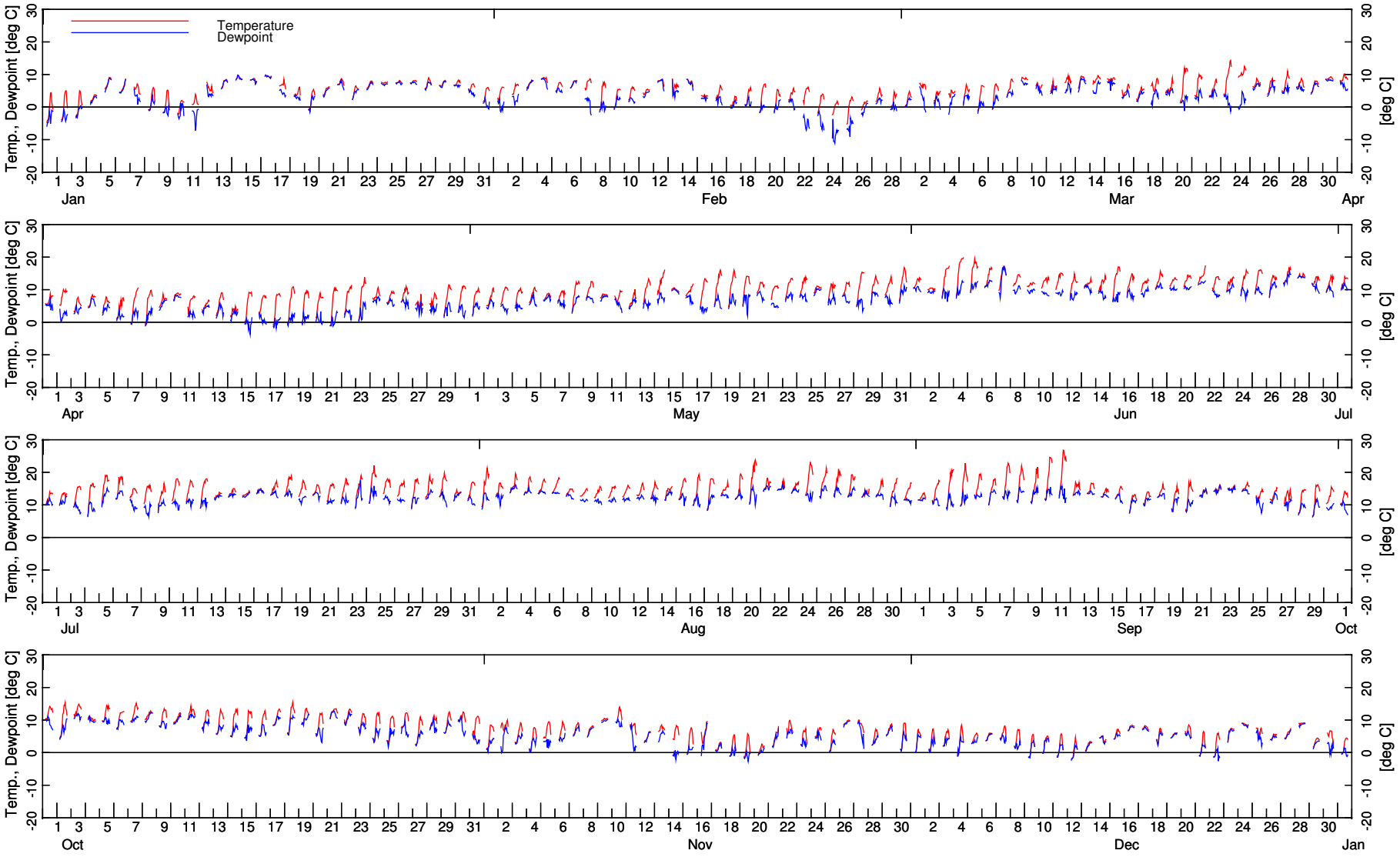
METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Hourly surface air temperature and dew point
Tatoosh Island: 2011

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 07, 2012

Figure C.21



NOTES

STATUS
ISSUED FOR USE

CLIENT

Kinder Morgan

eba
A TETRA TECH COMPANY

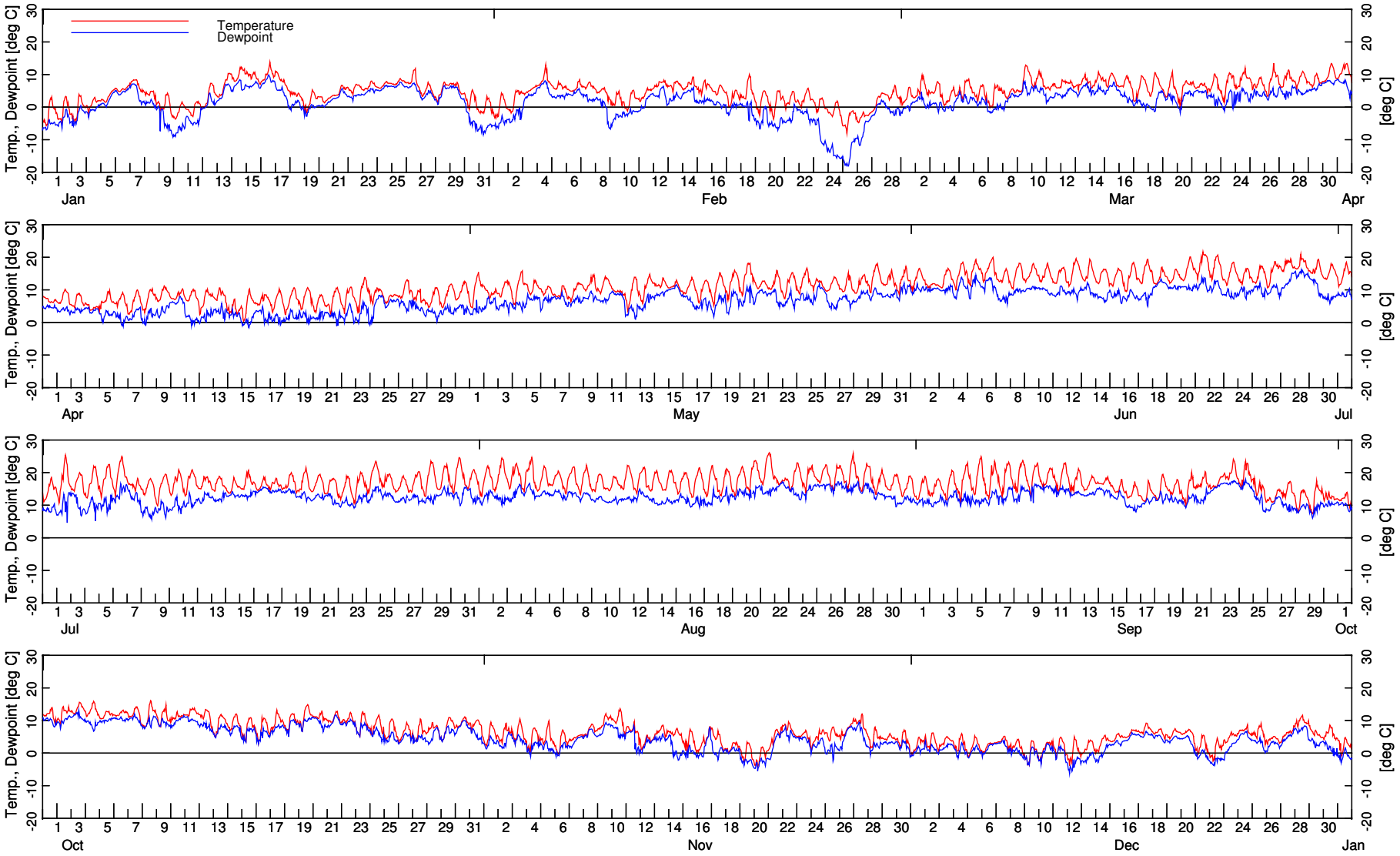
METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Hourly surface air temperature and dew point
Tofino Airport: 2011

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 07, 2012

Figure C.22



NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Hourly surface air temperature and dew point
Vancouver Intl Airport: 2011

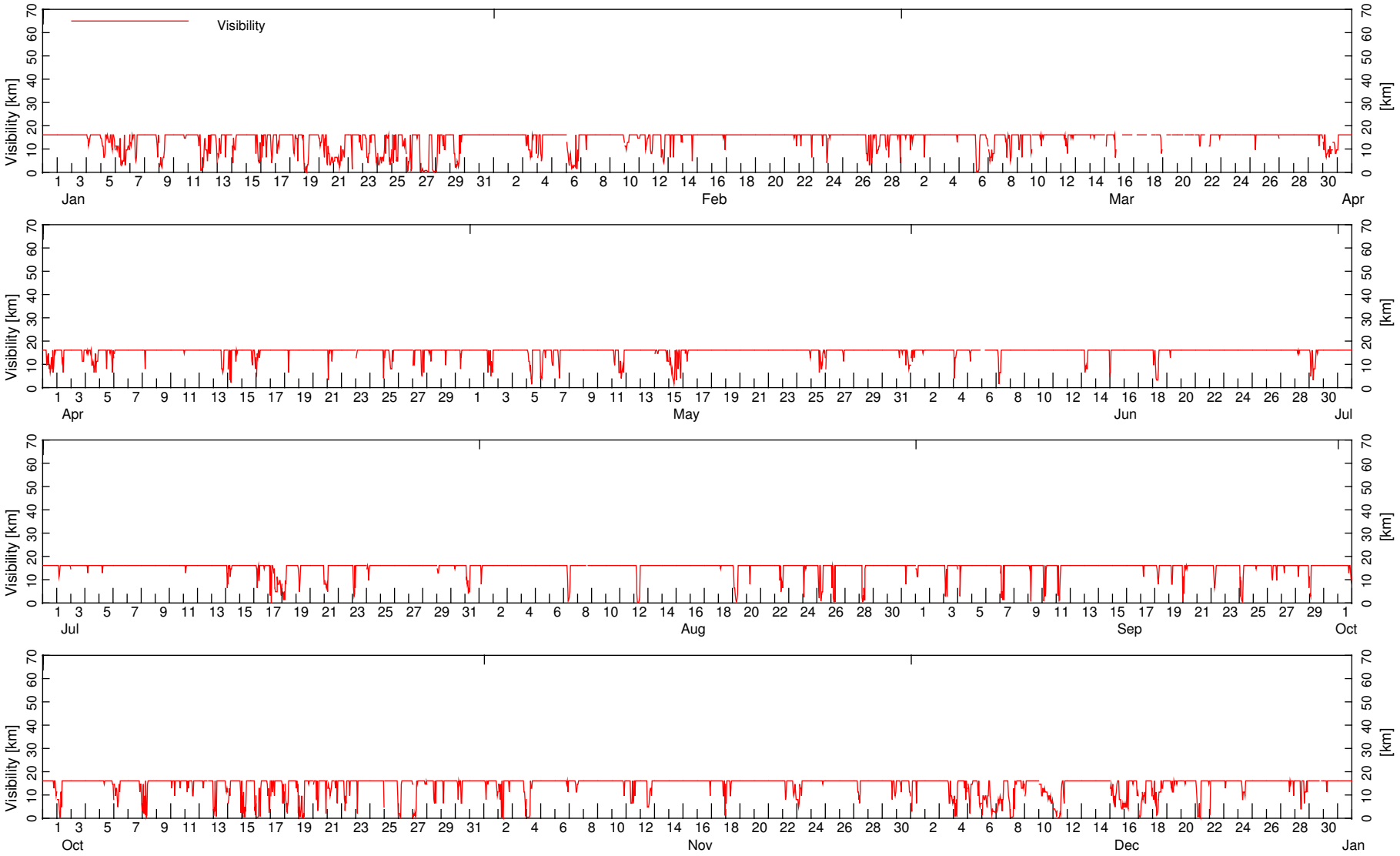
STATUS
ISSUED FOR USE

eba
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 07, 2012

Figure C.23



NOTES

STATUS
ISSUED FOR USE

CLIENT

Kinder Morgan

eba
A TETRA TECH COMPANY

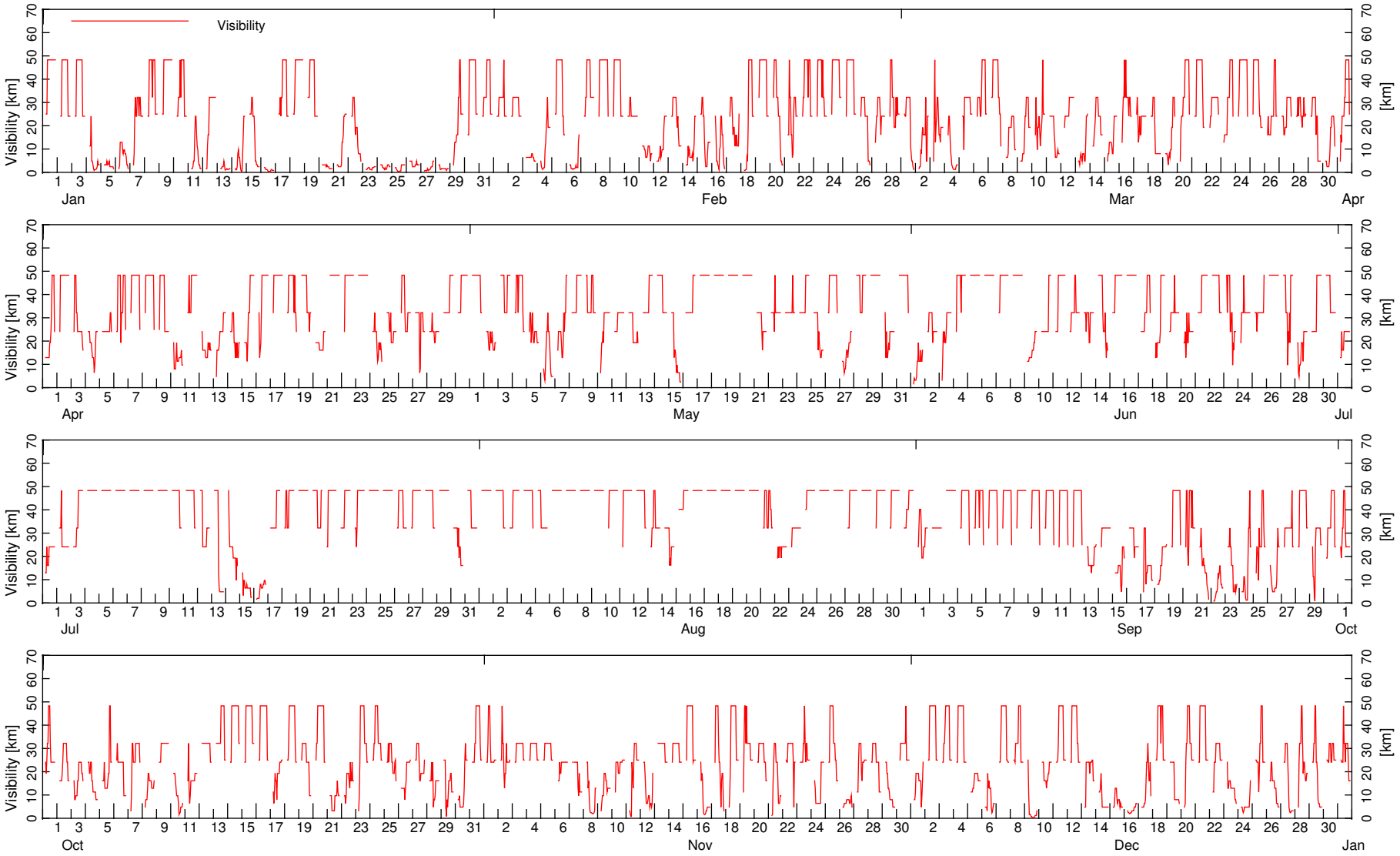
METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Hourly visibility
Bellingham Intl: 2011

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 07, 2012

Figure C.24



NOTES

STATUS
ISSUED FOR USE

CLIENT

Kinder Morgan

eba
A TETRA TECH COMPANY

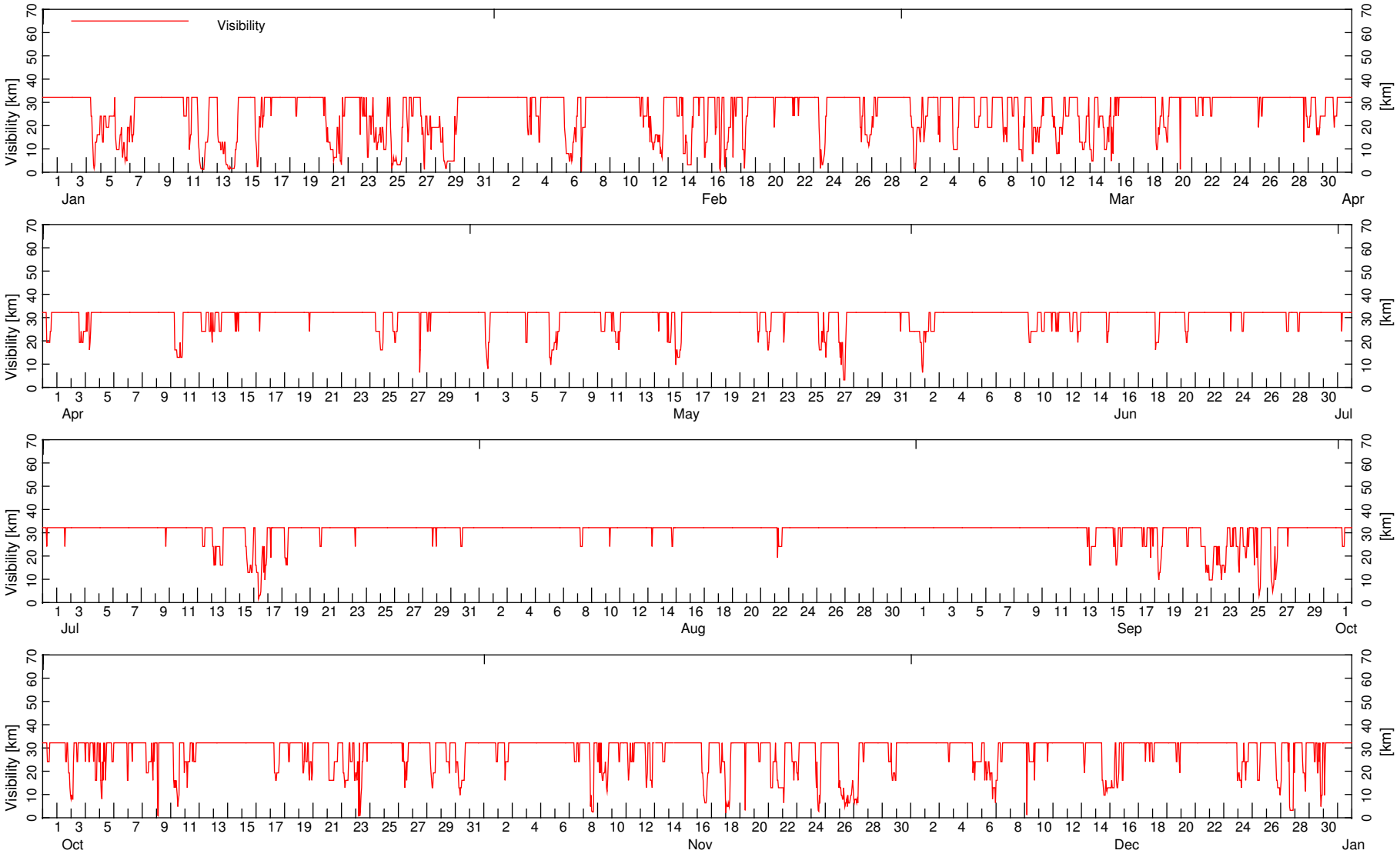
METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Hourly visibility
Campbell River Airport: 2011

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 07, 2012

Figure C.25



NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Hourly visibility
Comox Airport: 2011

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

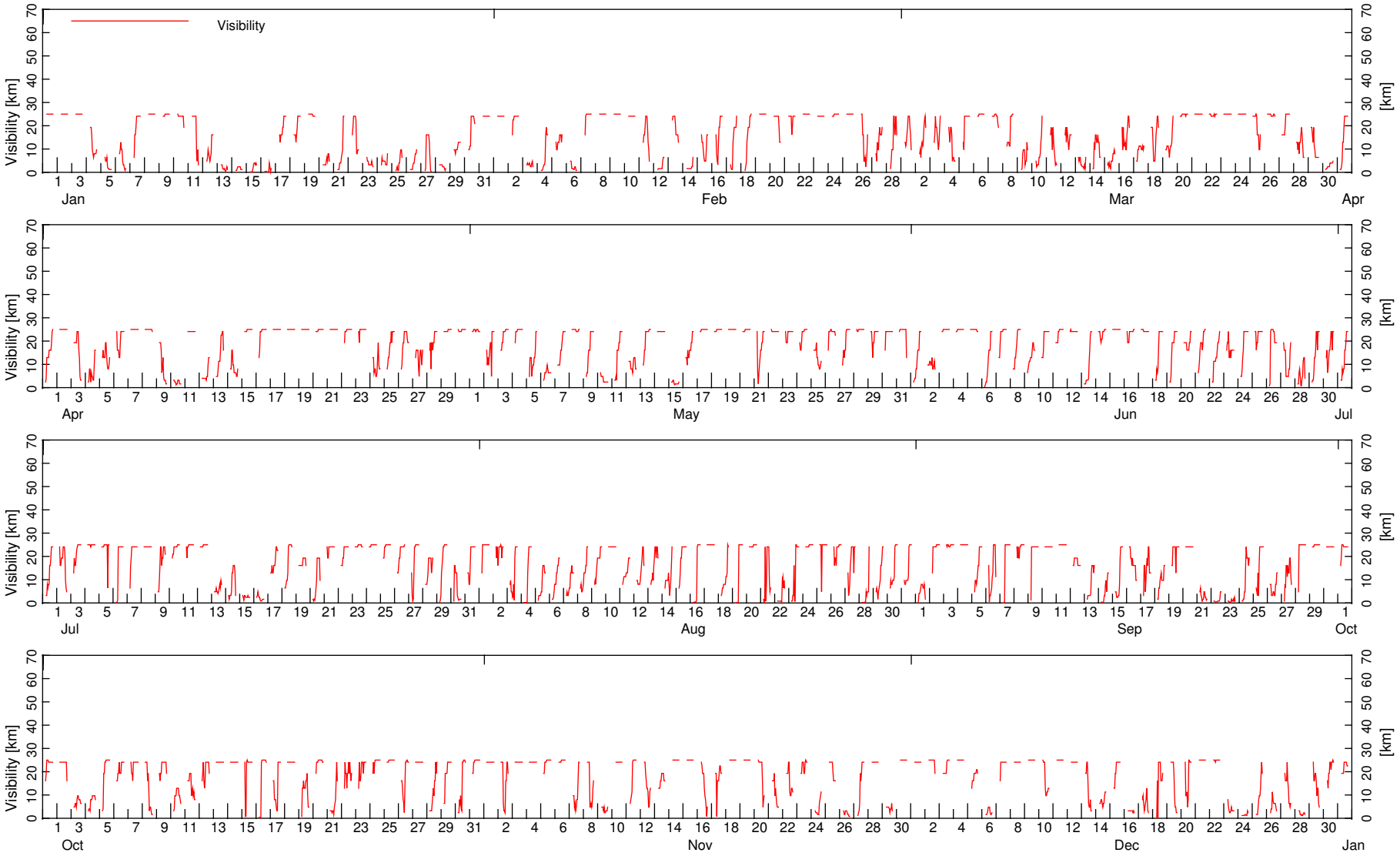
OFFICE	DATE
EBA-VANC	December 07, 2012

Figure C.26

STATUS
ISSUED FOR USE

eba
A TETRA TECH COMPANY

Fri Dec 07 19:35:57 2012:V:\V13203022 Trans Mountain\working\DD\01_EC\01_MetData_Scripts\Comox_Airport



NOTES

CLIENT

Kinder Morgan

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Hourly visibility
Tofino Airport: 2011

STATUS
ISSUED FOR USE

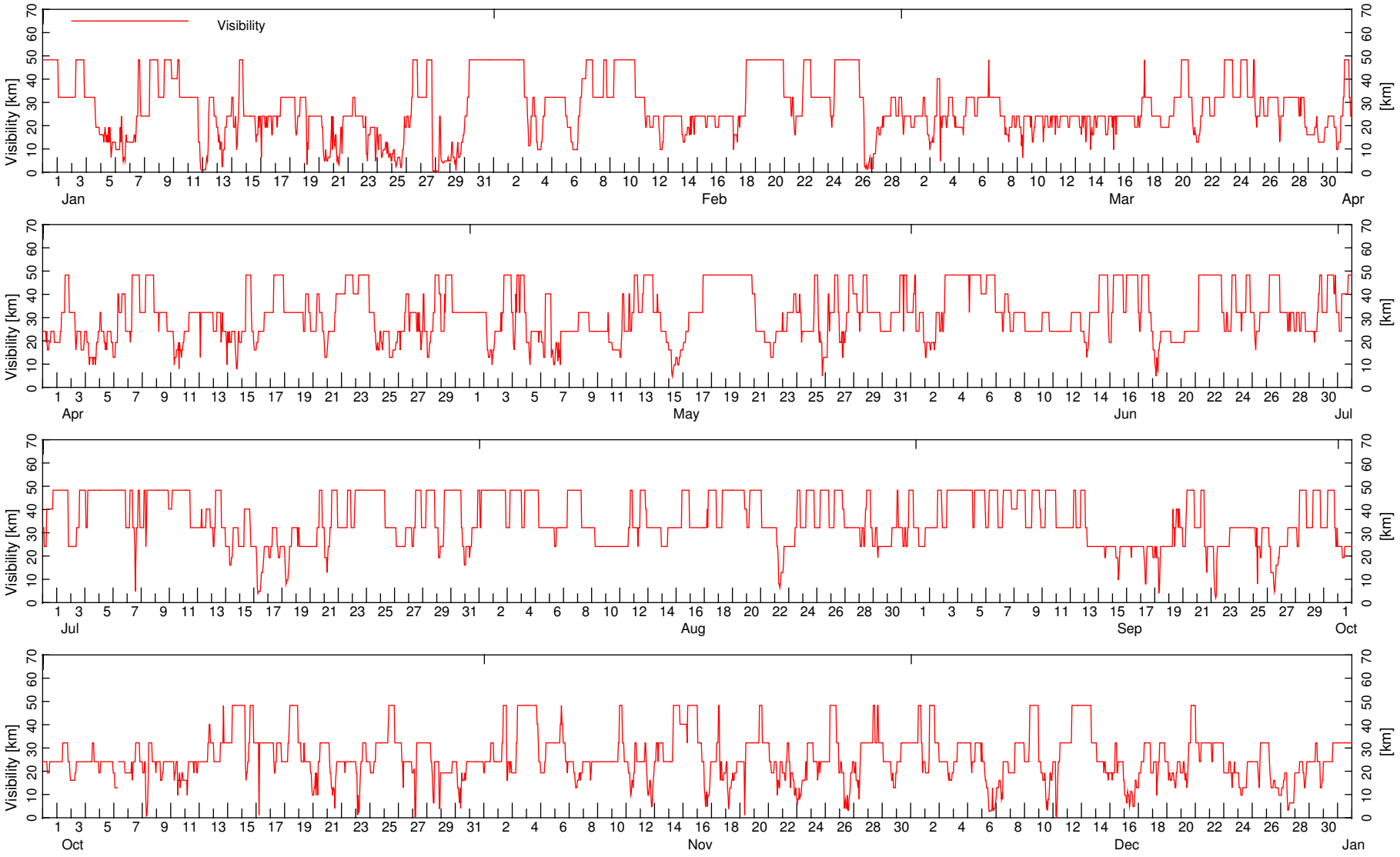
A TETRA TECH COMPANY

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 07, 2012

Figure C.27

Fri Dec 07 19:52:22 2012:V:\V13203022 Trans Mountain\working\DD\01_EC\01_MetData_Scripts\Tofino_Airport



NOTES

STATUS
ISSUED FOR USE

CLIENT

Kinder Morgan

eba
A TETRA TECH COMPANY

METOCEAN DATA
TRANS MOUNTAIN PIPELINE EXPANSION

Hourly visibility
Vancouver Intl Airport: 2011

PROJECT NO.	DWN	CHK	APVD	REV
V13203022	DD	JAS	JAS	0

OFFICE	DATE
EBA-VANC	December 07, 2012

Figure C.28

APPENDIX D

EBA'S GENERAL CONDITIONS

GENERAL CONDITIONS

DESIGN REPORT

This Design Report incorporates and is subject to these “General Conditions”.

1.0 USE OF REPORT AND OWNERSHIP

This Design Report pertains to a specific site, a specific development, and a specific scope of work. The Design Report may include plans, drawings, profiles and other support documents that collectively constitute the Design Report. The Report and all supporting documents are intended for the sole use of EBA’s Client. EBA does not accept any responsibility for the accuracy of any of the data, analyses or other contents of the Design Report when it is used or relied upon by any party other than EBA’s Client, unless authorized in writing by EBA. Any unauthorized use of the Design Report is at the sole risk of the user.

All reports, plans, and data generated by EBA during the performance of the work and other documents prepared by EBA are considered its professional work product and shall remain the copyright property of EBA.

2.0 ALTERNATIVE REPORT FORMAT

Where EBA submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed EBA’s instruments of professional service), only the signed and/or sealed versions shall be considered final and legally binding. The original signed and/or sealed version archived by EBA shall be deemed to be the original for the Project.

Both electronic file and hard copy versions of EBA’s instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except EBA. EBA’s instruments of professional service will be used only and exactly as submitted by EBA.

Electronic files submitted by EBA have been prepared and submitted using specific software and hardware systems. EBA makes no representation about the compatibility of these files with the Client’s current or future software and hardware systems.

3.0 ENVIRONMENTAL AND REGULATORY ISSUES

Unless so stipulated in the Design Report, EBA was not retained to investigate, address or consider, and has not investigated, addressed or considered any environmental or regulatory issues associated with the project specific design.

4.0 CALCULATIONS AND DESIGNS

EBA has undertaken design calculations and has prepared project specific designs in accordance with terms of reference that were previously set out in consultation with, and agreement of, EBA’s client. These designs have been prepared to a standard that is consistent with industry practice. Notwithstanding, if any error or omission is detected by EBA’s Client or any party that is authorized to use the Design Report, the error or omission should be immediately drawn to the attention of EBA.

5.0 GEOTECHNICAL CONDITIONS

A Geotechnical Report is commonly the basis upon which the specific project design has been completed. It is incumbent upon EBA’s Client, and any other authorized party, to be knowledgeable of the level of risk that has been incorporated into the project design, in consideration of the level of the geotechnical information that was reasonably acquired to facilitate completion of the design.

If a Geotechnical Report was prepared for the project by EBA, it will be included in the Design Report. The Geotechnical Report contains General Conditions that should be read in conjunction with these General Conditions for the Design Report.

6.0 INFORMATION PROVIDED TO EBA BY OTHERS

During the performance of the work and the preparation of the report, EBA may rely on information provided by persons other than the Client. While EBA endeavours to verify the accuracy of such information when instructed to do so by the Client, EBA accepts no responsibility for the accuracy or the reliability of such information which may affect the report.