original sea bottom elevation would reduce the risk of pipe-anchor contact to an acceptable level. (Timmermans, prefiled, p. 15.)

95. Applicant has concluded that only anchors heavier than 10,000 pounds are potentially damaging to the pipe. Such anchors would normally be carried only by a vessel of 30,000 DWT or larger. (Timmermans, prefiled, p. 16.)

96. Applicant has concluded that even if natural backfill did not occur, the risk of anchor contact would not be significantly increased. This was based largely on the supposition that a large anchor will travel through the soil horizontally and will not easily be deflected downward when crossing a trench which is not wider than approximately two to three times its depth. (Timmermans, prefiled, p. 16.) However, as noted in Finding 87, the expected trenching width will be four to five times its depth.

97. The pipe would cross that part of Admiralty Inlet designated a precautionary area where vessel traffic converges from four different directions. Because of converging traffic, potential accidents and emergencies are more likely than in normal traffic lanes. (Armstrong, TR 25848-49.) To avert a potential collision or other emergency, vessels likely would drop anchors despite the known location of the submarine

pipelines if the master or pilot felt a collision or emergency could be averted through an anchor drop. (Armstrong, TR 25848; Bennett, TR 25417-18.)

II.A.2.a. SUBMARINE PIPELINE PORTIONS

(Cross-Sound and Harbor)

II.A.2.a.(2) Port Angeles Harbor Submarine Pipeline

1. Two 48 inch diameter submarine pipelines would cross Port Angeles Harbor from Ediz Hook to the storage tanks at Green Point. Three possible routes for the unloading pipelines were studied in 1978. (Ex. 30, Fig. 1) One additional route, "Route D," was studied in 1979 and became the preferred route. (Ex. 31, p. 6 and Fig. 2) Two additional routes were hypothesized but not studied.

2. The unloading pipelines on Ediz Hook will be constructed by conventional methods and equipment. The submarine pipelines extending from Ediz Hook to Green Point will probably be laid by lay barge. Total construction time is estimated to be six months. If the submarine pipeline is installed by the bottom-pull or bottom tow method, a "tidal window" would have to be used. (TR 3802)

3. The two lines will be laid one at a time and will be spaced up to 1200 feet apart at the widest points. (TR 3625) At the shore approaches, the lines will be closely spaced and will occupy the same dredged trench.

4. The bottom sediments of Port Angeles Harbor along route D consist of recent marine sediments resting on older marine sediments (Type B) of Ediz Hook near the hook and /or older glacially overridden deposits. The glacially overridden deposits occur at or near the seabottom throughout the eastern portions of the harbor crossing. Along the western portions, toward the hook, the glacially overridden deposits occur at a progressively greater distance below the sea bottom. The Type A recent marine sediments consist of very loose to loose silty fine sand with occasional shells. The thickness of the Type A soil increases to over 40 feet in depth on parts of the route. (Ex. 31, Fig. 2.) The density of the Type A soils is very low. The Standard Penetration Resistance values (N-values) (penetration force) were zero to ten blows per foot in these materials while the T-values (penetration time) from the Vibracore samples rarely exceeded 5 seconds per foot of penetration. (Ex. 31, p. 5.) Type B materials which comprise the bulk of Ediz Hook and extend into the Harbor from the toe of Ediz Hook are similar to Type A materials, although they are slightly more dense and less silty than the Type A materials. (Ex. 31, p. 5.) The standard penetration resistance values for Unit B sediments range from 15 blows per foot to 200 blows per foot with average blow counts above 55 feet in depth ranging from 25 blows per foot to 45 blows per foot. Below 55 feet in depth, the standard penetration resistance averages approximately 70 blows per foot. (Ex. 30, p. 8 and Appendix A). The glacially

overridden sediments consist of very dense, slightly silty to silty sand with variable amounts of gravel. Hard over-consolidated clay and silt layers are interbedded in these glacially overridden sediments. There is no evidence of the existence of faults in the harbor area.

5. The existing slopes on the south side of Ediz Hook are presently very steep, averaging 30° and as steep as 45° in places. The existing slopes exceed their natural angle of repose in places. (Ex. 31, p. 9; Johnson, TR 23996.) The slopes of Ediz Hook are marginally stable, especially in the steeper areas. (Ex. 31, p. 9.) There is a slump feature near the proposed submarine pipeline alignment at the eastern tip of the Hook. (Ex. 31, p. 9 and Fig. B-5).

6. Bottom depths as great as 180 feet occur immediately south of the Hook at the locale of the proposed unloading facilities. Northward from Ediz Hook, the bottom of the Strait of Juan de Fuca rises from depths of about 360 to 420 feet to about 240 feet just north of Ediz Hook. (Ex. 30, p. 4.)

7. Consultants for Northern Tier Pipeline Company have conducted detailed geotechnical investigations of underwater parts of the terminal location and much of the submarine unloading line route. (Ex. 30; Ex. 31). These investigations

included underwater test borings at the tanker berth sites; geophysical surveys including side-scan sonar, Vibracore bottom sampling, and bathymetric survey of the berthing area; laboratory testing of berthing area bottom samples; and engineering studies and analyses to develop and evaluate design parameters and considerations. Standard penetration resistance tests were conducted at several locations in the berthing facility area to allow a determination of the relative density of the soils involved. The applicant's analysis of the geophysical conditions along the route of the unloading pipelines between Ediz Hook and Green Point includes test borings, bathymetric and subbottom profiling, side-scan sonar and magnetometer surveys, Vibracore bottom sampling, laboratory testing of bottom samples, and engineering studies. A total of nine borings were taken in Port Angeles Harbor and at Green Point for the 1978 study. (Ex. 30, p. 3, Fig. 1.) In 1979, 32 Vibracore samples were taken in the harbor to study the crossing. (Ex. 31, p. 3. Fig. 1.) Current meters were installed at four sites across Route "D."

8. The Type A sediments along the pipeline corridor in Port Angeles Harbor would be susceptible to liquefaction for their entire depth in the event of a Mercalli Intensity VII+ earthquake which produced maximum ground accelerations. (Ex. 31, p. 7.) The occurrence of a 7.1-7.5 Richter magnitude earthquake would potentially liquefy both the Type A and Type B

soils on Ediz Hook and in the western 3 miles of the Port Angeles Harbor crossing. (Johnson, TR 23995-96; Ex. 339, Fig. IV-2.)

9. Liquefaction of sediments would result in a loss of bearing capacity and support for the pipe. A pipeline extending through these sediments might either settle or float to the surface depending upon the bulk density of the pipe and contents compared to the bulk density of the liquified sediments. (Ex. 31, p. 8.)

10. Occurrence of a large earthquake has the potential to cause slope instability and slumping along Ediz Hook. The unconsolidated Type A material and to some extent the Type B soils, are prone to slumping in the event of a large earthquake. (Johnson, TR 23996-97.) Submarine landslides could also occur in slopes on the bottom of the Harbor which exceed 1°-3°. (Johnson, TR 23997; Buck.) Once a slide of liquefiable material is initiated, it could cause the movement of denser, non-liquefied materials as well. (Johnson, TR 24008-09; Buck, TR 33974.)

11. Submarine landslides could produce a differential displacement of materials and a shearing motion on the pipe. (Johnson, TR 23998-99.) The submarine pipelines in Port Angeles Harbor on Route D would cross some slopes of 4.4% to

17.5% steepness in a parallel direction. (Johnson, TR 23999-24000; Ex. 31, Fig. B-1 and Fig. 2.) The flowing material in a landslide perpendicular to the pipe would tend to be caught against the pipe and subject it to pressure. (Johnson, TR 24000; Buck, TR 33975.)

12. The submarine unloading line route is generally stable except near Ediz Hook. (Alsup, TR 8459.) Exceptions are described elsewhere in this section.

13. No great effect on the unloading pipelines would be expected from slope failures of the magnitude indicated by the small slump feature at the east end of Ediz Hook. If the slumping involved trench materials, no significant threat to pipeline integrity is anticipated because of the strength of the concrete coated thick-walled pipe compared to the low-strength low-density nature of the materials that could become involved in such slumping. In some parts of the harbor, bottom slopes between 2.5 and 10 degrees exist. If slope failures occurred, these could make a perpendicular impact on the pipeline. (TR 8460-61 Alsup.)

14. As the result of its 1978 investigation of the Port Angeles area, Shannon and Wilson recommended that the unloading pipelines in Port Angeles Harbor be trenched to a depth below the Type A sediments in order to avoid the hazards of

liquefaction and potential anchor damage. (Ex. 30, p. 26; Veatch, TR 3566-67.) Northern Tier's engineers concluded, subsequent to Shannon & Wilson's recommendations, that it was beyond the capability of the current technology to bury the pipeline below the Type A sediments (which extend below 40 feet in some areas) in Port Angeles Harbor. It may not be possible to achieve even 11 feet of trench cover. The engineers, therefore, recommended a minimum trench cover depth of four feet in Port Angeles Harbor. (Ex. 33, p. 1-5, 6.) The larger vessels expected to call at Port Angeles Harbor to offload oil could carry anchors weighing 30 tons or more (high loading power anchors). (Ex. 33, Table 6.3). In some cases, a 15-ton anchor can penetrate 19 feet of mud. (Ex. 33, Appendix A, pp. 1-5). Applicant itself has estimated maximum anchor penetration in Port Angeles Harbor soils from 9.8 to 10.9 feet. (Ex. 33, pp. 6-34).

15. It was recommended by the applicant that coverage of 11 feet be attempted where Type A soils are more than seven feet thick, if technically achievable and economically feasible. (TR 3626, 3682.) Before making this decision, a technical and economic feasibility study of dredge modification would have to be made. (TR 3639.) In shallow water near Green Point, 5.5 feet of rock backfill is recommended to a 20 foot depth. (TR 3626.) Beyond that, for approximately 3300 feet horizontally, natural backfilling would be augmented by ten-foot rock plugs placed at 100 foot intervals. (TR 3688-89.)

Rock backfill is recommended for the pipeline trench on the Ediz Hook slope. (TR 3626.)

16. Except for the shore approaches, natural backfill is relied upon by Northern Tier as the method of covering the submarine unloading pipeline trenches. (Ex. 33, p. 5-7.) No study was undertaken to determine whether natural backfill would fill the trench along the submarine route.

17. To construct the unloading pipeline section between Ediz Hook and Green Point, trenches will be excavated in bottom materials. In the deepest part of the harbor where the fine, loose sands are the thickest, the pipeline trench would be excavated with a suction dredge with airlift equipment. Where the fine, loose sands are thinner, the trench would penetrate the dense sediments, and a combination of some or all of the trenching methods would be used including the suction dredge with airlift, the suction dredge with cutter head, clamshell dredge, and a pipeline plow. Where the fine loose sands are very thin or non-existent, the trenching would be accomplished by means of a cutter suction dredge, clamshell dredge or the pipeline plow.

18. Rock backfill in the shore and surf zones will be required at both Ediz Hook and Green Point shore approaches. In order to assure that littoral sediment transport is not im-

pacted at Green Point, special pipeline burial requirements are applicable.

19. The natural bottom contours in the pipeline trench area between Ediz Hook and Green Point may be reestablished by the action of bottom currents over a period of time which will fill the pipeline trench with bottom sediments. The likelihood of, and the length of time required for, such natural backfilling will be dependent on the types of soils in the vicinity and the strength and direction of the currents in the particular location.

II. A. 2.b. TERRESTRIAL PIPELINE PORTIONS

1. The terrestrial pipeline route runs generally west to east from Green Point to Port Williams in Clallam County, crosses Whidbey and Camano Islands in Island County, and turns south near Arlington in Snohomish County. The route goes southeasterly through King County and begins its ascent over the Cascades near North Bend. In Eastern Washington, the route runs generally west to east through Kittitas and Grant Counties and along the Lincoln-Adams County Line. It exits the state southeast of Fairfield in Spokane County. The terrestrial pipeline corridor is legally described in Exhibit 312. Certification is sought for a corridor one-quarter mile on either side of a defined centerline, except at major river crossings, where the corridor narrows to an area 200 feet on either side of the centerline. The pipeline would be laid anywhere within the proposed corridor, and the final location would depend on landowner negotiations and a variety of other site-specific conditions. (Applic. II, Sec. 6.3.2.1) The pipeline system will consist of the mainline pipe, pump stations, a pressure reducing station, and mainline valves. (Applic. II, Sec. 6.3.1)

2. The pipeline, in both its terrestrial and submarine segments, will be designed, constructed, and operated in

accordance with the Hazardous Liquid Pipeline Safety Act of 1979, 49 U.S.C. subsection 2001 et seq., and with United States Department of Transportation (DOT) regulations regarding transportation of liquids by pipeline, 49 C.F.R. subsection 195. It will also comply with the standards set forth by the American National Standards Institute (ANSI) concerning "Liquid Petroleum Transportation Piping Systems" (Standard B31.4). (TR 5894-95 Sandmeyer)

3. Within the state of Washington, the pipeline will be 42 inches in diameter. It will be protected from corrosion by an external protective coating and by a cathodic protection system. Where the pipeline crosses streams and rivers, a concrete coating or concrete weights will also be applied to increase submerged weight and prevent the pipe from floating out of the trench. (TR 5903, 5906-07 Sandmeyer; 7338-39 Winegar; Applic. II, Sec. 6.3.2.4)

4. Northern Tier proposes burying the pipeline in an eight foot deep trench and backfilling with approximately four feet of cover, except where additional cover is needed or is otherwise required. In solid rock, the pipe will be buried so that there is 18 inches of cover between the top of the pipe and the ground. Where the route crosses major highways and railroads, the pipeline will be encased in a larger pipe or concrete coated, and will be installed by boring under the

roadway. Where the route crosses major streams and rivers, Northern Tier intends the top of the pipe to be buried at least 48 inches below the 100-year flood level scour depth unless rock is encountered. Installation of the pipeline at canal and ditch crossings will be in accordance with the requirements of the irrigation district having jurisdiction. Similarly, where the pipeline crosses buried cables and beneath electric power lines, design clearances and cathodic protection will be coordinated with local utility companies. (TR 5912-14 Sandmeyer; 6706-10 Everett; Applic. II, Sec. 6.3.2.4)

5. Mainline block and check valves will be installed at various points along the pipeline. Check valves automatically close to prevent backflow. Block valves, when closed, prevent flow in either direction. All block valves will be remotely controlled from the main control center at the onshore storage facilities but can also be operated manually. If a line break occurs, pumping would be stopped and the mainline block valves closed to isolate the leak. (TR 5900-01 Sandmeyer; Applic. II, Sec. 6.3.3.8)

6. Seven pump stations, Port Angeles, Arlington, Carnation, Bandera, Ellensburg, Odessa and Plaza, and one pressure reducing station at Quincy, are proposed for construction in Washington. Major equipment and support facilities at these stations may include, depending on the station, centrifugal

pump units, pressure reducing valves, a surge relief tank, internal pipeline cleaning equipment, strainers, a drain system consisting of an underground tank and drain lines, an injection pump, a control building, power supply and transformers, a communications tower, a heliport, roadway, an emergency generator, and fencing. (Applic. II, Sec. 6.3.4; TR 7343 Winegar)

7. Overall control of the pipeline system will be done by pipeline dispatchers at the main control center at the onshore storage facilities. The dispatchers will be aided by the computer-assisted SCADA system. Control buildings at the pump and pressure reducing stations will house equipment needed for remote control by, and communication with, the main control center, as well as a local control and instrumentation system. (Applic. II, Sec. 6.3.6.1)

8. Water needed at the stations will likely be supplied from on-site wells. Sewage, from those times when the stations are occupied for routine maintenance or emergency conditions, will be disposed of by a septic tank or a holding tank system serviced by commercial firms. Stations with surge relief tanks will also have an oil-water separator to process rain water and oil collected in dikes surrounding the tanks. (TR 7345-46 Winegar; Applic. II, Sec. 6.3.4.4) Electrical power will be provided by the utilities serving the areas where the stations are located. (TR 7379-80 Whiteside)

9. Each station will be equipped with fire detection monitors. If a fire occurs, the monitors will be designed to alert the system to shut the station down and alert the SCADA system to close block valves. Each station will be constructed of non-combustible material to the extent practicable to inhibit fires from beginning or spreading. Unauthorized entry alarms and fire alarms will be installed at each station. Additional fire protection will include combustion detectors and automatic fire extinguishing systems in the control building and substation areas, ultraviolet smoke detectors, and portable fire extinguishers. Surge relief tanks will be equipped with heat sensing devices, and, a Halon system (Inert gas extinguishing system). If the tanks are of the floating roof type, they will have dual gas detection systems; if they are the fixed roof type, they will have a floating internal seal. Northern Tier will coordinate its fire protection plan with that of local fire protection districts. (TR 7346-49 Winegar; TR 7391-93 Kirsop)

10. To prevent damage to the pipeline, line markers identifying the pipeline and listing a toll-free phone number to call before any construction or digging is begun will be installed at road crossings or other public access crossings. (TR 5907 Sandmeyer)

11. The Butler Associates, Inc.-Williams Brothers Engineering joint venture will oversee pipeline construction

and perform planning, surveying, right-of-way procurement, administration of contracts, and monitoring and inspection. (TR 6949 Evans)

12. Before beginning construction, the applicant will negotiate permanent and temporary easements with public and private landowners. The temporary easements will terminate upon completion of construction. The applicant will negotiate for purchase of sites for the pump and pressure reducing stations. Permits will be sought from agencies with jurisdiction for all inland waterway, river, irrigation canal, highway and railroad crossings, and to cross special land use areas such as Indian reservations and national forests. Temporary sites to store equipment and supplies during construction will also be leased. (TR 5896-98 Sandmeyer; Applic. II, Sec. 6.4.4.1) Easement negotiations and final implementation of pipeline design may require minor changes in pipeline routing and construction methods. (TR 5915-16 Sandmeyer)

13. Terrestrial pipeline construction will generally require the following steps: clearing and grading the right-of-way, hauling and stringing the line pipe, trenching, removing rock (if necessary), bending the pipe to conform to the terrain, welding the joints of pipe together, inspection of the welds, applying protective coating to the welded joints, installing bedding material where necessary, lowering the pipe into

the trench, and backfilling. Tie-in welds are made to connect adjacent sections of the pipeline at various locations, such as road and water crossings and mainline valves. (TR 6696-6703 Everett)

14. Mainline valves will be set in place and tie-in welds made to the pipeline after the valve is in place. The valves will be buried, but the manual and motor-driven actuator for each valve will protrude above ground and be surrounded by a fence. (Applic. II, Sec. 6.4.4.3)

15. During the construction period, Northern Tier proposes to continually inspect to ensure compliance with construction specifications. Field welds will be radiographically inspected in accordance with U.S. Department of Transportation regulations. As sections are constructed, they will be hydrostatically tested in accordance with U.S. Department of Transportation regulations.

16. The pump and pressure-reducing stations will be constructed by several different contractors so that all stations will be completed within approximately 16 months. Work will include general clearing, grubbing, and grading; fencing; excavating for foundations and piping; construction of the control building; installation of electrical instrumentation and control systems; installation of station piping; installation

of the mainline pumps and motors (at pump stations); construction of a surge relief tank (at some stations); and landscaping. (Applic. II, Sec. 6.4.4.7; TR 7350 Winegar)

17. The vast majority of construction access roads will be existing federal, state, and county roads. The applicant will also seek right-of-way agreements from landowners to use or improve existing private roads and/or construct new roads for temporary or permanent access, if needed. (Applic. II, Sec. 6.4.4.3)

18. Cleanup and restoration procedures will include removal of equipment, surplus material, and debris; revegetation; painting of structures; and landscaping of the pump and pressure reducing stations. (Applic. II, Secs. 6.4.4.6; 6.4.5)

19. Crude oil will be stored at the onshore storage facilities in batches defined primarily by sulfur content and gravity of the oil. When a particular type of oil is scheduled for shipment, the valves to the appropriate storage tank will be opened and the valves from the tank containing the preceding batch will be closed. The oil will then flow through the pipeline with the aid of the pumps at the pump stations. Through the SCADA system, the pipeline dispatcher will be able to know at all times where each particular batch is located within the

system. The pipeline is designed as a packed line (full of oil) during all operating conditions. (TR 7366-69 Winegar.)

20. A pipeline dispatcher will be at the main control center 24 hours each day. Pump stations are designed to operate by remote control from the Green Point control center, and will be inspected and maintained weekly. Northern Tier employees will be located at strategic points along the pipeline for routine maintenance and emergency repair. These employees will be supervised by personnel at the pipeline district offices tentatively planned for Port Angeles and Spokane. Local contractors will be retained for large maintenance projects and emergencies. (TR 5923-26 Sandmeyer.)

21. Station information available to the dispatcher through the SCADA system includes such information as suction and discharge pressures, status of pump units, flow rates, surge relief tank liquid levels, quantities of oil received and delivered, valve positions, oil and equipment temperatures, position of different oil batches, and whether pumps and motors are functioning properly. The dispatcher will be able to start and stop pumps, open and close valves, and adjust pressure settings by remote control. (TR 7369-73 Winegar.)

22. By remotely controlling pumps and valves, the pipeline dispatcher will be able to start up and shut down the

system during normal and emergency operations. Emergency shutdown could be occasioned by situations such as a line break or pipeline leak, a loss of power at a pump station, or an unauthorized mainline valve closure. An individual station is designed to shut down automatically if pressure exceeds a predetermined level or if certain other emergency conditions occur. (Applic. II, Sec. 6.5.3.1; TR 7364-65 Winegar.)

23. The interior walls of the pipeline will be cleaned by scrapers that will be sent through the line at various intervals. Traps for launching and receiving pipeline scrapers will be provided at selected stations along the route. (TR 7345 Winegar.)

24. The entire pipeline will be internally inspected for wrinkles, flattening, and dents. A similar internal inspection with a Caliper pig will be done after construction is complete and once a year thereafter. (TR 5927 Sandmeyer.)

25. Weather permitting, the surface conditions on and near the pipeline right-of-way will be inspected by an aerial patrol every two weeks. (TR 5926 Sandmeyer.)

26. When the facility is abandoned, removal of the oil from the pipeline system would be accomplished by displacing it with water obtained from local sources along the route. If

the steel in the pipeline is to be salvaged, the water would be displaced by air or an inert gas and retained in specially constructed ponds for processing through oil-water separators, prior to release to natural water courses. (TR 5931 Sandmeyer)

27. Removal and salvage of the pipeline mainline valves, and equipment at the remote stations would require activities similar to construction of the system, but with a more simplified work scope. It is possible that some sections of the line, such as inland waterway, river or road crossings, would not be removed because of the complications involved. In such cases, the ends of the pipeline on both sides of the crossing would be pumped full of mud, sealed, and covered with soil. (TR 5931-32 Sandmeyer)

II. B. ROUTE SELECTION FINDINGS

1. The Northern Tier route selection process began before the company moved its intended terminal location from Cherry Point to Port Angeles. Before that move, a preliminary route had been identified from delineation on 1:250,000 USGS maps, ground and aerial surveys, and some subsequent study based on 15 minute and 7½ minute quadrangle maps. Original route selection criteria included economic and social factors such as length, terrain, engineering and design criteria, maintenance and operational problems, accessibility from roads, and avoidance of populated and environmentally sensitive areas. In 1976, Northern Tier determined to move its port site from Cherry Point to Port Angeles.

2. As originally proposed to the Council, the Northern Tier route went from the port and tank farm site near Port Angeles across Clallam County and into Jefferson County on land, turned south and around the Sound on land through Mason and Thurston Counties, north around the Sound through Pierce County and into King County, across the Cascade Mountains at Stampede Pass into Kittitas County, and then further east across the Columbia River and through Grant, Lincoln, and Spokane Counties to the Idaho border. Maps and other information available to the engineer who did the original selection work did

not show the existence or location of such features as the Skagit Habitat Management Area, the Colockum Wildlife Refuge Area, or the Gloyd Seeps Wildlife Recreation Area.

3. Subsequently, Northern Tier amended its proposed route to include changes such as a move of the Cascade crossing point from Stampede Pass to Snoqualmie Pass to avoid the Cedar River and Green River watersheds; a change of approximately 16 route miles from Lincoln to Adams County, at the latter County's request; and a move to the south in Spokane County to avoid the primary recharge area of the Spokane-Rathdrum aquifer. In June, 1979, the company submitted an amendment containing substantial modification of the location for submarine unloading lines crossing Port Angeles Harbor, a rerouting between Green Point and North Bend to cross Puget Sound rather than proceed around it, and a following change to exit Whidbey Island at Polnell Point rather than Strawberry Point in order to avoid a prospective upland development.

4. The cross-Sound route would be more expensive than the around-Sound route. The decision to cross Puget Sound was made in order to make potential hook-up of the North Sound refineries a more attractive feature of the total Northern Tier proposal. Northern Tier has made no evaluation of the costs or likelihood of hook-up. The cross-Sound route met two concerns: the increasing determination on the part of the Federal

Government to establish a single unloading port for all of Puget Sound at a point at or west of Port Angeles (an amendment to the Marine Mammal Protection Act effectively prohibits constructing a major crude petroleum unloading port at any point east of Port Angeles. The Public Utility Regulatory Policies Act (PURPA) facilitates construction of such an unloading port but gives direction toward inclusion of a hook-up feature in any such project.) Second, construction of a total project configuration which would decrease the total miles between the unloading port and the four North Sound refineries and thereby marginally reduce the tariff charged North Sound refineries for any service rendered. (See Section VII, Finding #2.)

5. The present route is described above in section II.A.2.

6. An important consideration in route selection was utilization of existing utility corridors. As proposed in 1979, over 30% of the route in Washington lay adjacent to, but not yet in, existing utility corridors.

7. Northern Tier decided against various alternate routes for portions of its proposal. For example, the company decided against crossing Puget Sound at a point south of Port Townsend because there were problems with going through a residential district on Marrowstone Island; because of the

perceived difficulty of trenching at that point on the bottom of the Sound; and because of the unusual angularities it saw as being required to avoid the Whidbey Island Historical Preservation District.

8. The company decided to avoid following the Yakima River downstream for a considerable distance because of the narrowness of the Yakima's plain, which already contains the river and a railroad track. Congestion at Stevens Pass caused by a highway, railroad tracks, an existing pipeline, and general narrowness militated against crossing the Cascades at this pass.

9. In the route selection process, several points were considered sufficiently important to become controlling points. That is, choice of crossing for a particular feature became of primary importance in the overall process, and general route selection for adjacent areas flowed from the particular alignment chosen for the particular feature. One such controlling feature was the crossing of the Columbia River. No other petroleum line crosses the Columbia upstream from the Bonneville dam. (Only the Olympic Pipeline which ships petroleum products crosses downstream.) Many high, steep, and relatively impervious landforms exist in the region of the river through which Northern Tier anticipated its project. Steep cliffs eliminated some alternatives to the chosen Columbia crossing, while others

were eliminated because of effect on wildlife refuges. Northern Tier considered an area from roughly the site of the proposed crossing on the north to Beverly, Washington, on the south.

10. Though information was available, Northern Tier's route selectors failed to discover the Skagit, Gloyd Seeps and Colockum Wildlife Refuge Areas. They knew of the Colockum Hills as a geographic feature. The route follows an existing utility corridor as it enters the Colockum HMA on the west. However, the proposed pipeline corridor leaves the utility corridor several miles west of the Columbia River and continues across the Colockum HMA to the Columbia. (Wilson TR 6614). Northern Tier chose part of the route across the Colockum Habitat Management Area because of the existence of a utility corridor.

11. Northern Tier's primary consideration in routing its unloading lines over six miles across the mouth of Port Angeles Harbor, instead of around Ediz Hook and up through the City, then east to the Green Point tank farm, was congestion in the area of the Crown Zellerbach mill located near the base of Ediz Hook. Lesser considerations included community impact problems associated with any route ascending the bluff which rises close to the base of the Hook, selection of a feasible route to the east which did not enter Olympic National Park, and the possibility of increasing pumping capacity from the berths if the present tank farm site were to be maintained.

The company did not consider a shallow-water crossing of the Harbor in that area immediately east of the congested Crown Zellerbach mill.

12. At the Port Williams landfall, the centerline site, located on a sheer 65-70 foot bluff, was chosen over a mile-to-the-south cut which runs down to sea level, the cut contains a boat launch and a park. Northern Tier understands the landward centerline to avoid the Grey Marsh Farm habitat area.

13. Route selection across major rivers other than the Columbia was made by an engineer who was permitted to work to a maximum of 100 to 300 feet on either side of the already-chosen centerline. The trench-and-fill construction method was assumed as a design criterion for these crossings; therefore, the crossing sites were studied for their amenability to this method, as opposed to other methods of crossing. Before the crossing sites were publicly identified, the engineer in charge had not done much ground reconnaissance. His recommendations within the preselected corridors were made largely on the basis of overflights and 1:12,000 aerial photographs (on which the width of a pencil line approximates 100 feet). Original crossing selection preceded environmental review and discussions with state fish and game personnel. The crossing selection effort was not intended to show any flaw in the original corri-

dor alignment. Within the restricted zones, river crossings were to be selected to achieve the following goals: minimal width and depth, stable and straight banks and channel, suitable terrain, 90° angle crossing of the stream, avoidance of bedrock, avoidance of fine grained soils, minimal effect on existing development, environmental insensitivity, suitable site for a staging area, minimal river velocity, and access to existing roads. Salmon spawning areas would have been regarded as sensitive but may not have been considered.

14. West Pass was the only wetland which affected Northern Tier's routing considerations. The company elected to place its centerline at the narrowest point in order to affect the least amount of West Pass wetlands.

15. In selecting its North and South Fork Stillaguamish crossing points, Northern Tier was unaware of the water intake locations for the Cities of Arlington and Marysville although the information was readily available. The respective intakes are downstream nominal distances from the proposed crossings of the respective forks. The company discarded a more westerly I-5-oriented route through much of Snohomish County because it appeared more populated and often under water.

16. King County route selection did not consider location of old growth forests, archaeological sites, proposed parks, or the location of the City of Snoqualmie's water line.

17. A basic route selection criterion was that lands chosen should have a ready potential for obtaining right-of-way agreements. Consequently, known Indian reservations, national park lands, state park lands, and similar enclaves were avoided.

18. Northern Tier proposes use of significant stretches of Bonneville Power Administration transmission corridors for the NTPC pipeline route. To use the corridors, Northern Tier will ordinarily have to receive permission from BPA and then negotiate successfully with those landowners from whom BPA has obtained its rights. BPA may allow work to within 25 feet of its towers.

19. Northern Tier's environmental consultant reviewed the selected route for environmental considerations. This consultant recommended minor route modifications for environmental reasons.

20. The proposed route has not been surveyed. The legal description of the centerline is derived from maps.

21. Northern Tier intends, if certified, to conduct an on-the-ground survey as well as engineering and other studies to determine the precise alignment of its route.

22. NTPC requests certification for a one-half mile corridor within which it may choose to locate its pipeline right of way at any point. NTPC proposes to locate the pipeline on the designated centerline and has determined that is the best location according to its routing engineers. NTPC anticipates numerous deviations of 100 feet or so from the centerline depending on actual site conditions. The necessity for deviations cannot be determined at this point. NTPC has identified a centerline in the corridor as the company's preferred route and about which some site specific information has been presented in the record. The USGS quadrangle maps used are on a scale of 1 inch to 2000 feet or 1 inch to 5200 feet. These maps show a single line with no corridor. Their centerline represents no specific width. It is identified in the legal description with approximations of rounded-off distances in feet from section lines. (TR 22655, 22657, 22660, Ex. 311, 312, TR 22637, 22673.) The maps do suffice to convey a generalized understanding of the centerline's location.

23. Discrepancies exist in the record with respect to centerline location. (TR 22660, 22644, Ex. 311, TR 22638, 22639)

24. The general location of the pump stations has been identified. No site specific legal description has been given or can be provided until final design. An area of some seven acres for each pump station is marked on NTPC Volume IV maps. (TR 2658-59).

25. Minor river crossings, as the term is used by NTPC, could be located anywhere within the half-mile corridor. Major river crossings would be located anywhere within a 400-foot area surrounding the centerline. The only site-specific information NTPC has presented on river crossings pertains to major crossings being on or near the centerline. (TR 22637, 22673, Ex. 70, Koloski testimony).

26. No new studies were undertaken when NTPC narrowed its corridor from two miles to one-half mile in width. (TR 22642).

27. Northern Tier proposes to locate its pipeline on the centerline wherever possible, but anticipates numerous deviations of up to 100 feet. The necessity for specific deviations has not been determined at this time.

28. NTPC would expect to survey the line before it acquired easements from landowners. (TR 22666).

29. Assuming the parallel utility concept takes precedence for pipeline routing, site-specific evaluation of environmental impacts and sensitive areas adjacent to the existing utility should be undertaken prior to route selection to insure minimum adverse environmental impacts. NTPC has located its centerline generally parallel to existing utility and transportation corridors; however, it did not consider route alternatives within such sites to minimize environmental impacts. No present law or rule mandates that Northern Tier conduct such an evaluation. For example, major rivers were examined only at centerline locations. Minor rivers and streams were not examined at all. The record shows only a few instances of alternate routes within the corridor being examined for any purpose, including environmental. There is no support in the record for the proposition that the choice of the terrestrial centerline was based upon analysis which included environmental characteristics within the corridor. (Currie TR 36847, 36853-55, Yuill, Reyes-French). (Ex. 716 and 717, TR 36501, 36502).

30. The Marine Mammal Protection Act effectively prohibits siting a major petroleum transshipment facility east of Port Angeles. Limiting consideration to Olympic Peninsula port sites, the following is properly found concerning the configuration chosen by Northern Tier:

a. A location inside Ediz Hook is the only location considered which presents a fire and explosion risk to an urban community.

b. Because of winds and currents and because the Hook is closer than any other legal site, a large spill from inside Ediz Hook is at least as likely to reach Dungeness Spit, Protection Island, Discovery Bay, the San Juan Islands, Admiralty Inlet, Puget Sound, and all the other marine waters and beaches east of 123° west longitude as is a spill from any other possible port site. The decision to cross Port Angeles harbor by submarine pipeline avoids going through the community of Port Angeles, but also substantially increases the exposure of marine resources to oil spills above the exposure risk already posed by the selection of the Harbor as a port site.

c. Both because of its location and because of the attendant hazards and complexity of the geology, currents, and other aspects (discussed below), the submarine crossing of Admiralty Inlet exposes the resources listed in Finding 30b, to a risk as great as might be reasonably conceived in establishing a pipeline connection between the Olympic Peninsula and the Washington mainland.

d. Unless the abandoned Strawberry Point landfall were redesignated, Saratoga Passage could not be crossed by a route more hazardous to the Skagit delta than the one chosen.

e. The landward portions of Northern Tier's 1979 Application amendment also carry a hazard for Island, Snohomish and King County features such as West Pass, Davis Slough, the forks of the Stillaguamish, Pilchuck River and Pilchuck Creek, the Skykomish, Snoqualmie and Snohomish Rivers, and possibly the water supply for Whidbey Island.

III. A. GEOLOGY AND SEISMIC RISK

1. The history of seismicity in the state of Washington is widely varied. The Puget Sound region is an active zone which has experienced frequent earthquakes of varying intensities. The Cascade Mountains and eastern Washington are characterized by less frequent and lower energy seismic activity. The energies of earthquakes are described in terms of two basic scales, the Richter Magnitude Scale which is a measure of the energy release at the hypocenter of an earthquake, and the Modified Mercalli Intensity, which is a measure of the "felt effects" of an earthquake on the ground surface. In this discussion, where possible, reference will be made to Richter magnitudes.

2. Northern Tier has used a design level earthquake of VII+ (Modified Mercalli Intensity) with a ground acceleration rate of 0.20 g. for Western Washington. (Veatch, TR 3496; Ex. 30, p. iii; Ex. 84, p. 16; Alsup, TR 8745). Seismologists generally equate a Mercalli Intensity VII-VIII with a Richter magnitude 6 earthquake, a Mercalli Intensity IX-X with a Richter magnitude 7, and a Mercalli Intensity X-XII with a Richter 8. (Rasmussen, TR 23970; Ex. 30, Fig. 33). Northern Tier's design earthquake is equivalent to a Richter magnitude 6.0 earthquake. (Rasmussen, TR 23970; Alsup, TR 8719-20, 8722). The total energy released by a Richter magnitude 7.0 earthquake at the hypocenter

is roughly 60 times the energy released by a Richter magnitude 6.0 earthquake. (Rasmussen, TR 23970). Richter magnitudes will be used in this analysis.

3. The proposed Northern Tier facilities in Clallam, Jefferson, Island, Snohomish and King Counties lie within a very seismically active region, referred to as the "Puget Sound" or "Puget Sound-Vancouver Island" tectonic province. This province is approximately 2° longitude wide and has a north-south trend in Washington State from southern Thurston County to about latitude 48° north, where it continues in a northwesterly direction through much of Vancouver Island. This province lies to the east of, and is parallel to, the subducted Pacific plate. (Rasmussen, TR 23960-61, 24430-32).

4. The Puget Sound province can be subject to large earthquakes. A magnitude 7.3 (Richter Scale) earthquake occurred on Vancouver Island in 1946, a magnitude 7.1 event in southern Puget Sound in 1949, and a magnitude 6.5 earthquake also in Puget Sound in 1965. (Rasmussen, TR 23962).

5. The largest possible earthquake which may take place along the proposed Northern Tier route through Western Washington is a Richter magnitude 7.5 event. (Rasmussen, TR 24432-33; Crosson, TR 42650).

6. There is no reliable basis upon which to subdivide the Puget Sound region as to its seismic risk for large earthquakes. (Rasmussen, TR 24430-32; Crosson, TR 42655).

7. The seismic record for the Puget Sound province is historically short. The actual occurrence rate of large earthquakes cannot be estimated with great accuracy based on past history. (Rasmussen, TR 23963). An earthquake such as the 1949 Olympia earthquake might occur only every 100 to 200 years. (Crosson, TR 42727, citing "Causes, Characteristics and Effects of Puget Sound Earthquakes," by Hawkins & Crosson (1975), p. 111). In the 1946-65 period alone, however, three large earthquakes occurred.

8. The 7.5 magnitude earthquake could occur anywhere in the Puget Sound area, including any point along the Northern Tier pipeline route in Western Washington. (Rasmussen, TR 23965; Crosson, TR 42728).

9. The Puget Sound area experiences both deep (more than 40 kilometers of depth) and shallow (less than 30 kilometers) earthquakes. In the past, the large earthquakes (over 6.0 magnitude) have occurred in the deeper levels. A deep earthquake affects a larger geographic area than a shallow earthquake, (Crosson, TR 42723), though the rupture surface from such large, deep earthquakes probably will not reach the ground

surface due to an intervening "soft layer." (Crosson, TR 42629-30). Both deep and shallow earthquakes could occur at any point along the Northern Tier route in Western Washington. (Crosson, TR 42722-23).

Design Earthquake

10. Earthquakes produce corresponding ground motion which is normally quantified in relation to the ordinary force of gravity acting at the earth's surface. The term 1.0 g means the acceleration which would occur from the ordinary force of gravity. The greater the magnitude of the earthquake at any point, the greater is the acceleration which will occur. (Rasmussen, TR 23967).

11. Acceleration rates from an earthquake will vary depending upon depth, topography, and type of soil within which the ground motion occurs. Acceleration in soils can be higher than bedrock acceleration in most, but not all, cases. (Rasmussen, TR 23967; Crosson, TR 42665-66, 42675-76).

12. Ground accelerations can be estimated through several methods, including the performance of a dynamic analysis of the soils for the subject site. Northern Tier has not performed a dynamic analysis of the soils along the project in Western Washington, (Rasmussen, TR 23970-71; Crosson, TR 42654-

55, 42663-64), nor has it specified design accelerations corresponding to the different soils in which the project facilities would reside.

13. The appropriate design level earthquake and accelerations are a function of the degree of risk associated with damage to a particular facility. It is inappropriate to emulate nuclear power plant design level considerations per se for an oil transportation system, given the widely different risks associated with each, and given differing soil types being considered.

14. Design acceleration levels are most important with respect to above-ground structures at the marine terminal, the tank farm facilities, and the submarine portions of the pipeline route, including the submarine unloading lines. Since a buried pipeline normally moves with the ground, acceleration levels are of less concern with respect to direct impacts on the terrestrial portions of the pipeline. (Alsup, TR 8451). In the 1949 Southern Puget Sound event, a .31 g peak acceleration was recorded. In the 1965 Puget Sound event, a .23 g acceleration was recorded.

15. For the proposed Sohio pipeline project from Long Beach, California, to Midland, Texas, the maximum earthquake that could occur within the project region was used as

the design earthquake for the project. (Rasmussen, TR 23948-49, 23951-52, 23966-67).

16. Northern Tier and its consultants have performed all engineering and design judgments for the project based upon a design earthquake of Richter magnitude 6.0 with a maximum ground acceleration of 0.20 g. (Veatch, TR 9066-67). Northern Tier has not investigated the impacts on the proposed facilities from larger earthquakes with higher ground accelerations. (Alsup, TR 8745; Veatch; Forman).

17. Northern Tier submitted an acceleration table indicating that a Richter 6.0 earthquake could have ground accelerations up to 0.20 g in "firm bedrock," up to 0.27 g in "average foundation" conditions, and in excess of 0.50 g for "below average soil" material. (Ex. 89).

18. Local soil conditions are one of the dominant factors in determining the extent of ground motion during an earthquake. (Crosson, TR 42669-70). Ground acceleration amplification factors of 2.0 or more have occurred in soils in the Puget Sound region in past earthquakes. (Crosson, TR 42665-68).

19. The probability of a Richter 6.0 earthquake in the Puget Sound region is estimated to be 85% in twenty years

and 100% in thirty years. (TR 30032). The life of the project is unknown.

20. A design earthquake of Richter magnitude 7.1-7.5 range should be used in the design of critical facilities; that is, those for which oil spills or loss of life could occur in the event of structural failure. (Rasmussen TR 23966). The corresponding earthquake design acceleration level should be 0.31-0.35 g.

21. To evaluate the adequacy of design information of the facility with regard to seismicity, ground motion data is required showing a time history of ground motion in the form of a response spectrum or the data from which such a spectrum is generated. (TR 30359). Northern Tier's application and consultant reports do not supply this type of information. (TR 30360). A single acceleration factor for each facility is not sufficient to evaluate the risk of structural failure due to seismic activity. (TR 30376).

22. The central Cascade Mountain region is one of low seismicity. Activity with Richter magnitude of 6.0 or above has not been reported in the area around the corridor. No surface faulting related to the seismic history of record has been identified. (Applic. III, Sec. 1.1-13)

23. No active faults have been mapped along the eastern Washington pipeline route. No major (Richter 6.0) earthquakes in the vicinity of the corridor are known to have occurred. (Applic. III, Sec. 1.1-15)

Marine Terminal

24. The tanker unloading facilities are to be located along the south side of Ediz Hook, a west-to-east trending accretionary longshore spit forming the north side of Port Angeles Harbor. Ediz Hook consists primarily of sand and gravel, with some cobbles, all derived from eroding sea cliffs to the west, and sands, silts, and gravels carried to the shoreline west of Ediz Hook by the Elwha River. These surficial and near surface recent marine sediments are likely underlain by older marine sediments consisting of medium dense to very dense silty to clean sand. The older marine sediments are likely underlain by glacially overridden sediments consisting of very dense, slightly silty to silty sand with variable amounts of gravel. Bedrock appears to exist presently beneath the site at depths greater than 300 feet below sea level. No boring on Ediz Hook reached "glacially overridden sediments." (Ex. 30, p. 8 and Fig. 4).

25. The marine sediments on the south side of Ediz Hook have been classified into three types A, B, and C. Type A

sediments are very loose to loose, younger sediments. These sediments range from 1.5 to 16 feet in depth in the terminal area. Type A soils are underlain by Type B sediments of much greater relative density. The thickness of these sediments could be greater than 200 feet. The Type B sediments may be underlain by glacially overridden sediments denominated Type C, though no borings reached such sediments. (Ex. 30, p. 8) No faults are known to be present at or close to the site.

26. The relative instability of the Hook is indicated by the historical record; the non-cohesive nature of the marine sediments; the differential compaction of soils; the subsurface wedge-shaped geometry of the Hook (Ex. 347); and the steep slopes. (Rasmussen, TR 23971, 23977; Veatch, TR 3332).

27. No soil borings were taken by Northern Tier on the dryland portions of Ediz Hook. Shannon and Wilson undertook one underwater test boring at the site of the proposed tanker unloading facilities on the south side of the Hook. (Ex. 30, p. 3. Fig. 1). The information gathered so far is insufficient for final design.

28. The onshore storage site is located on glacial deposits which overlie bedrock at depth. The site is mantled with a thin cover of silt. Below the surface layer, there is very dense sand, clay, gravel and silt. The storage facilities

will be situated behind the Green Point sea cliff which is a near vertical 120 foot high bluff which has been regressing at a rate of approximately eight inches per year. There is no evidence of significant landsliding or instability at the site. However, Northern Tier did not have sufficient soils data to perform a quantitative stability analysis of the Green Point Bluff. There have been landslides at bluffs to the west of Green Point. Shallow slumping in the area is related to the bluff regression and should not hamper construction or operation of the facilities. (TR 8413-14 Olmsted) Drainage from the site is generally northerly to the Strait and northeasterly to Seibert Creek.

29. Occurrence of a large earthquake has the potential to cause slope instability and slumping along Ediz Hook. The unconsolidated Type A material and to some extent the Type B soils, are prone to slumping in the event of a large earthquake. (Johnson, TR 23996-97). Submarine landslides could also occur in slopes on the bottom of the Harbor which exceed 1°-3°. (Johnson TR 23997; Buck). Once a slide of liquefiable material is initiated, it could cause the movement of denser, non-liquefied materials as well. (Johnson, TR 24008-09; Buck, TR 33974).

30. The marine terminal facilities, if designed and constructed to withstand an 0.31-0.35 g acceleration level,

would not be expected to incur damage from seismic events during the lifetime of the project. While the Type A sediments in the marine terminal area are potentially liquefiable under less than design earthquake conditions, the pilings upon which the terminal facilities are to be built will be driven through the Type A materials into Type B and C soils. Type C soils, which are not subject to liquefaction, reduce any risk that the liquefaction and movement of the softer sediments might pose to the integrity of the structures.

31. A 0.31-0.35 g design acceleration level for marine terminal facilities does not include a factor for significant amplification of peak ground accelerations over those for bedrock. The Council makes no finding at this point as to the likelihood of significant amplification.

32. Some relocation of surface materials will result from construction activities at the tanker unloading facilities. Driving of pilings will cause local displacement of bottom and subbottom materials. (TR 8456 Alsup).

33. Construction of the unloading pipeline section on Ediz Hook will not have significant impact because of the flat surface of the Hook and the character of materials that will be excavated. (Applic. III, Sec. 2.1.2.1).

34. Rock backfill in the shore and surf zones will be required at both the Ediz Hook and Green Point shore approaches. In order to assure that littoral sediment transport is not impacted at Green Point, special pipeline burial requirements are applicable.

35. Excavation of a pipeline slot in the Green Point bluff will cause temporary disturbance of vegetation in the construction area, risk of erosion problems, and temporary interference with the littoral drift of bottom/shoreline materials. The pipe will be recessed at least 30 feet behind the face of the bluff and the slot will be backfilled with a soil-cement mixture designed to erode at the natural rate of bluff erosion. The backfill will be periodically maintained. There will be no riprap barrier at the base of the bluff to retard bluff regression or potentially interfere with littoral drift. The construction method for the shore approach at Green Point will have virtually no significant long-term impact on littoral drift or bluff erosion and therefore is not expected to impact the normal beach processes at Dungeness Spit. The chosen method offers the most protection for the Spit of any considered.

36. Surficial soils and glacial till will be disturbed by construction of roads, berms and other facilities at the onshore storage site. The glacially overridden deposits that will be exposed, however, are relatively resistant to ero-

sion. A forested buffer zone will be maintained by the applicant to control sedimentation from excavated and disturbed materials into the Strait and Seibert Creek. Disturbed areas will be seeded to reduce erosion. (TR 8463-64 Alsup; Applic. III, Sec. 2.1.3.1).

37. Where extensive grading or other site preparation is required during construction at the onshore storage site, settling ponds will be maintained to minimize the introduction of sediment into Seibert Creek or the Strait. (Applic. II, Sec. 6.4.3.1).

38. Following construction, operation of the tanker unloading facility should cause no significant change to the geologic conditions at the Ediz Hook site. (TR 8956 Alsup).

39. Following construction, normal operation of the onshore storage facilities will cause no significant change to the geologic conditions at Green Point (Applic. III, Sec. 2.1.3.2).

40. Detailed submarine geology is discussed in Section II.A.2.

III. B. VESSEL TRAFFIC AND TERMINAL OPERATIONS

1. The Strait of Juan de Fuca is a significant maritime artery carrying vessels of all kinds. In 1977, 15,216 vessels voluntarily reported transit through the Strait to the Coast Guard Vessel Traffic Service. Of these, 7,198 were freighters and 1,204 were tankers. The rest were tugs, government ships, ferries and miscellaneous vessels. These numbers include both inbound and outbound vessels. In 1978, a total of 18,154 vessels were reported, including 8,318 freighters and 1,343 tankers. This number represents a daily average of approximately 51 vessel movements, including 23 freighters and 4 tankers. There are no comparable statistics for Saratoga Passage, but it is not a part of any shipping lane.

2. Port Angeles harbor is approximately one mile by three miles with a one-mile opening. Depth restrictions limit the effective harbor entrance to approximately 4200 feet for loaded tankers of 120,000 DWT and larger.

3. Port Angeles harbor traffic consists of ferries, freighters, tankers, tugboats or towboats, barges, log rafts, fishing boats, recreational boats, pilot boats, and Coast Guard vessels. In 1980, the vessel traffic in Port Angeles harbor was approximately 25 to 30 vessels of all kinds (excluding pleasure and fishing craft) per day, of which five to six

were deeper draft vessels, such as freighters, tankers and ferries. Incoming vessels for Port Angeles and all points east pick up pilots at Port Angeles, and outgoing vessels discharge them there. The pickups and discharges occur outside the Hook, except in severe weather conditions.

4. Log tows also constitute a large volume of inbound traffic on the north shore of the harbor where the Northern Tier terminal would be situated. Log tows present special maneuvering problems for oil tanker traffic because log tows are difficult to maneuver, control or stop. No other port has competing marine traffic of log tows and large crude oil tankers.

5. No traffic lanes are designated by the Coast Guard for the entrance to or exit from Port Angeles harbor, or for the pilot pick-up area located approximately one-half to one mile northeast of the end of Ediz Hook. However, Northern Tier is committed to seek a vessel traffic plan through the Coast Guard.

6. During construction of the submarine pipelines from Ediz Hook to Green Point and from Port Williams to Point Partridge, a pipelaying barge and attending barges and vessels will be deployed along the route. Vessels crossing the route will have to navigate clear of the pipelaying equipment and associated anchor lines. As pipelaying will be a continuous

operation and proceed at a rate of about 1,000 to 2,000 feet per day, it is expected that within Port Angeles harbor, a deep draft navigation zone can be maintained across the pipeline route at either end of the pipelaying spread. This condition is expected to last 30 days. Across the Strait of Juan de Fuca the construction may take 60 days.

7. Northern Tier estimates that at the maximum throughput rate (933,000 barrels/day), its marine terminal will receive a minimum of 395 tanker calls and 47 fuel tanker calls per year. Vessel traffic in Port Angeles will be increased by these calls as well as by support vessel movements, such as supply and line handling launches and tugboats. Northern Tier has described tanker berthing and departure maneuvers as requiring a minimum of two tugs per operation.

8. The applicant's estimate of tanker calls per year assumes that 116 crude oil tankers could supply 350,000 barrels per day to the four North Puget Sound refineries, should hook-up be made. Witnesses from three of these refineries dispute this figure and maintain that approximately 230 calls would be needed to supply oil to the North Sound facilities. If this figure is correct, total vessel calls at the Northern Tier terminal would be approximately 527 per year, assuming no additional fuel tanker calls would be required beyond those the applicant has already estimated.

9. Any discussion of vessel traffic volumes to serve the needs of the four north Puget Sound refineries through Northern Tier's pipeline remains hypothetical; the applicant's project, as proposed to the Council, does not contemplate service to the North Sound refineries. (See VII, Potential Future Activities).

III. C. 1. FIRE AND EXPLOSION

1. Northern Tier selected Port Angeles Harbor for its proposed marine terminal primarily on the basis of facilitating handling and unloading of crude oil tankers and controlling oil spills. The consequences of a major fire or explosion near an urban area are potentially grave.

2. Ships at the the proposed unloading berths would be situated less than 7,000 feet from downtown Port Angeles.

3. Oil ports capable of accommodating Very Large Crude Carriers and Ultra Large Crude Carriers and actually constructed in recent years have been sited miles away from residential and urban communities. The port at Bantry Bay in Ireland is separated by miles and geographic features from the nearest town. The port at Europoort in The Netherlands was intentionally located some 15 miles from associated refineries and their environs. (TR 26914, 26945-46).

4. The tankers calling at the Northern Tier terminal would include vessels as large as 327,000 dead weight tons (DWT).

5. Crude oil tankers of the size 100,000 DWT or greater are qualitatively different than the smaller vessels that have traditionally called at U. S. ports. The larger vessels have different design and operating characteristics, and possibly a greater frequency of fires and explosions resulting in total vessel loss. (TR 26916, 26919, 26920, 26551, 26533, 26653, 26506, 25432, 25778, 25775).

6. The worldwide tanker data base used by Environmental Resources and Technology, Inc. (ERT) in its fire and explosion analysis for Northern Tier does not include relevant experience with large tankers because the data were too old (1971-1972).

7. Of the eight U. S. port systems examined by the Oceanographic Institute of Washington (OIW) in its tanker risk analysis, five were unable to receive tankers greater than 60,000 DWT. The terminals at Los Angeles/Long Beach and San Francisco can accommodate vessels as large as 120,000 DWT but vessels of that size represented only 2.2% and 0.3%, respectively, of total traffic in those ports. (TR 25382).

8. None of the U. S. port systems examined by OIW has ever received tankers of the maximum size that would be calling at the Northern Tier facilities in Port Angeles Harbor. (TR 25431).

9. The number of total vessel losses during 1979 through the first half of 1980 indicates more total losses from fires and explosions for large tankers than for smaller vessels. (TR 26612, Ex. 362).

10. Northern Tier's fire and explosion studies were not factors in regard to site selection.

11. The OIW analysis is a competent study of traditional U. S. unloading terminal experience but is invalid with regard to describing the level of risk that will be imposed by the supertankers calling at Port Angeles, because it did not include data for similarly sized ships.

12. The risk probabilities predicted by ERT and OIW are made more conservative because several mitigating features which could reduce the estimated probabilities, such as recent improvements in the mandatory vessel traffic system, dual steerage and collision avoidance systems, and, after 1983, segregated ballast, were not included. (TR 10715-16). At present, the extent to which these features may lower casualty rates appears not to be quantifiable.

13. By 1983, U. S. Coast Guard regulations will require inert gas systems (IGS) for all crude oil tankers over 20,000 DWT and all product tankers over 40,000 DWT.

14. Perhaps no other single element of tanker casualty risk analysis discussed in the applicant's case has been more disputed than the effect IGS will have on lowering or reducing the risk of tanker explosions.

15. A properly designed, operated and well-maintained IGS can prevent the vapors left in emptied cargo tanks from becoming explosive, thereby preventing some explosions.

16. Certain types of tanker accidents in recent years indicate that such systems are irrelevant in the prevention of some explosions and fires.

17. Even where cargo tanks are properly inerted, the addition of oxygen in sufficient quantities will allow an explosive mixture of gases to return. A cargo tank containing inert gas can be breached by a collision or ramming and can cause an exposure to oxygen sufficient to create a simultaneous or near-simultaneous explosion. (TR 26552-53).

18. From 1979 through April, 1980, 18 explosions resulting in total vessel loss occurred in tankers ten years old or less. Fourteen of these involved tankers of 100,000 DWT or greater. (TR 26658). Some of these vessels were not equipped with IGS. Of those that were, the inerting systems had nothing to do with the cause or result of the casualties. This evidence

indicates that there are circumstances that can produce explosions that are not affected by the presence of IGS.

19. Some of the crude oil brought to the Northern Tier terminal will probably arrive in Oil Bulk Ore carriers, known as "OBO boats". (TR 26547).

20. OBO vessels are a specific type of tanker designed to carry crude oil on one leg of a voyage and bulk cargo, such as coal, ore, minerals or grain on the return leg. They presently make up approximately 15 percent of the world tanker fleet. Because many of these vessels are in the preferred size range of approximately 100,000 DWT, it is likely that there will be an increase in the number of OBO boats calling at ports on the West Coast. (TR 26934-35, 26547, 25783).

21. OBO boats are substantially different in design from conventional crude oil tankers; they contain additional and unintended void spaces that tend to trap explosive vapors.

22. OBO boats are more difficult to inert properly than are conventional tankers.

23. After discharging their cargoes, it is possible that some of the OBO boats calling at the Northern Tier facil-

ity would conduct tank cleaning operations in Port Angeles Harbor. (TR 26547).

24. Unless the tanks being cleaned have been properly inerted, tank cleaning can produce hazardous circumstances leading to fire and explosion. (TR 26546).

25. The potential additional risks presented by OBO boats have not been specifically considered by Northern Tier.

26. Northern Tier has not considered potential secondary or chain-reaction consequences of a single tanker casualty. An example of the type of consequences omitted by the Northern Tier studies is the casualty involving the tanker CHEVRON HAWAII which set on fire four barges that were in the vicinity. (TR 26963).

27. Port Angeles Harbor is presently used by crude oil tankers conducting operations such as tank cleaning and lightering (the ship-to-ship transfer of cargo). These operations present risks of explosions.

28. Northern Tier acknowledges that this risk cannot be quantified due to lack of data as to the number of tankers

currently laying over, lightering, tank washing or engaging in other activities in Port Angeles Harbor.

29. Chemicals associated with various industries near the Port Angeles waterfront, and creosoted pilings represent potential hazards in the event of a major tanker fire or explosion and have not been specifically addressed in risk probability and consequence analysis.

30. The force of the exploding tanker SANSINENA blew the vessel's mid deckhouse approximately 750 feet into the air and 150 feet inland. Based on this incident, Northern Tier calculated a maximum range of projectiles from a tanker explosion to be 1,500 feet. (TR 10,658). (See Finding 66 et seq. concerning the SANSINENA casualty).

31. The explosion of the tanker BETELGEUSE in 1979 blew a 1,027 pound piece of steel cargo tank 2,000 feet from the ship. An explosion involving the tanker CORINTHOS blasted valves and rivets approximately one-half mile (2,600 feet) away. (TR 26555).

32. One witness estimated that a SANSINENA-type explosion could blow objects such as heavy rivets as far as one to one and one-half miles away. (26944-26945). The report

filed by the Coast Guard subsequent to the explosion of the SANSINENA did not report the distribution of small projectiles.

33. OIW estimates that the tankers calling at the Northern Tier terminal will create a risk of about one fire every 18 years. The probability of one or more fires in the harbor would be five percent in any year and about 67 percent during the first 20 years of operation. (Ex. 106, III-6).

34. The Northern Tier facility would increase the fire risk in Port Angeles Harbor from tankers more than 16 times. (Ex. 106, III-6).

35. OIW concluded that the chance of death resulting from tanker fires at the Northern Tier terminal would be 2.4 percent per year. The probability of a nonlethal injury would be slightly less. (Ex. 106, III-6, III-10).

36. OIW modelled tanker fire impacts, assuming that oil had been spilled and had spread for one hour prior to ignition. The thermal radiation model was based on a flame burning everywhere. (Ex. 106, III-10).

37. OIW described a pool fire resulting from the spill of one wing tank on an 80,000 DWT tanker. The radius of such a fire was stated as 1,700 feet. (Ex. 106, III-12, Fig.

III-1). The area of the fire would be somewhat more than 4,500,000 square feet.

38. Within such a fire's perimeter, if at Berth No. 2, are the bunker fuel barge, berth and piping; the Berth 2 access tower and tanker service platform; the access trestle connecting Berth 2 to Ediz Hook; all dolphins and connecting appurtenances of Berth 2; the entire booster pump platform (including the pumps and surge relief tank); the walkway between Berths 2 and 1; the access tower and berth service platform at Berth 1; and more than half of any vessel tied up at Berth 1.

39. The radius for a pool fire from one wing tank of a 327,000 DWT tanker at Berth 2 is 2,460 feet. The area encompassed by such a fire would exceed 9,000,000 square feet. (Ex. 106, Fig. III-2).

40. The facilities within the burning area would include those mentioned in Finding 38, supra, as well as the entire access trestle to Berth 1 and all appurtenances; any vessel moored at Berth 1; and the small boat berth located between Berth 1 and Ediz Hook.

41. A fire consuming the contents of one wing tank of an 80,000 DWT tanker would cover much of the traffic path in and out of the harbor. (TR 11237).

42. OIW's worst case pool fire would result from a spill of the entire cargo of a 327,000 DWT tanker. The fire radius after one hour of spreading would be 5,700 feet, (Ex. 106, Fig. III-3) and the area encompassed would exceed 51,000,000 square feet. Most of the harbor and most of the open harbor anchorage areas would be within the fire radius.

43. There is no testimony addressing the amount of time required for ships at anchor to evacuate the harbor.

44. A worst case pool fire occurring near the city shoreline would include an area reaching from a point east of the ITT facilities to a point west of the Penply plant (Ex. 106, Fig. III-4), and would damage much of downtown Port Angeles. (Ex. 106, III-12). OIW calculates the likelihood of such a fire to be less than 0.6% in 20 years. (Ex. 106, III-12).

45. OIW's oil spreading model did not include the effects of wind, tidal forces, continued spreading or site-specific factors, but did assume an instantaneous spill and a coherent flame.

46. Quite frequently, an oil slick will break away from the main source of the spilled oil and drift separately. This can result in separate burning oil slicks being dispersed in different directions as changes occur in wind and tidal

movement. (TR 26586, 26587). OIW's modeling includes no such dispersion.

47. OIW calculates the probability of one or more tanker explosions along the Strait of Juan de Fuca involving Northern Tier tankers to be 1.4 percent per year and about 25 percent in 20 years. (Ex. 106, III-18).

48. Within the harbor area, OIW has concluded the risk of explosion is 2.2 percent per year and 36 percent over 20 years. This increases the existing risk of explosion in Port Angeles Harbor from tankers by more than a factor of 20. (Ex. 106, III-21).

49. OIW predicts that the probability of one or more fatalities from an explosion is 5 percent per year and 62 percent over 20 years. The probability for nonlethal injury is 4 percent per year and 57 percent over 20 years. (Ex. 106, III-26).

50. The blast from a tanker explosion can cause human injuries including eardrum rupture, fractures and lung damage. The lethality threshold is reached at a blast over-pressure of 6 psi. At 7 psi, the probability of death reaches 50%, assuming direct exposure to the blast wave. (Ex. 106, III-29).

51. Damage radii vary with blast size. OIW's worst case is the explosion of an empty 327,000 DWT vessel. The worst case lethality threshold then is 1,100 feet, with near 100 percent lethality at 940 feet, and eardrum rupture out to 1,900 feet. (Ex. 106, III-31). A worst case explosion at Berth 2 would include within the near 100 percent lethality radius, the bunker fuel barge, approximately one-half of the walkway connecting the two berths, the entire tanker access trestle to Berth 2 and the tanker service platform for the berth, the booster pump platform, and much of the width of Ediz Hook to the north. (Ex. 106, Fig. III-5). Types of blast damage to structures at varying overpressures include glass failure, glass shattering, light and moderate structural damage, and structural collapse. (Ex. 106, III-30). Structural damage resulting from the explosion at Berth 2 of a 327,000 DWT tanker includes typical glass failure, occurring out to a distance of 3.1 miles and including practically all of downtown Port Angeles. Moderate damage to reinforced concrete buildings according to OIW would extend 750 feet and would include much of the bunker fuel barge, the service platform, and the access trestle. Within 1,000 feet, the explosion would cause moderate damage to the booster pump platform. (Ex. 106, Table III-18).

52. A fire at the tank farm is predicted at a rate of once every 40 years. A worst case tank farm fire was modeled as the overfilling or rupturing of a storage tank (545,000 bar-

rels), resulting in the flooding and subsequent ignition of the holding basin. The resulting fire would produce flames 300-400 feet high and within 30 seconds would cause skin to blister at a radius of 1,000 feet. The radius of severe burns or fatalities would be 200 feet. In the event an empty tank were to explode, a radial distance of 670 feet from the explosion would define the lethality threshold; lethality near 100 percent probability would exist at 575 feet from the exploding tank. The distance where rupture of the eardrum becomes possible is 1,175 feet.

53. In the assessment of potential structural damage resulting from a tanker explosion, no consideration was given to the types of building foundations in Port Angeles. (TR 11260). Many of the buildings along the Port Angeles waterfront are wooden structures and are more susceptible than normal to damage from crude oil fires or explosions within the harbor. Many structures on the waterfront were built on pilings and lack normal foundations, possibly creating weaknesses and problems for firefighting. Moreover, there are many cavities or areaways in the downtown Port Angeles area which underly sidewalks. These cavities or areaways also present risks of collapse and problems for firefighting. After a spill has occurred, it is possible that heavy hydrocarbon vapors could collect in these cavities. In a confined area, heavy hydrocarbon vapors can explode. (TR 11260, 11264, 28944).

54. In any explosion, very little blast energy is transmitted through ground shock. (TR 11261).

55. A worst-case explosion at a pump station surge relief tank could cause severe structural damage to reinforced concrete buildings 100 feet away and moderate structural damage 150 feet away. (TR 11278).

56. The strength of the proposed unloading pipelines was not analyzed on the basis of the lines' ability to withstand damage from an explosion. However, these unloading pipelines do connect to the surge relief tank and would sustain damage at the point of connection if the tank were destroyed. (TR 11283).

57. ERT calculated a combined fire and explosion frequency for tankers in the harbor of one accident every 7.69 years. (TR 10666).

58. OIW concluded that such an accident could be expected to occur in the harbor once every 13.3 years (TR 10666).

59. In January 1980, ERT completed a study for Northern Tier entitled, "Risk of Smoke Impingement on Olympic Memorial Hospital from Tanker Fires in Port Angeles Harbor." That study became Exhibit 105. The conclusion reached in the study is that the risk of having to shut down the hospital

during a tanker fire is negligible under almost any set of circumstances. (Ex. 105, 9).

60. The possibility of smoke impingement on Olympic Memorial Hospital as a result of an oil fire at the berthing facilities was examined by ERT. It was found that a large fire would have a high rate of combustion and produce a smoke plume with high buoyancy. The buoyancy would cause the plume to rise vertically and resist being bent by wind toward the hospital and the downtown. Conversely, it was determined by ERT that a small fire would produce a plume that could be bent in the direction of the hospital but that such a fire would only last a few minutes. (TR 10649A).

61. A sustained fire can produce a smoke plume capable of being bent by the wind toward Port Angeles and the hospital when a burning slick is being fed continuously by a leak from a tanker. In this case, a fire having small buoyancy and a long burning time would result. (TR 10649A).

62. An "oil lamp" effect refers to an oil fire that burns over a prolonged period rather than burning out after a single spill. This can result when a source of oil feeds the fire in a sustained manner. The fire involving the tanker BURMAH-AGATE lasted 61 days and is an example of this effect. Due to insufficient data, ERT was unable to determine the probability

of a sustained "oil lamp" fire. The set of circumstances required for a sustained tanker fire would tend to reduce the overall probability of occurrence. (TR 10662-63).

63. The longer the duration of an "oil lamp" fire, the greater are the chances of the smoke plume intersecting Olympic Memorial Hospital. (TR 10662-63).

64. The tanker BURMAH-AGATE burned five miles offshore of Galveston, Texas, for 61 days. (TR 10662-63).

65. The ERT analysis was limited to possible smoke impingement from oil pool fires or fires aboard tankers. The study did not include smoke from dock fires or potential secondary fires.

66. On the evening of December 17, 1976, the Liberian-registered crude oil tanker SANSINENA exploded in Los Angeles Harbor after it had unloaded its cargo and while it was in the process of taking on ballast and bunker fuel. (Ex. 110,1).

67. Subsequent to the accident, the U. S. Coast Guard prepared a casualty report that is one of the few documents detailing the distances of actual damage caused by the explosion of a crude oil tanker. (TR 11099).

68. The SANSINENA was a 70,000 DWT vessel constructed in 1958 with a configuration typical for its time but that is no longer built or in common use: the ship had a midship house in addition to an after deckhouse. The Coast Guard concluded that the explosion resulted in part from the vessel's design features and from poor operating procedures. There probably would have been no casualty had there been no midship house which helped trap a stationary hydrocarbon vapor cloud in the vicinity of the afterdeck. The midship house was blamed not only for trapping the vapor cloud but was also regarded as the possible source of ignition that caused the cloud to explode. (Ex. 110, 5-6).

69. The Los Angeles Fire Department initially responded with two task forces, four engine companies and five fireboats, followed by three more engine companies and three more task forces. Altogether, the fire department used ten task forces, seven single-engine companies, five foam apparati, five fireboats, nine rescue ambulances, two helicopters, two tankers, two light utility units and various miscellaneous equipment. Five task forces and two single-engine companies were held in reserve. Approximately 240 uniformed firefighting persons were actively engaged in the firefighting operation. (Ex. 110, 13-14).

70. In addition to firefighting personnel, several Coast Guard units assisted in firefighting, survivor and body searches, evacuation of survivors, traffic control and pollution surveys. Among the units that assisted were three 82-foot cutters and one 41-foot utility boat. (Ex. 110, 14).

71. Land units were hampered because of scattered debris in approaching the berth area and were required to hand-lay about 700 feet of fire hose. (Ex. 110, 13-14).

72. The initial fire caused by the explosion was extinguished within approximately three hours. Flare-ups continued on the dock, however, due to oil supplied by a broken crude oil pipeline that was severed by the explosion. Water, aqueous film-forming foam, high expansion foam and liquid protein were used to fight the fire. (Ex. 110, 14).

73. Portions of the midship deckhouse and the main tank deck penetrated approximately 16 feet into the earth and severed a 30-inch fuel pipeline near the terminal manifold. The fuel from the broken pipeline fed a fire which burned sporadically throughout the deckhouse for several days. The break was plugged with drilling mud four days later. (Ex. 110, 21).

74. The casualty resulted in six members of SANSINENA's crew known dead and 22 injured. Two crew-members

and one terminal security guard were never found and were presumed dead. (Ex. 110, 3-4).

75. Approximately 36 personal injuries were suffered by the general public. An additional 100 or so non-crew personal injury claims were made, mostly for injuries from flying glass fragments. (Ex. 110, 4).

76. The vessel was a constructive total loss. Total damages in all forms, including the ship, damage sustained by the dock and to surrounding property, pollution cleanup, and salvage amounted to about $21.6 million. (Ex. 110, 1).

77. Onshore property damage was found to vary from severe (i.e., major structural damage) to "scattered" (broken windows and interior furnishings) depending on the proximity and degree of exposure to the explosion and on what the Coast Guard termed the "vagaries" of the concussion wave. Severe damage occurred within approximately one-half mile of the explosion; damage that was classified as "heavy" occurred at distances ranging from 1 and 1/16 miles to the west to 1½ miles to the north. ("Heavy" damage was categorized as damage to plate glass windows, shades and screens). Scattered damage occurred as far west as 3 and 1/16 miles to the west. Other minor damage was reported in the city of Carson, about six miles north of the explosion. (Ex. 110, 15-16).

78. The SANSINENA is not necessarily the most severe explosion in the history of petroleum shipping; it is, however, one of the most closely studied.

79. Wreck removal operations required approximately four and one-half months.

80. Focusing, the condition in which atmospheric factors affect the travel of blast waves, can significantly extend the distances of low overpressures but should not significantly affect high overpressures. Low overpressure can cause window breakage; high overpressures are associated with more severe damage. Topography also can affect the intensity and direction of blast waves. (TR 10660).

III. C. 2. FIRE PROTECTION

1. The explosion of the crude oil tanker SANSINENA in Los Angeles Harbor was followed by a fire that was described as relatively small. Approximately 240 uniformed firefighting personnel were actively engaged in combatting that fire. The fire involving the CORINTHOS in Pennsylvania is regarded as a large tanker fire and was fought by several hundred firefighters supported by several hundred mutual aid responses from surrounding communities. Approximately 20 pieces of floating equipment were used to fight the fire. The pier fire at the Todd Shipyard in Seattle required the response of over 800 firefighters and 42 pieces of equipment. (TR 27087-88, 28915, 28856; Ex. 110, 13-14). (See Findings 66-79, Section III.C.1)

2. The Port Angeles City Fire Department provides fire protection services for the structures and people within the city limits of Port Angeles. The Department has a paid staff of 16 firefighters and an additional 24 volunteer firefighters. Its equipment includes two pumper trucks, one combination ladder-pumper truck, one rescue truck, and three additional small vehicles. One other 25-year-old pumper truck with limited equipment is kept in reserve. (TR 28918, 28935-36).

3. The Port Angeles Fire Department is land-bound despite the need for waterborne firefighting due to the shipping traffic, harbor uses and industries situated on the waterfront. The fire department currently has no fire boat or special waterfront firefighting capabilities. The fire department currently has no equipment, personnel, or training to meet the existing risk of fires on vessels calling within Port Angeles Harbor or entering within the harbor, other than borrowing small boats from the Coast Guard if available. The Department personnel are not trained to fight petroleum or tanker-related fires. There is no capability to fight from the water shore-based fires which cannot be effectively attacked from the land. (TR 28936).

4. The Department is presently understaffed and its equipment resources are inadequate for the current fire protection needs of Port Angeles. The Department lacks the expertise and capability to combat a marine waterfront fire. (TR 28935, 27061-62; Beatteay, Patterson).

5. Northern Tier's proposed fire protection system for the marine terminal consists generally of two pumps, water mains and hydrants located on the trestles, berth and booster pump platforms, water monitors, four foam monitors and one proposed fireboat. This system is designed primarily to protect the berthing facilities and not for fighting crude oil fires on tankers or on water. (Applic. II, 6-20; TR 28848-49).

6. No fire protection system, including Northern Tier's is capable of extinguishing a fully involved tanker fire; a major tanker fire generally must be left to burn itself out. (TR 28835, 27066).

7. One vessel with firefighting capability would not be adequate to control a significant tanker fire or a spill burning in the harbor. A number of firefighting vessels would be required to control such a fire; one of the vessels could be a fireboat and the rest tugboats with firefighting capability (TR 28876-77; Patterson, Hansen).

8. The extent of marine firefighting capability that is required will depend on the size of fire that is expected to be controlled. A fire covering an area of 60,000 square feet could require five to six vessels with firefighting capability simply to control the spread of oil burning across the water. (TR 28883).

9. The fire involving the tanker CORINTHOS at Marcus Hook, Pennsylvania, covered an area of approximately 140,000 square feet. OIW has calculated that the burnable spill of one wing tank from a tanker of 80,000 DWT (the most credible spill of the four OIW modeled) would have a radius of 1700 feet, or a total surface area of about 4.5 million square feet.

10. There is not necessarily a relationship between the size of a crude oil tanker and the manageability of the fire it can create. A tanker that is small by modern standards can easily supply a fire that is beyond the capability to extinguish. (TR 28898).

11. The nature of crude oil firefighting and the potential for movement of oil on the surface of water indicate that several firefighting vessels would be required to provide multiple points of attack on the fire and to control the movement of burning oil away from the tanker. Several vessels would also be necessary to provide adequate cooling of the ship's tanks to prevent further explosions and ruptures and to prevent burning oil from destroying containment booms. Fireboats must be resupplied with foam and other materials during firefighting operations; this would require a supplies warehouse or stockpile in Port Angeles and the use of smaller vessels to transport supplies to firefighting vessels. (TR 28853, 42838; Hansen, Patterson).

12. During firefighting operations, the Port Angeles Fire Chief should be in command of all fireboats and firefighting vessels. (TR 28853, 42836; Patterson, Hansen).

13. The unprotected steel trusses and other steel members of the proposed off-loading piers should be sprinklered

or in some other way satisfactorily protected or replaced by fire resistant material, such as prestressed concrete. Unprotected steel has no fire resistance and a major fire beneath the structures could cause their failure within 15 minutes of exposure. (TR 28854, 28865, 42814, 42829; Patterson, Hansen).

14. For explosions and/or vessel fires of a certain size, there should be an adequate alarm and notification system and an evacuation plan for the Port Angeles area. (TR 28855).

15. Assuming that the monitors, sprinklers and other elements are not destroyed and, further, that the steel trusses and members of the piers are made properly fire-resistant, Northern Tier's proposed fire protection system would provide reasonable and adequate fire protection to Northern Tier's berthing facilities against design or smaller fires within the system's reach. (TR 27066, 28836, 42806, 42843, 28891). (See Finding 26 for a definition of "design fire").

16. The proposed system would not be effective for fighting tanker fires away from the berthing area and would have only limited usefulness in attacking a crude oil fire on board a vessel. (TR 28837, 27065-66; Beatteay, Patterson).

17. A crude oil fire on a tanker or a fire spreading over the water of the harbor could threaten additional vessels and waterfront facilities. (TR 27070). Northern Tier's system would not be effective in these situations.

18. No mutual aid agreement will be entered into by the City of Seattle with either Port Angeles or Northern Tier. The two Seattle fire boats could not be relied upon for assistance. (TR 28855).

19. Northern Tier's proposed tank farm and pump station at Green Point and a portion of the terrestrial pipeline running eastward from Clallam County are within the area serviced by the Clallam County Fire Protection District No. 3. Stipulations between Northern Tier and Fire District Three have been submitted to EFSEC.

20. Mr. Patterson, Northern Tier's witness, indicated that if there were no disabling explosion at the facilities and if boats and equipment over and above those proposed by Northern Tier were in place, he would be inclined to believe that such equipment could confine a fully involved fire originating on a vessel at berth (not a pool fire) sufficiently to prevent an extension of the vessel fire to where it tends to overrun the city. (TR 42912).

21. Ediz Hook is a long, extremely narrow peninsula which provides the only land access to the proposed berthing sites. Marine Drive, a constrained two-lane road is the only route available for fire protection vehicles. Between the berth site and the Crown Zellerbach mill, the Hook's greatest width is approximately 200 feet; a more typical width is 120 feet. Near the berth sites, the entire width of the Hook is within the expected range of debris from a substantial explosion.

22. Northern Tier did not consider the risk or consequence of fire or the level of fire protection that could be provided when it selected Port Angeles for its port site. (TR 2251, 2381).

23. The fire protection system that would be installed at the berthing facilities would be adequate to protect those facilities; the system would not be effective to combat a fire spreading across the harbor or a major fire aboard a vessel.

24. Fires involving the crude oil tankers SANSINENA and CORINTHOS required responses by hundreds of personnel and many pieces of equipment. The firefighting capability in Port Angeles is inadequate for the current fire protection needs of Port Angeles, including the present risk of petroleum fires.

25. A response such as that provided by firefighting personnel at Los Angeles-Long Beach for the relatively small fire caused by the SANSINENA does not appear possible in Port Angeles.

26. A "design fire" refers to the largest fire which may reasonably be controlled by a given fire suppression system. A pool fire burning the contents of a single tank of an 80,000 DWT vessel could ignite an area vastly greater than the largest design fire discussed for the Northern Tier facility. Northern Tier will be receiving calls from tankers as large as 327,000 DWT.

III. D. OIL SPILL RISK

III. D. 1. SPILL PROBABILITIES

1. The risk of oil spills within the marine waters of the State of Washington will increase substantially if the proposed Northern Tier project is placed in operation. The increase in risk may be roughly gauged by comparing the volume of crude petroleum Northern Tier proposes to transship, 933,000 average barrels per day (bpd) with the amount presently arriving at the four North Sound refineries, somewhat more than 300,000 bpd; (some still arrives by way of the Trans Mountain line). Another comparison can be made on the basis of vessel calls. Northern Tier proposes approximately 395 vessel calls per year at its facility, exclusive of bunker fuel movements, and this number has been challenged as too low. The North Sound refineries receive up to 230 crude-delivery vessels per year. As to a comparison between the risk posed by Northern Tier and all present crude and refined petroleum movements on the state's inland marine waters, it may be observed that, should Northern Tier begin operations and join the Clean Sound Cooperative, it would do so as a 60% member, with all present members then comprising the other 40%. By any of these standards, it may fairly be said that Northern Tier would more than double the present risk.

2. Several aspects of crude oil movement may be related to the dimension of risk a facility poses. It is generally conceded that the risk of a spill incident from tankers is proportional to the number of tanker trips. Northern Tier would add a minimum 395 tanker calls per year at Port Angeles, which currently has very few tanker calls. Bunker fuel and petroleum barge movements pose an added risk. Risk varies with the length of a pipeline; Northern Tier would add approximately 345 miles of terrestrial line and 33 miles of submarine line within the state. Spill risk and probability also vary with the relative safety of pipeline construction and operation conditions. The particular hydrologic and geologic conditions of Admiralty Inlet and the Strait of Juan de Fuca contain severe hazards which the applicant has not shown it can master.

3. Northern Tier has presented the Council with an assessment of spill volume risk which is significantly inaccurate in several respects. The company appears to have substantially understated the maximum volumes of oil which might be released from worst case ruptures of its proposed submarine crossings of Admiralty Inlet (40,000 barrels rather than 25,000 barrels) and Saratoga Passage (27,000 barrels rather than 17,000 barrels) and has placed its worst case sites for these spills in locations notably less vulnerable than the actual worst case spill sites.

4. Northern Tier has presented the worst case spill occurring on the Port Williams - Point Partridge submarine crossing as being a spill of some 25,000 barrels, which Northern Tier states would occur in a relatively stable, low current and low vessel traffic area near the Port Williams landfall. In fact, analyzing the route, (testimony of Veatch and Timmermans, with exhibits) and applying Northern Tier's assumptions, the worst case spill in Admiralty Inlet would occur at a point north-east of Protection Island on the main Admiralty Sill. The point is some 44,500 feet east on the route from the Port Williams landfall, at the approximate site of Shannon and Wilson's core sample point TM 438. If a two fathom depression (to 51 fathoms) remains in existence some 3700 feet northeast along the route, if Northern Tier's centerline, now on the depression's south-eastern extremity, stays in that depression on construction; if the Point Partridge valves are located at a low enough elevation and stay sealed upon shutdown; and if the crude in the submarine portion is not too high in specific gravity; a line rupture at this point would produce a spill in the 40,000 barrel range. Should any of the cited restraining factors fail, a line rupture would produce a spill in the 55,000 to 70,000 barrel range, depending on the interplay of the restraining factors.

TM 438 is near a three-mile long zone which Northern Tier stated would be subject to liquefaction in a .2 g seismic event. The eastern boundary of this liquefaction zone was placed halfway between TM 438 and TM 433, the next westerly core sample. Northern Tier found the sample at TM 433 to be characteristic of liquefiable soils. The record contains no opinion as to whether the soils at TM 438 would liquefy at the higher design acceleration.

TM 438 is near the main vessel traffic lanes in the Eastern Strait of Juan de Fuca and the mouth of Admiralty Inlet. Currents in the area are stronger than those expected at Port Williams. At depth, there is a net inflow across Admiralty Inlet and into the upper basin of Puget Sound.

5. Northern Tier has placed its worst case Saratoga Passage spill in the deepest part of the passage, an area of relatively minimal currents, stable soils, and infrequent large vessel traffic, and has estimated the worst case spill to be approximately 17,000 barrels. According to the Council's analysis, the worst case spill in Saratoga Passage occurs some 4000 feet east of Brown Point in a shallow bottom liquefaction zone a short distance from the Skagit Flats. A line rupture at this point would produce a spill of approximately 27,000 barrels.

6. Northern Tier did not do a formal worst case study for the submarine unloading lines crossing Port Angeles Harbor. The following approximate cases, derived from Northern Tier's data and using Northern Tier's methodology, may be taken

as representative: At a 100-foot depth, a rupture of one unloading line would produce a 26,450 barrel spill; at an 80-foot depth, a rupture would produce a 30,430 barrel spill; at a 60-foot depth, a rupture would produce a 36,530 barrel spill; at 40 feet, a rupture would produce a 52,700 barrel spill. The figures are approximations which assume that the line is in a dynamic rather than a static state. Should a single event rupture both unloading lines, the spill sizes would be essentially doubled.

7. The Council's analysis of worst case spills used for the applicant's submarine pipeline proposal contains certain limiting assumptions, such as that the leak detection system is working properly; that the dispatcher at the Green Point control center perceives the information accurately and moves promptly to shut down the line; that the shutdown system in fact does what the dispatcher directs; and that the valves close completely in a timely manner. It also assumes 933,000 barrels per day throughput, which is 95% of actual operating capacity, a factor affecting dynamic loss.

8. A more extreme event might occur if the leak detection and shutdown systems were to falter, or if there were a long-term substantial leak at a volume (3500-4500 barrels per day) below the detection system's level of recognition.

9. The most sizable single spill risk the facility poses to the state's environment is a total cargo loss of 327,000 tons or 2,400,000 barrels. A single maximum size cargo tank could spill up to 80,000 barrels. A clean break in the Admiralty Inlet or Saratoga Passage submarine pipelines at any point would produce a <u>minimum</u> spill of approximately 10,000 barrels.

10. There is no accurate, reliable way of foretelling how much petroleum would be spilled during the operating life of any offloading port, of foreseeing the recurrence of major spills, or of predicting the size of the largest spill to occur during the operating life. It can, for example, be said that the great majority of tankers which would call at the Northern Tier facility would carry cargoes of between 500,000 and 2,400,000 barrels. The number (if any) of such vessels which would actually sustain a total cargo loss in Port Angeles Harbor or the Strait of Juan de Fuca during the project's life cannot be stated. Likewise, the total quantity of oil to be spilled from the submarine pipeline portions of the facility cannot be computed before abandonment.

11. To properly evaluate the effect of an energy facility upon the public interest, the scope of risk posed by a project should be considered. Perhaps the best method of consideration is to learn the unavoidable risks of a facility and

to insure that all which should be done in terms of reconnaissance, study, location and design, has been done in order to minimize unavoidable risks. There is also some value in properly done statistical estimates of quantitative risks. Such estimates, though inexact, may provide a general view of the scope of a particular set of risks.

12. Northern Tier presented two quantitative risk analyses, one done by Oceanographic Institute of Washington (OIW) and one contained in the application.

13. The U. S. data base relied upon by Northern Tier excludes consideration of supertankers of the size expected to call at Port Angeles; those data are drawn from eight U. S. ports and none of these can accommodate tankers more than half the size expected at Port Angeles. (Five of the eight ports can accommodate vessels only up to 60,000 DWT; none of the U. S. data considers spills or accidents involving vessels greater than 120,000 DWT.) The Northern Tier study made no adjustment for fog or other site specific factors and recognized no factors for storms or the increasing age of the world tanker fleet because of declining tanker construction. For all spills other than those occurring at berth, Northern Tier's OIW study relies on an exposure variable, "distance traveled per port call," which assumes that each mile traveled by the tanker has the identical risks and hazards which lead to oil spillage. A test

to confirm or deny the OIW hypothesis can be performed by examining the casualty locations in Puget Sound. (Stewart, TR 37213-14.) This test shows that the hypothesis is not supported by the historical record, that the majority of vessel collisions, groundings and rammings occurred in the principal ports within Puget Sound and that there are long stretches of channel where no casualties have been recorded. (Stewart, TR 37117-18, 37213-14.) The worldwide average spill size per tanker incident has risen in the last several years (reflecting the increasing use of larger tankers) from 4,349 tons per spill in 1977 to 11,131 tons per spill in 1979. During the 1973-1976 period relied on by OIW, the average spill was 3,442 tons per incident. Exclusion of large tanker data removes from consideration the comparative difficulty these ships have in turning, slowing, and stopping.

14. For submarine spills, both analyses assume better geotechnical and design work than has been performed on the submarine pipeline. For vessel spills, neither assumes certain navigational, vessel characteristic and data problems noted in finding 13 above. Both therefore understate actual risks. Each deals only with the first 20 years of operation. This 20-year figure relates to the time required to pay interest on debt, and not to project life.

15. The OIW analysis (Ex. 165) made the following quantitative predictions for major oil spills in accidents over a 20-year period:

	Oil Spill Source	Percentage Chance of Occurrence over 20 Years
1.	Tanker spill	
	10,000 bbls or more (in-transit and at berth)	27.5%
	2,000-10,000 bbls	61%
2.	Submarine pipelines (any spill size greater than 2.4 barrels)	42%
3.	Terrestrial pipeline (OIW excluded all pipeline and river crossings east of Cascades) (any size spill greater than 2.4 barrels)	99%
4.	Tank farm spill (spill greater than 1,000 bbls)	31%

(Exhibit 165, p. III-13 and 24; V-8; IV-10.) Oil spills of some size are a certainty both from tankers in-transit through the Strait of Juan de Fuca and Port Angeles harbor and from tankers at berth. (Exhibit 165, p. III-10 and 22) (99% probability of each). OIW's study is not representative of and likely underestimates spills from foreign flag tankers. (Stewart, TR 30483.)

16. The Northern Tier analysis presented in Application 76-2 made the following quantitative predictions for oil spill incidents over twenty years:

	Oil Spill Source	Percentage Chance of Occurrence over 20 Years
1.	Oil tanker spill (total loss only; excludes all losses other than total vessel loss)	29%
2.	Submarine pipelines in Port Angeles harbor (unloading lines; all leaks)	17%
3.	Submarine pipeline crossing Admiralty Inlet (all leaks)	30%
4.	Submarine pipeline crossing at Saratoga Passage (all leaks)	8%
5.	Terrestrial pipeline spill (spills of 5,000 barrels or more)	28%
6.	Tank farm (major fire or explosion)	20%

(Exhibit 168.) There is a 73% probability of one of these events occurring, and a 23% probability of two of these events occurring, over a 20-year period. (Exhibit 169; Murphy, TR 14074, 14112.) There is a 31% probability of a total tanker loss of both crude oil and bunker fuel tankers. (Murphy TR 14036-7.)

17. Quantitative oil spill risk analyses are not well developed. They either deal with a limited aspect of the problem, use questionable data or theory, or use statistical

models which are extremely hypothetical. (Stewart, TR 37108, 37147, 37144-5.) The integrity of a quantitative analysis is compromised to the extent a study purports to display oil spill probabilities in great detail and by various sizes. (Stewart, TR 37220-1.) The OIW risk analysis, Exhibit 165, contains these shortcomings, including an overly detailed display of oil spill probabilities by various sizes. (Stewart, TR 37108, 37152-3, 37269-70, 37163, 37254.)

18. Probability numbers used in the OIW risk analysis are hypothetical and of questionable reliability. (Stewart, TR 37115, 37202-3, 37163-4.) The use of "distance traveled per port call" as the exposure variable for in-transit spill estimates is not substantiated by the data or the analysis presented. (Stewart, TR 37116, 37177-8, 37207.) This exposure variable inaccurately uses statistical parameters for oil spill discharges. The OIW analysis assumes a least squares methodology, which is inappropriate for the Poisson distribution and equations set out in OIW's technical appendix. (Stewart, TR 37187-8, 37174.) Consequently, OIW's conclusion of a "strong correlation" is incorrect. Such a correlation cannot be developed with only the eight port samples. (Stewart, TR 37116, 37174, 37187-90, 37268.)

19. The "confidence levels" set forth in Exhibit 165 indicate a possible range of uncertainty of the OIW oil

spill frequency estimates. These confidence levels are based entirely on the assumption that the exposure variable is correct. The confidence levels are therefore products of an incorrect hypothesis. (Stewart, TR 37120.)

20. OIW reliably correlated at berth spills with "port calls." (Stewart, TR 37118-9, 37177-8, 17202-3, 37207.)

21. Over-all average spill size for in-transit and at-berth spills is extremely sensitive to the inclusion or deletion of any particular ports or large spills. The average spill sizes listed in Exhibit 135 are unreliable. (Stewart, TR 37248-9, 37218.) The at-berth spill sizes and submarine pipeline spill sizes are likely unrepresentative of typical sizes for the facility. (Stewart, TR 37123.)

22. The risk analysis in Application 76-2 relied on an exposure variable developed by OIW in 1974 and no longer used by OIW. (Murphy, TR 13842, 13847; Moore, TR 13849-50.) Northern Tier made several adjustments which lowered the oil spill probabilities it calculated with OIW's exposure variable, but Northern Tier made no upward adjustment in risk based on any factors or site-specific characteristics of the Strait of Juan de Fuca or Port Angeles which would tend to increase the probability of oil spills. (Murphy, TR 13865-66.)

23. Northern Tier lowered its oil risk estimate by an across-the-board assumption that only young U. S. flag tankers would carry Alaskan oil to Port Angeles. (Bennett, TR 25439.) The application understates oil spill risk by at least 27% due to this assumption. (Murphy, TR 13953, Bennett, TR 25439.) Northern Tier has not committed to receiving only young U. S. tankers or to shipping only Alaskan crude.

24. Northern Tier also reduced the calculated probabilities of oil spill risk because of the presence of a vessel traffic system in the area. Northern Tier did not show that other ports in its data base did not have such systems. To the extent such systems were in existence, the results from the data base were improperly reduced. (Stewart, TR 37243-5.)

25. Northern Tier has not performed a site-specific analysis of oil spill risks. (Bennett, TR 25439, 25443.) In addition to previously considered factors, such a study should include consideration of anchor damage risk to submarine pipelines, Port Angeles Harbor traffic and considerations, and channel width and traffic lanes of the harbor approaches.

26. The submarine pipelines in Port Angeles Harbor and Admiralty Inlet could spill oil due to anchors dropping in the vicinity of those lines. Anchors could be dropped on or

near the submarine pipeline if an emergency existed, if an error in judgment occurred, or by accident.

27. A number of factors make it more likely for vessels to drop anchor in the area of the submarine pipelines in Admiralty Inlet and Port Angeles Harbor than at other locations in the Strait of Juan de Fuca and Puget Sound. Among these are collision or emergency avoidance, bad weather (notably the problem of vessels crossing inside Ediz Hook in bad weather in accordance with U. S. Coast Guard Pilot specifications to pick up pilots), and anchor drag. A master or pilot will drop anchor when he thinks it necessary to protect his ship.

28. A tanker or other vessel which loses power will likely drop anchor if a grounding or collision is threatened. A vessel is more likely to experience a steering failure or engine failure as it approaches port than while steadily traveling in the open sea. (Armstrong, TR 25851.) To the extent a vessel has a steering failure or power loss in the Strait of Juan de Fuca, vessels may have little time before grounding on the shoreline.

29. There is a high correlation between fog and vessel accidents such as collisions or groundings. (Stewart, TR 27112, Bennett, TR 25395.) Fog causes or contributes to vessel collisions because of difficulties in detecting the pre-

sence and location of other ships, and in part because poor visibility prohibits the vessels from visually coordinating their maneuvers even after detection. (Bennett, TR 25397.) The Washington coast, its approach, and the Strait of Juan de Fuca experience a high incidence of fog. (Armstrong, TR 25842.)

30. There have been 60 major oil spills worldwide (i.e., greater than 1,550,000 gallons or 35,000 barrels) from tankers in the years 1967 to 1979. Those 60 spills over thirteen years spilled a total of approximately 500 million gallons of oil, which is an average spill size of 8,332,150 gallons (1,112,156 barrels). (Sorenson, Ex. 845, p. 5-6.) These years correspond with the introduction and use of large crude oil tankers in the 100,000, 200,000 and 300,000 DWT size category. Approximately one-half of the vessels calling at Northern Tier's terminal, and all of the foreign flag vessels, are estimated to be in that size range. In recent years, large spills have also originated from small tankers. The company expects large and small tankers to call at its facility.

31. There will likely be numerous spills ranging in size from a few gallons to several hundred gallons during the operation of, and cargo discharging at, the Northern Tier terminal. (Bayliss, TR 26005.) Large spills during cargo discharging also are possible. (Bennett, TR 25444-45.) Spills of refined petroleum products such as diesel fuel and hydraulic

oils will likely occur during cargo transfer and terminal operations. (Bayliss, TR 26009.)

Summary

32. The Northern Tier Pipeline project will result in a significant increase in oil exposure in the waters of the State of Washington. First, the large volume of crude oil handled will lead to numerous, small, operational spills which will constitute a new source of chronic oil pollution in the Strait of Juan de Fuca. Second, the large size of the crude carriers, the heavy tanker traffic, and the submarine pipelines will significantly increase the likelihood of a prominent oil spill in state waters. (Reid PFT p. 4) Properly designed and operated tankers and submarine pipelines are transportation forms with relatively low orders of risk. Improper design or operation increases risk. The consequences of a major spill incident involving a tanker or submarine pipeline are high in biologically productive waters.

Terrestrial Pipeline Spill Probability

33. OIW's estimated risk of a terrestrial pipeline spill in Western Washington is one spill 2.4 barrels or larger every 3.7 years. The terrestrial pipeline estimates of spill risk did not adjust for Northern Tier's commitment to build its pipe according to the latest technology and with cathodic

protection. The absence of such an adjustment makes OIW's estimate more conservative. The maximum spill from a terrestrial pipeline rupture under original design is 64,000 barrels. (Application 2.3-31, 2.11-85.) Crude oil from a terrestrial spill could enter a river or stream or ground water. The likelihood of such events is unquantifiable.

34. Operational spills at the onshore storage facilities are possible. Allowance for such spills is included in the design of the facilities. Even in the unlikely event of the entire contents of a full tank being released, all of the oil should be contained by the dikes. (TR 13797-98 Murphy, Applic. III, Sec. 2.11.2.1).

III. D. 2. SPILL DISPERSION

1. Oil spill trajectory prediction is still in its infancy. No methodology currently exists that can accurately predict the fate of an oil spill. Many factors influence the dispersion of oil spilled on the water, e.g., currents, winds, vertical mixing, spreading, diffusion, dissipation, sinking, absorption, emulsification, oxidation, evaporation, and bacterial removal. Of these factors, the most important are currents and winds. Several of the parameters most important to any prediction (including wind speed, wind direction, current speed and current direction) cannot be determined until the time of the spill. There is not sufficient knowledge about many of the physical and chemical processes involved to consider adequately the many factors important to accurate prediction. The problem is heightened by complex wind patterns and tidal currents such as those that occur in Puget Sound. (TR 31026-29, 31037-38 Raj).

Currents

2. Currents in the Strait of Juan de Fuca are characterized by a typical fjord-like pattern, with a mean flow at the surface flowing out-strait (westward), and in-strait (eastward) near the bottom. The dividing line between mean flow to the west and mean flow to the east (the depth of no