Seismic Risk and the Onshore Pipeline Portion of Sakhalin Energy Investment Company's

Sakhalin-II Phase 2 Project:

UNANSWERED QUESTIONS

A Report to Sakhalin Environment Watch, Friends of the Earth Japan, ISAR, Pacific Environment and WWF Russia

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I INTRODUCTION

A. *The Sakhalin-II Phase 2 Project*

1. The Sakhalin Energy Investment Company (SEIC) has secured government approvals to produce hydrocarbons from offshore deposits near the north end of Sakhalin Island for transport, via buried oil and gas pipelines, approximately 800 kilometers to a terminal complex at the south end of the island. (Figs. I.1, I.2.) From there, oil and gas will be exported to international markets via tanker. The project is known as Sakhalin-II Phase 2, denoting the fact that it is the second phase of development under the 1994 Sakhalin-II production sharing agreement (PSA) between the Russian government and international corporations. The three companies that own and are executing this project – Shell (55%), Mitsui (25%) and Mitsubishi (20%) – intend to transport 195,000 barrels of oil per day (bpd) across Sakhalin in 2006 and say they will invest $10 billion in the entire project before it is completed.[1] Although Phase 2 pipeline construction has

Figure I.1 Sakhalin Area Map

Figure I.2 Sakhalin-II Project

1 For a project overview, see "Sakhalin II Project" at the Sakhalin Energy Investment Company (SEIC) web site, http://www.sakhalinenergy.com/. SEIC identifies the three project owners as Shell (Shell Sakhalin Holdings B.V.; 55%), Mitsui (Mitsui Sakhalin Holdings B.V.; 25%) and Mitsubishi (Diamond Gas Sakhalin B.V.; 20%).

already begun on Sakhalin, engineering design has yet to be completed. (Figs. I.3, I.4, I.5.) Meanwhile, controversy over various aspects of the project, including the wisdom of burying the pipelines in seismically active terrain, continues.

Figure I.3 Road Construction, Big Garomay River, Northern Sakhalin (November 2003)

Figure I.4 Sokol Staging Yard, Central Sakhalin (November 2003)

Figure I.5 Prigorodnoye Terminal, Southern Sakhalin (November 2003)

B. About This Report (January 25, 2004)

1. This interim report explores SEIC's approach to the risks associated with the burial of the Sakhalin-II onshore pipelines. The information presented here is based on research conducted between October 28, 2003 and January 25, 2004. During this period, under the auspices of the non-governmental organization Sakhalin Environment Watch, we toured the proposed pipeline route, met with SEIC and government officials and reviewed relevant portions of SEIC's voluminous public submissions. The latter included information provided in the company's principal responses to seismic concerns. To evaluate this information, we addressed questions about the project to various parties, consulted with geophysical and geotechnical experts and reviewed relevant technical literature. We considered the information and understandings gathered in this process in light of the experience of the Trans-Alaska Pipeline System (TAPS), a project cited frequently in discussion of the proposed Sakhalin onshore pipelines.

2. During this process, we followed the general guidelines of the California Geological Survey (CGS), a public agency with long experience evaluating seismic questions in an earthquake-prone environment. According to CGS, decisions on developments in seismically active areas typically rest with government

agencies, whose decision makers must go beyond geologic facts to consider economic impacts and acceptable levels of risk. In these situations, CGS notes, (a) reports must be adequately documented and carefully written to facilitate review; (b) conclusions should be consistent and unbiased; and (c) recommendations should be clearly separated from conclusions of fact.[2] Using these guidelines, CGS maintains, the general observer should be able to provide clear and constructive evaluation of technical arguments.[3]

3. According to SEIC, during the public hearing and consultation process "[d]oubts and fears expressed most frequently were related to . . . environmental safety, particularly in relation to seismicity."[4] Although SEIC has acknowledged that information gaps in its environmental impact assessment may need to be addressed,[5] at year-end 2003 there was no indication that SEIC considered earthquake risks or plans for dealing with them, to require special attention.[6]

4. SEIC's tight planning and construction schedule increases cause for concern in this regard. While engineering design work for the onshore pipelines is still in process, current design decisions will be guiding construction in the field in the very near future.[7] Experience on TAPS indicates that field changes to construction plans are liable to result in confusion, delays and the necessity to go back and do the same job over again. Unexpected conditions encountered in the field can be expected to compound this problem.[8] In short, the chaos of large pipeline construction is akin to the fog of war.

5. To insure that design and construction requirements will result in a safe pipeline, we believe that clear, comprehensive information on seismic issues must be available in a timely manner. In view of the importance of these issues, on December 29, 2003 Research Associates presented a series of detailed questions to SEIC designed to resolve confusion and close what we believe are significant information gaps in SEIC's presentations on seismic risks associated with the on-shore pipeline portion of Sakhalin-II Phase 2 project (Appendix B).[9] To the extent that these questions reflect unresolved design engineering issues, failure to address them carefully and in a timely manner could impair both the efficiency of pipeline construction and,

2 California Geological Survey, Guidelines for Evaluating the Hazard of Surface Fault Rupture (Note 49; 2002) (http://www.consrv.ca.gov/CGS/information/publications/cgs_notes/note_49/note_49.pdf).

3 This approach has served Research Associates and this report's principal researcher well in previous analyses. For example, in September 2001 report on seismic liquefaction on the Trans-Alaska Pipeline System (TAPS) right-of-way, the author of this report called attention to a document prepared by the Alyeska Pipeline Service Co. (builders and operators of TAPS) that catalogued geotechnical information on the pipeline right-of-way. Over the decades, that document had fallen into disuse. Subsequent to publication of the author's report, Alyeska commissioned a technical evaluation of the pipeline route based on this previously overlooked internal study. (Richard A. Fineberg, "TAPS Seismic Liquefaction Stability Concerns" [Draft Supplemental Technical Report Submitted with Comments on TAPS Operations at Scoping Meeting for the TAPS Right-of-Way Renewal Application), Sept. 20, 2001], in: The Emperor's New Hose: How Big Oil Gets Rich Gambling with Alaska's Environment [Alaska Forum for Environmental Responsibility], June 2002, Appendix B [on-line at http://www.alaskaforum.org/]).

4 Sakhalin Energy Investment Company, Technical and Economic Substantiation of Construction (TEO-C), Environmental Impact Assessment (EIA[3]), July 2002 (Vol. 7, Book 1, Executive Summary), p. v. Public interest in seismic issues is also mentioned in SEIC's updated Environmental Impact Assessment: SEIC Phase II Development (EIA[4]), 2003, Vol. 1, p. 4-12. SEIC released both EAI(3) and EIA(4) on CD-ROM disks and has published EIA(4) on the company's web site (http://www.sakhalinenergy.com/about/abt_eshia_eia.asp).

5 EIA(4), Vol. 1, p. 1-3.

6 SEIC's special reports cover such subjects as western gray whales, stream crossing methodology and the oil spill response program; additionally, SEIC has indicated that it plans to update its EIA catalogue of salmon streams that will be affected by pipeline construction.

7 In late December 2003, SEIC's web site stated that "[o]nshore pipelines detailed design is currently under way in the Starstroi offices in Moscow and design subcontractor offices in Samara as part of the onshore pipelines EPC [engineering, procurement and construction] contract. Separately, most of the aerial survey data has been made available as input to detailed design." According to the project timeline, "onshore pipelines construction started in December 2003, " less than six months after the onshore pipeline contract was signed with the lead execution contracting company. First oil is expected to flow through the pipeline in April 2006, with first natural gas eight months later. (See Sakhalin-II Phase 2 project timeline at http://www.sakhalinenergy.com/project/prj_timeline.asp).

8 See Robert Douglas Mead, Journeys Down the Line: Building the Trans-Alaska Pipeline (New York: Doubleday, 1978), pp. 228-229 and 283-284.

9 Richard A. Fineberg (Research Associates), letter to Ms. Rachele Sheard (Head of Issues and Stakeholder Management, SEIC), Dec. 29, 2003.

later, operational safety. On Jan. 26, 2004, SEIC responded with a four-page letter accompanied by a stack of documents approximately four inches high (Appendix C).[10] Despite its bulk, SEIC's response to our inquiries (a) failed to address many of our fundamental questions, (b) deferred transmission of key reports and information to a later, unspecified date and (c) advised that seismic issues will be addressed in an addendum to its 2003 Environmental Impact Assessment (EIA[4]), which SEIC plans to release in March 2004.

6. In the interim, this report has been prepared to assist interested parties in assessing the significance of the seismic risks to the onshore pipeline portion of the SEIC project and the manner in which SEIC has addressed the assessment and mitigation of those risks.[11] To this end, Research Associates has gathered the best information available on the legal framework (Section II), the current state of the science of earthquakes (Section III), the seismicity of Sakhalin (Section IV) and that of the pipeline route itself (Section V), SEIC's public presentation of the project (Section VI) and lessons to be learned from the TAPS experience (Section VII), frequently cited for comparison purposes. This report concludes with a general summary (Section VIII) and, finally, discussion and basic recommendations designed to help resolve unanswered questions about seismic hazards associated with this project (Section IX). Figures can be found at the back of the report (or accessed by hyperlinks), followed by appendices that provide support documentation.

II. LEGAL AND REGULATORY FRAMEWORK

1. The federal government of the Russian Federation, which controls three-quarters of the territory of the Former Soviet Union (and much of its vast resources), is responsible for the enforcement of approximately 25,000 code provisions, rules and regulations. Adding to the complexity of the developing Russian federal system, international standards adopted by the national standards organization may have the same legal power as Russian standards. And, finally, there is also a system of private-sector voluntary standards.[12]

"Important things to consider" when dealing with Russian standards:

Standards classification systems may not be compatible with worldwide systems and may be found under categories not normally associated with the document's subject.

Design and installation requirements may be scattered among many individual, unrelated documents.

Various codes may contain inconsistent or conflicting design criteria.

Directives, resolutions, instructions, notices, and other circulars... are often more important than the standards themselves.

Irregular revision practices can undermine the integrity of the overall standards system.

10 Julian Barnes (External Affairs Manager, SEIC), letter to Richard A. Fineberg, Jan. 26, 2004, p. 1 (see Appendix C).

11 The preponderance of this report was completed in draft form prior to receipt of the SEIC's Jan. 26, 2004 materials; on inspection, we determined that the SEIC response confirmed rather than resolved our chief concerns, and that the draft report did not require substantive revision.

12 See: SNIP Register, "Russian National Standards System" (http://www.snip.com/).

Unless covered by international conventions to which Russia is a signatory, foreign standards cannot be used unless adopted by the appropriate authorities.

From "National Standards: The Russian Way" (http://www.snip.com/)

2. Under the 1994 Sakhalin-II Production Sharing Agreement (PSA) with the Russian Federation, overall supervisory responsibility lies with the Ministry of Economic Development and Trade; the Ministry of Natural Resources addresses licensing and environmental issues; the Ministry of Energy is primarily concerned with the project's production volumes, conditions and export schedules;[13] establishment and oversight of project construction standards fall under the jurisdiction of the Russian Federation State Department of Construction.[14]

3. In its 2003 Environmental Impact Assessment (EIA[4]), SEIC listed 18 environment-related issues covered in the Production Sharing Agreement (PSA) between SEIC and the Russian Federation (RF). That document also described the complex system of laws and regulatory documents governing natural resources and environmental protection, listing 22 Russian Federation laws, 13 RF regulations and procedures and 9 RF guidance documents, as well as 11 Sakhalin Oblast laws and 10 Sakhalin Oblast decrees and resolutions.[15] On the international front, SEIC identified 11 international standards and 33 international conventions that "are potentially applicable to the project" and "are used as benchmarks for international practice." SEIC noted that "the status of these conventions within the Russian Federation may not always be clear... Nevertheless, SEIC intends to comply with the spirit of these agreements."[16] SEIC also declared its environmental policy of continuously improving its operational performance while protecting the natural environment. Among the means listed, SEIC said it would seek external certifications for its environmental programs, prevent pollution and minimize environmental impact by reducing risks "to a level as low as reasonably practicable" and recognizing the priority of preventing oil and chemical spills.[17]

4. The complexity of the legal framework governing the Sakhalin-II project, and the difficulty of discovering and then interpreting the relevant legal provisions, are illustrated by the following:

(a) Under the National Codes and Standards of the Russian Federation, SNiP 2.05.06-85* generally determines whether a pipeline is buried or constructed above the ground. According to SNiP 2.05.06-85*, pipelines are sited above or below ground using the following general guidelines: (a) pipelines must be buried;[18] (b) above-ground construction is permitted as an exception when a pipeline encounters (1) desert, (2) mountain, (3) bog, (4) landslide, (5) unstable permafrost and (6) other natural and artificial obstacles;[19] and (c) above-ground construction must be used where a

13 Russian Federation Government Resolution #86, February 2, 2001 (see: http://www.bisnis.doc.gov/bisnis/isa/020131OilGasCertReq.htm, citing U.S. Foreign Commercial Service, "Basic Certification Approval Procedures and Requirements for Oil and Gas Projects and Equipment in Russia," January 31, 2002).
14 Interview with Elena D. Nevenchina, Deputy Chief, Division of Geology, hydrocarbon production and environmental protection, Department of Oil and Gas Complex of Sakhalin Region, November 4, 2003.
15 EIA(4), pp. 2-4 – 2-12.
16 EIA(4), pp. 2-14 – 2-19.
17 EIA(4), pp. 2-19 – 2-20.
18 SNiP 2.05.06-85*, Sec. 1.1. (National Codes and Standards of the Russian Federation [SNiP]; Moscow, 1997 [in Russian]).
19 SNiP 2.05.06-85*, Sec. 7.1.

pipeline crosses active faults (emphasis added).[20]

(b) Another government directive states that "[d]esign and analysis of the possibility of construction in seismic areas shall be based in its entirety on regulations of SNiP II-7-81* Seismic Building Code, published in 2000 by Code Development Center of the State Department for Construction of Russian Federation along with Amendment #5" (emphasis added).[21]

(c) The project document Design Concepts (DC) of Buildings or Structures in Regions with High Seismicity in Combination with Other Adverse Loads Sakhalin II asserts that "[t]he provisions of these DC shall serve for regulatory use for engineering work, including, selection and preparation of construction sites, architectural and structural design of superstructure and foundation, for buildings and structures including oil and gas pipelines, as well as infrastructure of sea terminal under Sakhalin II Project" (emphasis added).[22]

(d) From the foregoing, it would appear that SNiPs 2.05.06-85* and/or II-7-81* are the standards that set seismic design criteria for the Sakhalin-II Phase 2 pipelines. But another document apparently supercedes them in key respects. The Project Specific Technical Specifications (PSTS) for Sakhalin II Onshore Pipeline Designs states that "[o]nshore pipelines should be of underground design," and that active faults should be avoided or buried using "special protective measures" to provide for "pipeline free motion and deformation," as specified in an attachment to the PSTS.[23]

(e) The PSTS was created from a list of Russian and international standards that includes both SNiP 2.05.06-85* and SNiP II-7-81*. The PSTS reverses some of the requirements of SNiP 2.05.06-85* (most importantly, the provision requiring above-ground crossing of active faults) but incorporates other parts wholesale and modifies still others.[24] Which portions of these diverse standards apply to the project and the justification for their selection are not always clear.

(f) The descriptions of the legal framework governing the Sakhalin-II Phase 2 project in EIA(3) and EIA(4)[25] do not discuss how conflicts over the application of the various laws, norms, directives and other government requirements will be resolved.

20 SNiP 2.05.06-85*, Sec. 5.37.

21 State Committee of Russian Federation, Residential and Building Politics, "RE: Amendment #5 of SNiP II-7-81*, 'Construction in seismic areas'" (in: SEIC, Design Concepts [DC] of Buildings or Structures in Regions with High Seismicity in Combination with Other Adverse Loads Sakhalin II, [Doc. No. 1000-S-90-01-S-1506-00-01], circa May 2002, Appendix 13 [pp. 92-93]).

22 Design Concepts (DC) of Buildings or Structures in Regions with High Seismicity in Combination with Other Adverse Loads Sakhalin II, p. 8.

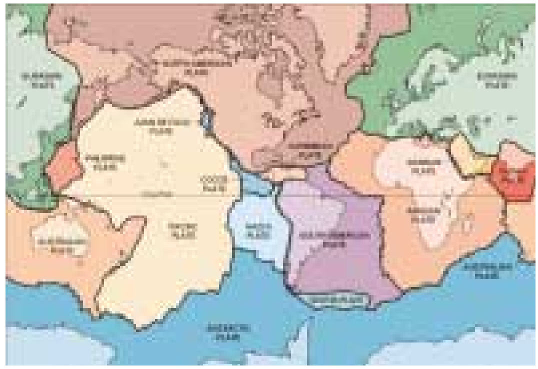
23 SEIC, Project Specific Technical Specifications (PSTS) for Sakhalin II onshore pipeline designs, May 2002 (Doc. No. 1000-#-90-01-S-1501-00), pp. 9, 10, 14 and 20 (prepared by OOO "VNIIGAZ," AO "VNIIST" and "Starstroi;" approved by Gosstroi of Russia and Gosgortekhnadzor of Russia).

24 For example: The PSTS guidelines incorporate SNiP 2.05.06-85* requirements for route selection, road and railway crossings, burial depth, distance from utilities and manufactured fittings; but modify SNiP 2.05.06-85* for determining the minimum required distance from settlements and other sensitive sites and ignore that SNiP's requirements for fault crossings (PSTS, pp. 13, 14, 15, 16, 25).

25 EIA(3), Ch. 2 and EIA(4), Vol. 1, Ch. 2.

III. THE SCIENCE OF SEISMICITY, UNCERTAINTY AND PIPELINE DESIGN

Figure III.1 The Earth's Tectonic Plates (USGS)



The following observations and information provide general background on seismic hazards and their relationship to pipeline routing and design.

1. Ninety percent (90%) of the world's earthquakes occur on ten percent (10%) of the earth's surface. That portion of the surface where earthquakes are most likely to occur is in the interface between the dozen or so large, interlocking plates that form the earth's crust.[26] (Fig. III.1.)

2. Earthquakes can cause sudden, large movements of the earth at faults, which are fractures in the earth's crust. Earth scientists know the regions of the earth where these events are most liable to occur. But within those regions, they have no idea exactly where or when the next major earthquake will occur.

"Our current knowledge of fault zone processes is so poor that not only are we unable to make reliable short-term earthquake predictions, we don't know whether such predictions are even possible."

Professor Mark Zoback, Stanford University (BBC News, "Project to drill into Earth fault," Dec. 5, 2002

[http://news.bbc.co.uk/2/hi/science/nature/3293947.stm]

3. "[T]he investigation of sites for possible hazard of surface fault rupture is a deceptively difficult geologic task. . . . the evidence for identifying active fault traces is generally subtle or obscure and the distinction between recent active and long-inactive faults may be difficult to make."[27]

4. Large earthquakes can and do occur on faults classified inactive. For example in October 1999, a major earthquake at Hector in California's Mojave Desert created a 40-meter-long surface rupture with as much as five meters of slip on a fault that had not broken in at least 5,000 years and was classified by expert observers as inactive.[28]

5. The San Andreas Fault in the western United States (perhaps the most studied fault in the world) demonstrates the uncertainty of earthquake recurrence. The San Francisco earthquake of 1906 culminated 70 years of major earthquakes on the fault, but it remained relatively quiet thereafter for another 73 years. More recently, several major earthquakes have occurred in the San Francisco area.[29]

26 The Earth's rigid outer shell, or lithosphere, is broken into a mosaic of oceanic and continental plates which can slide over the ppermost layer of the Earth's mantle. The plates are in constant motion. Where they interact, along their margins, important and sometimes violent geological processes, such as the formation of mountain belts, earthquakes, and volcanoes, take place. See: U.S. Geological Survey, "Earthquakes and Plate Tectonics" (http://neic.usgs.gov/neis/plate_tectonics/rift_man.html).

27 California Geological Survey, Guidelines for Evaluating the Hazard of Surface Fault Rupture.

28 "Hector Mine, 1999," at http://www.goldenstatemuseum.org/gehector.htm and seminar materials of Dr. Thomas Rockwell, Department of Geological Sciences, San Diego State University (http://www.geology.sdsu.edu/activities/seminar/fall99/rockwell/text.html).

29 Louis Pakiser and Kaye M. Shedlock, "Can We Predict Earthquakes?" http://mceer.buffalo.edu/infoService/faqs/predict.asp (adapted from U.S. Geological Survey sources).

6. The temporal clustering of earthquakes suggests that in many places, the assumption of random occurrence through time may not be valid. One reason for the difficulty establishing earthquake timing is that the release of strain along one part of a fault system may actually increase the strain on another part.[30]

7. The estimated return period for an earthquake (sometimes expressed in terms of intervals ranging from 50 to 10,000 years) is a mathematical expression of probability. Experts caution that estimates of earthquake recurrence can be misleading because earthquakes do not occur on a regular cycle.[31] This warning bears remembering when assessing risk analysis methodology: Before the Exxon Valdez oil spill, industry engineers estimated that a tanker sailing from the port of Valdez, Alaska could be expected to have a major oil spill only once every 241 years.[32] This probability provided little comfort when the tanker ran aground in March 1989, before the end of the twelfth year of operations from Valdez.

8. One difficulty predicting earthquakes is that the processes within the Earth, where earthquakes originate, are not visible from the surface of the earth.

"To really understand earthquakes, we need to see up close the processes that cannot be observed from the Earth's surface." • Bill Ellsworth, USGS (BBC News, "Project to drill into Earth fault," Dec. 5, 2002

[http://news.bbc.co.uk/2/hi/science/nature/3293947.stm]

9. A second major problem predicting seismic effects is that surface disturbances resulting from earthquakes are liable to occur unexpectedly and at points distant from the locus of the earthquake's origin.

The largest inland earthquake on North America in almost 150 years occurred on Alaska's Denali Fault, approximately 100 kilometers west of the TAPS, on Nov. 3, 2003. The earthquake was 4.2 kilometers below the surface of the earth. In this reporting of preliminary data, note that surface movement at the fault increases as one moves away from the earthquake epicenter:

Total length of fault rupture:	*320 km*
Horizontal movement near epicenter (on previously unrecognized fault):	*< 1.5 meters (5 feet)*
Large landslides (approximately 80 km east of epicenter	*—*
Horizontal movement of highway near TAPS (approx. 100 km east of epicenter):	*2.5 meters (8 feet)*
Horizontal offset of highway 100 km east of TAPS (approx. 200 km east of epicenter):	*6.9 meters (22 feet)*

Sources: Alaska Division of Geological and Geophysical Services, "Denali Fault Earthquake, M7.9, November 3, 2002" (http://wwwdggs.dnr.state.ak.us/earthquake.html) and Alaska Earthquake Information Center, "M 7.9 Denali fault earthquake of November 3, 2002 "(http://www.aeic.alaska.edu/M7.9_quake_2002/M7.9_quake.html)

30 "Can We Predict Earthquakes?"

31 Paul C. Thenhaus and Kenneth W. Campbell, "Seismic Hazard Analysis," in Wai-Fah Chen and Charles Scawthorn (eds.), Earthquake Engineering Handbook (Boca Raton: CRC Press, 2003), p. 8-44.

32 As part of an effort to convince the State of Alaska to relax statutory requirements to prepare for a large spill, in the late 1980's the TAPS owners commissioned Woodward-Clyde to assess probability of a major spill; the report estimated that a catastrophic oil spill could be expected "once every 241 years." (Course syllabus of Professor Van Noy, Radford University; http://www.radford.edu/~rvannoy/rvn/307/assignment2.htm. See also: Wall Street Journal, July 27, 1989.)

10. There are two common ways to measure earthquake severity: (a) Magnitude indicates the energy released within the earth where the rupture initiated and (b) intensity represents the effects of an earthquake at the surface:

***Magnitude** is measured on the Richter scale (a logarithmic scale, on which a magnitude 8.0 earthquake is 30 times more powerful than a 7.0).*

***Intensity** is typically rated by observed effects on a linear scale with 12 levels.*

Project seismic requirements are stated in terms of the MSK intensity scale, which is a 12-point rating sysem quite similar to the Modified Mercalli Index (MMI) typically used in the United States.[33]

11. "When strained in tension, corrosion-free steel pipe with arc-welded butt joints is very ductile and capable of mobilizing large strains, associated with significant tensile-yielding, before rupture." However, seismic events may damage buried pipelines in a variety of ways that include strong ground motion at the time of the earthquake or permanent ground deformation (PGD) due to changes in the earth's crust caused by seismic liquefaction and landslides.[34]

RICHTER SCALE	MMI/MSK SCALE*	MMI EFFECTS
MILD:		
0.0 – 4.3	**I-III**	People feel no movement
MODERATE:		
4.3 – 4.8	**IV**	Dishes, windows and doors rattle; parked cars rock
	V	Sleeping people disturbed; doors swing open
INTERMEDIATE:		
4.8 – 6.2	**VI**	Objects fall from shelves; plaster might crack
	VII	People have difficult standing; loose bricks fall from buildings
SEVERE:		
6.2 – 7.3	**VIII**	Houses might shift on foundations, chimneys twist and fall; ground water levels might change
	IX	Considerable building damage; some underground pipes broken; ground cracks; reservoirs damaged
	X	Most buildings, some bridges destroyed; large cracks; railroad tracks slightly bent
CATASTROPHIC:		
7.3 – 8.9	**XI**	Most buildings collapse; some bridges destroyed; underground pipelines destroyed; railroad tracks badly bent
	XII	Almost everything is destroyed; objects thrown into air; ground moves in waves or ripples; large amounts of rock may move

* Sometimes expressed in Arabic numbers.

Adapted from various web sites (see, for example, http://earthquake.usgs.gov/)

33 SEIC, Design Concepts [DC] of Buildings or Structures in Regions with High Seismicity in Combination with Other Adverse Loads Sakhalin II, p.29.
34 Michael J. O'Rourke, "Buried Pipelines," in Earthquake Engineering Handbook, pp. 23-1, 23-6, 23-14 and 23-15.

"[B]uried pipelines . . . generally cover large areas and are subject to a variety of geotectonic hazards. They can be damaged either by permanent movements of ground or by transient seismic wave propagation. Permanent ground movements include surface faulting, lateral spreading due to liquefaction, and landsliding. The hazard is usually limited to small regions within the pipeline network, however the potential for damage is very high."

M.J. O'Rourke and X. Liu, Response of Buried Pipelines Subject to Earthquake Effects, Multidisciplinary Center for Earthquake Engineering Research, 1999, preface [http://mceer.buffalo.edu/publications/monographs/buriedlines.asp]

12. The principal methods of avoiding exposing pipelines to potentially damaging ground movement are re-routing and vertical isolation.

"When . . . alternate locations are unavailable, impractical, or cost prohibitive, isolation techniques can be used to mitigate against seismic damage to pipelines. In this case, the pipeline traverses the hazardous area but is isolated from the effects of large ground movement by realignment in the vertical direction. A classic example is the placement of the trans-Alaskan pipeline on above-ground, "goal post"- type supports at fault crossing locations. That is, for strike-slip faults there is enough "rattle-space" between the uprights such that the potential fault movement can be accommodated without overstressing the pipe. This method can be used for most types of PGD hazards; however, proper implementation often requires a low-friction sliding surface between the pipes and its horizontal supporting member.

"For certain PGD hazards, the same objectives can be obtained by directional drilling technology... However, this technique cannot be used effectively at faults, since it is not possible to place the pipe "below" the fault."

M.J. O'Rourke, "Buried Pipelines," in Earthquake Engineering Handbook, p. 23-33.

IV. THE SEISMICITY OF SAKHALIN

1. Sakhalin is on the boundary of the Eurasian and North American plates.[35] (Figs. I.1, III.1.)

2. Sakhalin is generally regarded as a region of high seismicity or "high earthquake hazard,"[36] where active movements of the earth's crust are prominent.[37] According to EIA(4), "[s]eismic activity is a potential problem throughout Sakhalin."[38]

3. More than 2,000 people died when 17 residential buildings collapsed during a major earthquake that struck Neftegorsk, in northern Sakhalin, on May 27, 1995.[39]

4. The Neftegorsk earthquake struck in a zone "considered to be inactive," causing a rupture 46 kilometers long with an average slip value of 3.9 meters.[40] Prior to the quake, the area was rated with an expected intensity of 7 on the MSK scale; the actual event was rated between 9 and 10.[41]

5. After the Neftegorsk earthquake, the seismic intensity ratings for much of the pipeline route were increased, requiring the pipeline and buildings to be constructed to withstand earthquakes of greater severity.[42]

6. Research subsequent to the Neftegorsk earthquake has identified new faults on Sakhalin and new research tasks.[43]

7. In recent years, the island of Sakhalin has experienced several significant seismic events.

Examples of recent earthquakes on Sakhalin include the following:

On August 5, 2000, *a quake registering 6.0 on the Richter scale triggered mudslides, damaged a small power station and caused many residents to seek shelter in nearby hills.*[a]

One year later, *another "magnitude six" earthquake was reported in the Dolinsky region of Sakhalin, again with no casualties reported.*[b]

Smaller quakes were also were reported during the first week of ***August 2002****.*[c]

On Sept. 26, 2003, *the U.S. Geological Survey issued a preliminary report of an earthquake that registered 5.2 on the Richter scale southeast of Yuzhno-Sakhalinsk.*[d]

a – BBC, "Earthquake strikes Sakhalin," Aug. 5, 2000. [http://news.bbc.co.uk/1/hi/world/europe/867396.stm]

b – English Pravda, August 6, 2001 [http://english.pravda.ru/region/2001/08/09/12127.html]

c – Pravda On-line, "Earthquakes on Sakhalin and Kuril Islands; no damage and victims," Aug. 5, 2002 [at http://english.pravda.ru/region/2002/08/05/33821.html]

d – Accessed on National Earthquake Information Center web site, Oct. 20, 2003. [http://neic.usgs.gov/]

35 U.S. Geological Survey, "Earthquakes and Plate Tectonics" (http://neic.usgs.gov/neis/plate_tectonics/rift_man.html).

36 According to SEIC documents, the entire pipeline route lies in areas capable of generating earthquakes with intensity ratings between 8 and 10 (SEIC, Design Concepts [DC] of Buildings or Structures in Regions with High Seismicity in Combination with Other Adverse Loads Sakhalin II, pp. 8, 29).

37 Jan Kameda, et al., "Geology of Northern Sakhalin, Russia and its Relation to the Relative Convergence between the Eurasia and North American Plates," Journal of Geography, Vol. 109, No. 2 (2000) pp. 235-236.

38 EIA(4), Vol. 1, p. 5-23.

39 Vitaly Khalturin and Brian Tucker, "Lessons from Armenia and Sakhalin for Central Asia," IRIS Newsletter, 16(1): 1997 (http://www.iris.iris.edu/newsletter/spring97.news/almaty.html).

40 S. Arefiev, et al., "The Neftegorsk (Sakhalin Island) 1995 earthquake: a rare interplate event," Geophysical Journal International, Vol. 143, No. 3, p. 595.

41 "Lessons from Armenia and Sakhalin for Central Asia."

42 In its 2003 Environmental Impact Assessment, SEIC reports that "the seismicity rating of much of the route has been raised from the occurrence of one magnitude 6 to 7 event every one thousand years to one magnitude 8 to 9 event every one thousand years" (EIA[4]), Vol. 4, p. 1-25).

43 Several of the articles in a Journal of Geography compendium on Sakhalin seismicity (Vol. 109, No. 2 [2000]) suggested the need for further research on Sakhalin. See, for example, Jan Kameda, et al., "Geology of Northern Sakhalin, Russia and its Relation to the Relative Convergence between the Eurasia and North American Plates," p. 236 ("The dextral extrusion boundary in northern Sakhalin may be traced along the eastern coast of Sakhalin to the northern edge of the Kuril Basin, where active seismicity has been observed although a detailed study of focal mechanisms and other tectonic aspects is needed in the future.").

V. SEISMICITY AND THE SAKHALIN-II PHASE 2 ROUTE

1. The SEIC on-shore pipeline route crosses faults SEIC has classified "active" at 22 locations. SEIC defines active faults as "those which have displaced the surface of the ground within the last 10,000 years."[44]

2. According to SEIC's EIA(4) five of the active fault crossings are in the Yuzhno-Sakhalinsk region, where "steps must be taken to further reduce the risks to people within this area of the pipeline. This is to be carried out at the next stage of engineering design."[45]

3. SEIC's 2002 Map of Geotechnical Zoning, Including an Assessment of Geological and Geotechnical Hazards (Map of Geotechnical Zoning and Hazards) identifies at least 33 additional fault crossings on the SEIC pipeline route. We presume that SEIC considers these additional faults to be inactive.[46]

4. Based on our calculations from SEIC's Map of Geotechnical Zoning and Hazards, approximately one quarter of the 808-kilometer pipeline lies within territory where the earthquake potential is rated at 9 or higher on the MSK scale.[47]

5. In addition to the direct earthquake effects, the pipeline route passes through areas subject to sudden, large movements of the earth that could be triggered by an earthquake; these phenomena include landslides, mudslides and avalanches.[48]

6. In discussing project alternatives, EIA(4) does not mention whether SEIC considered elevating all or portions of the on-shore pipelines above the ground.[49]

7. According to SEIC, the project design premise addresses "the major seismic hazards that can affect pipelines including fault movement, liquefaction, landslides, seismic wave propagation and ground shaking." The basis of that design is that a buried pipeline can be engineered and constructed "to accept comparatively large strains" resulting from seismic phenomena without rupturing.[50]

VI. SEIC PUBLIC INFORMATION ON SEISMIC HAZARDS AND THEIR MITIGATION

1. Since 2002, SEIC has released two environmental impact assessment (EIA) reports for Phase 2 of the Sakhalin-II project. The first was prepared as part of SEIC's formal submission to the government of the Russian Federation as part of its Technical and Economic Substantiation of the project (TEO-C). According

44 Julian Barnes (External Affairs Manager, SEIC), letter to Richard A. Fineberg, Dec. 10, 2003, pp. 2-3 (see Appendix A). pp.
45 EIA(4), Vol. 4, p. 2-25.
46 SEIC, Map of Geotechnical Zoning, Including An Assessment of Geological and Geotechnical Hazards (Environmental Centre IFPA, Moscow, 2002). On this 85-sheet map of the pipeline route the faults identified by SEIC as active are shown in red; the 33 additional fault markings are in blue. See discussion of active and inactive faults in Section III., above. The blue (inactive) fault crossings, with their approximately location by SEIC kilometer post ("KP") and map sheet number are shown in Appendix D.
47 Estimated from Map of Geotechnical Zoning and Hazards (see Section VI.6[a], Figs. VI.3, VI.4, VI.5, VI.6 and Appendix D, below).
48 EIA(4), Vol. 4, p. 1-26 (Fig. VI.1).
49 See: EIA(4), Vol. 1, Ch. 5 (discussion of project alternatives).
50 Barnes letter to Fineberg, Dec. 10, 2003, pp. 1-4.

to SEIC, the TEO-C EIA (EIA[3]) was the company's third project environmental impact assessment and "acts as a kind of summary EIA for the complete set of facility specific Environmental Protection Books (EPBs) submitted as part of the TEO-C." Early in 2003, SEIC published EIA(4). SEIC described that seven-volume document as "the only EIA that has been carried out to international best practices standards."[51]

2. EIA(4) acknowledged "gaps in information, which, if crucial to the adequate assessment of aspects of the project, will need to be filled."[52] However, EIA(4) did not recognize the existence of shortcomings in its seismic analysis; except for the unidentified "steps [that] must be taken" to increase seismic hazard mitigation in the Yuzhno-Sakhalinsk area (Sec. V.2, above), EIA(4) did not identify gaps in the company's analysis or presentations of seismic hazards to the onshore pipelines, or risk mitigation plans to address those hazards.

3. According to SEIC, doubts about the safety measures the company will implement with regard to earthquake danger were one of the most frequently raised concerns during the public hearing and consultation process for the Sakhalin-II project.[53] Nevertheless, in contrast to other issues of public concern that have led SEIC to produce special reports,[54] SEIC has not provided the general public with a comprehensive presentation of the seismic issues faced by the onshore pipeline plans, or by the project as a whole.

4. Both EIA documents lack important information relevant to the assessment of seismic hazards and SEIC's plans for dealing with those hazards. Examples of missing information include the following:

(a) The English-language version of both EIA documents published by SEIC contain maps purporting to showing the pipeline route in relation to the seismicity rating and fault crossings but neither map contains the promised information. In EIA(3), Figure 1-29 is captioned "Seismic Zoning and Fault Crossings Along the Pipeline Route."[55] (Fig. VI.2.) However, the figure does not show the pipeline route, faults or fault crossings. That information does appear in the Russian-language version of the EIA(3) map. (Fig. VI.3.) In EIA(4), SEIC states that "[t]here are 24 locations where the pipeline crosses seismic faults, as shown in Table 1.2. These are also shown in Figure 1.10 along with the seismic zones of Sakhalin Island." While Table 1.2 of EIA(4) does include a list of 24 fault crossings by kilometer post,[56] Figure 1–10 of the EIA shows neither fault crossings nor seismic zones.[57] (Fig. VI.1.)

(b) In the concluding chapter of EIA(3), SEIC identifies "[s]eismic events – earthquakes" and "[l]andslides and earth movements" on a short list of key environmental hazards.[58] But the conclusion contains no further discussion of seismic hazards or the manner in which SEIC proposes to mitigate them.

(c) In its lengthy listing of laws and regulations related to the design and environmental management of the Sakhalin-II Phase 2 project, EIA(4) makes no reference to the section of the National Codes and Standards of the Russian Federation governing pipeline construction in general (SNiP 2.05.06-

51 EIA(4), Vol. 1, pp. 1-3 and 1-9. SEIC released both EIA(3) and EIA(4) on CD-ROM disks and published EIA(4) on the company's web site.
52 EIA(4), Vol. 1, pp. 1-3, 1-9. In EIA(4), SEIC noted that "[t]he relevance of potential data gaps and its effect on the impact assessment are clearly stated and the ways forward will be defined as part of environmental management actions to be taken by SEIC."
53 EIA(4), Vol.1, p. 4-12. Similar statements can be found in EIA(3), at Exec. Summary, p. v and Ch. 7, pp. 7-17 and 7-23.
54 SEIC has issued focused information in the form of special reports on various subjects of public concern, including western gray whales, stream crossing methodology and the oil spill response program. Additionally, SEIC plans to update to its EIA catalogue of salmon streams that will be affected by pipeline construction.
55 EIA(3), Figure 1-29 ("Seismic Zoning and Fault Crossings Along the Pipeline Route").
56 EIA(4), Vol. 4, pp. 1-16 -1-19. (For reasons that will be discussed in Paragraph VI.5.C., below, the fault information in SEIC's table is difficult to decipher.)
57 EIA(4), Vol. 4, pp. 1-25 and 1-26.
58 EIA(3), Chapter 9, p. 9-1 (Table 9-1).

85*) or the PSTS that apparently supercedes it.[59]

(d) EIA(4) contains a 14-page list of approximately 200 "baseline surveys" completed between 1992 and 2002, including approximately 30 reports on geologic issues. This list does not include the 2002 Map of

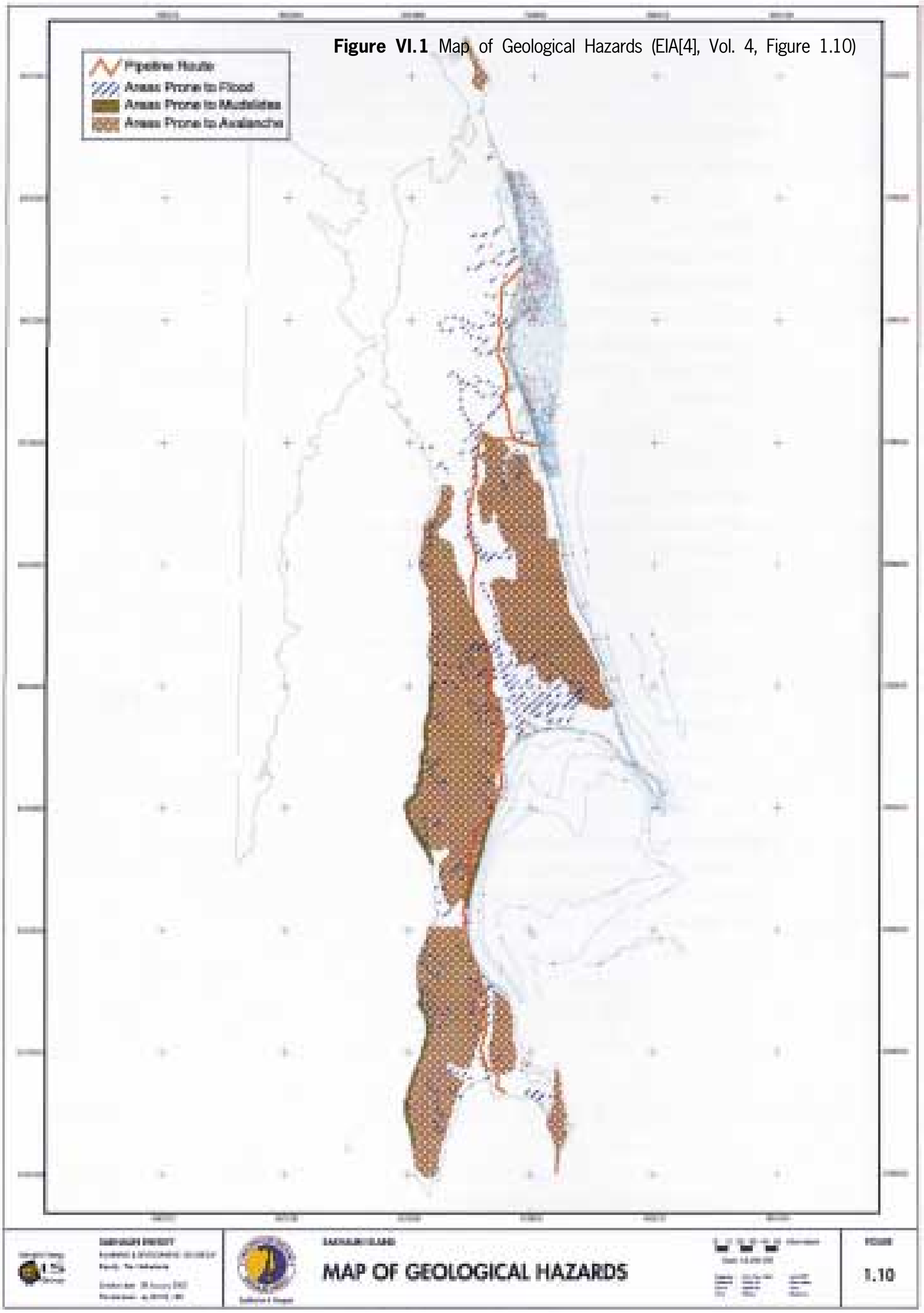


Figure VI.1 Map of Geological Hazards (EIA[4], Vol. 4, Figure 1.10)

59 For description of these regulations see Sections II.3, II.4. and II.5.

Geotechnical Zoning and Hazards for the pipeline route discussed in Sections V.3 above and VI.6 below.[60] (e) Discussions of project alternatives in EIA(3) and EIA(4) do not mention the possibility of siting the on-shore pipelines above ground.[61]

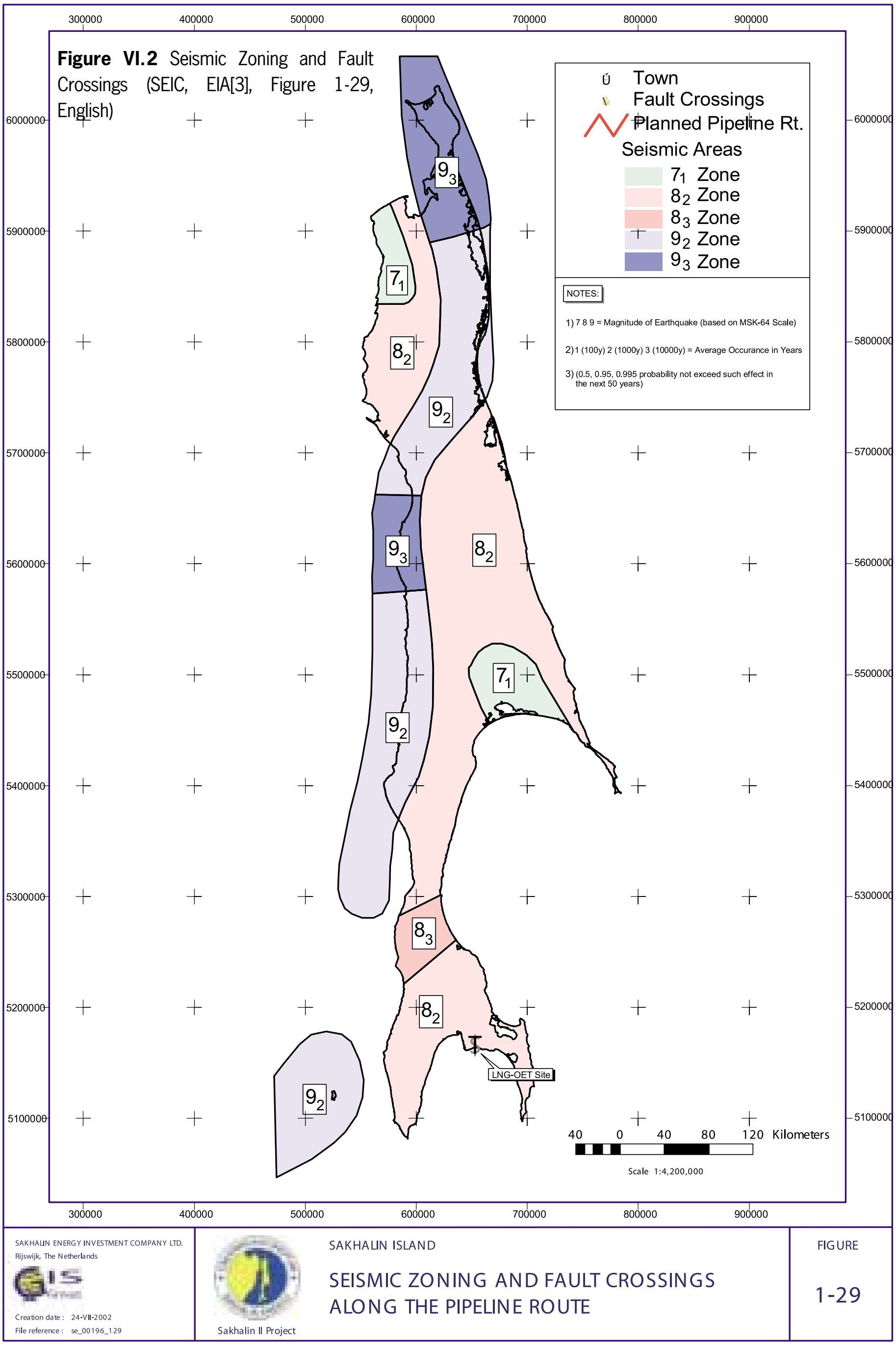


Figure VI.2 Seismic Zoning and Fault Crossings (SEIC, EIA[3], Figure 1-29, English)

60 EIA(4), Vol. 1, Appendix A. (These references do include at least three geological studies conducted in 1998 [pp. A-3 – A-4]).
61 EIA(3), Chapter 4, pp. 4-1 – 4-9. ; EIA(4), Vol. 4, pp. 5-1 – 5-32.

(f) In response to a request for "site-specific risk analyses performed to assess the possible effects of earthquakes on onshore facilities, including the planned oil and gas pipelines," SEIC referred Research Associates to tables that "capture the significant risk features along the pipeline route including where

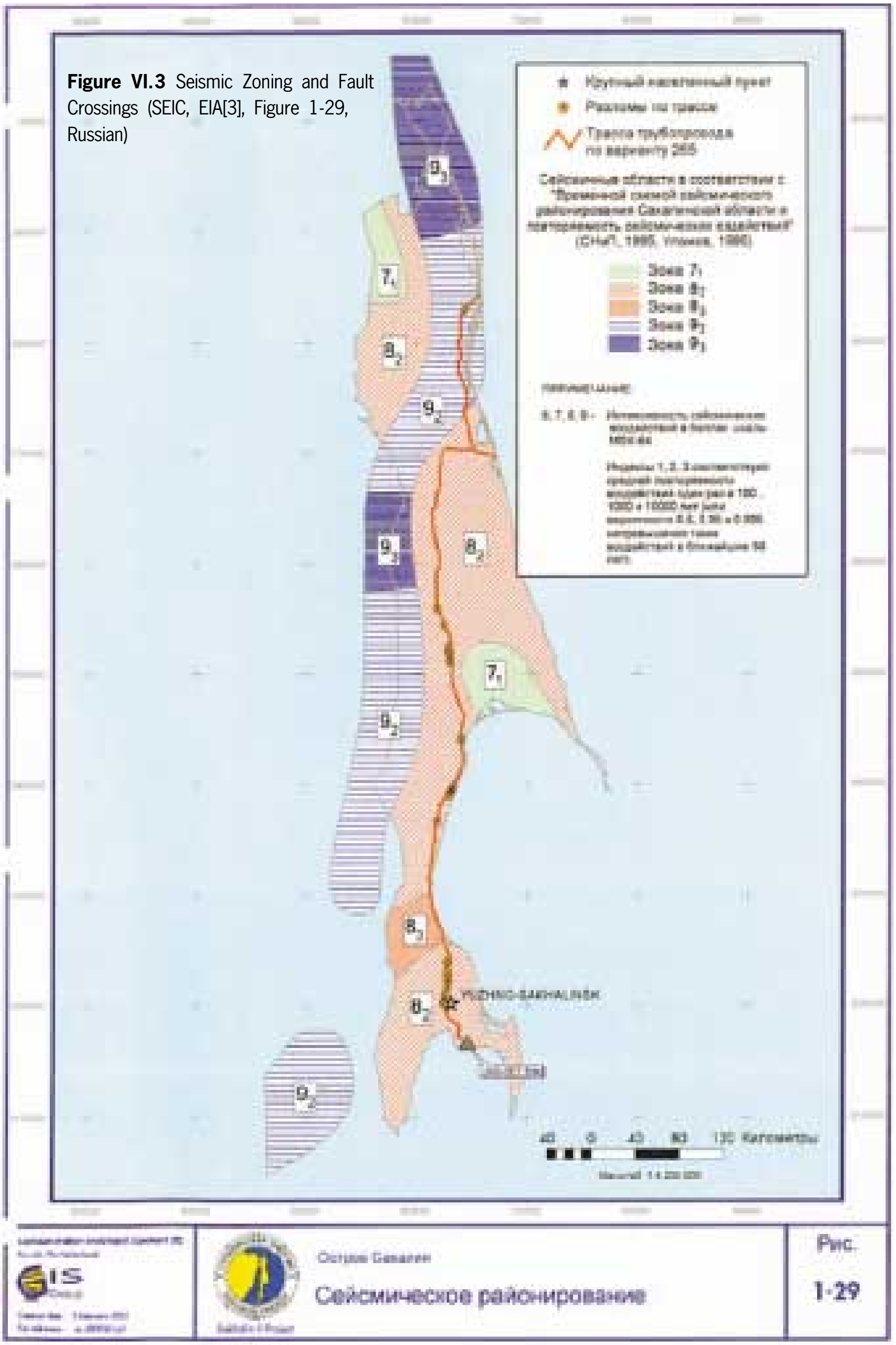


Figure VI.3 Seismic Zoning and Fault Crossings (SEIC, EIA[3], Figure 1-29, Russian) the pipeline crosses active faults."[62] The referenced tables appear to present only a summary or composite of all risks, including non-seismic hazards.[63] Without the inputs on seismic risks and the methodology SEIC used to estimate those risks, we were unable to determine how SEIC has evaluated seismic risks, or how SEIC believes those risks will interact with other geologic or non-geologic risks or how the outcomes might affect the safety of the pipelines. In response to our follow-up request for information on seismic risks, SEIC responded that "[t]he design is based on no rupture for the specified loads."[64]

(g) The SEIC EIA documents provide no empirical evidence, theoretical calculations, quantitative analysis or discussion to support the presumption that a buried pipeline will provide a measure of safety from rupture appropriate to the geotechnical risks along the pipeline route.

5. The information that SEIC does provide on seismic issues in its various formal submissions is often scattered and difficult to find; once found, information is often presented in a manner that is needlessly confusing. For example:

(a) Scattered information: In EIA(4), the geology of Sakhalin and the pipeline route is discussed in Volume 4, Chapter 1 ("Existing Environment"); however, important information on the seismic conditions on the pipeline route is also found in Chapter 2 ("Project Description").[65]

(b) Information that is difficult to find: (1) In the TEO-C a summary presentation of seismic conditions along the entire pipeline route is found under a heading for Booster Station #2, a single facility on the pipeline route (see Section VI.4[f]).[66]

(c) Information that is needlessly confusing: In EIA(4), the table that shows the location of pipeline fault crossings divides the pipeline into nine pipeline segments. The segments are not numbered in sequence from one end of the pipeline to the other; as a result, fault crossings are listed in seemingly haphazard order that is difficult to relate to the physical locations.[67] Compounding this problem, faults are identified by kilometers post (KP) that are difficult to locate for two reasons. First, SEIC's KP numbering does not begin exactly at KP zero; secondly, as the pipeline travels south, KP numbers start over twice from points that are not clearly identified.[68]

6. Comparisons between the various, scattered materials on seismic hazards in the voluminous public record presented by SEIC to date reveal significant apparent discrepancies. Consider the following:

(a) In the TEO-C depiction of the zones of earthquake intensity, we estimate approximately 126 kilometers (15.6%) of the pipeline route is located in areas with a seismic intensity rating of 9.[69] However, our review of SEIC's Map of Geotechnical Zoning and Hazards (also submitted in 2002 with the TEO-C), indicates that approximately 234 kilometers (29.0%) of the pipeline route lies within areas with a seismic intensity rating equal to or greater than 9. There are two principal reasons for this

62 Barnes letter to Fineberg, Dec. 10, 2003, p. 1.
63 TEO-C, Vol. 3, Book 9, Tables 6.3 and 6.4.
64 Barnes letter to Fineberg, Jan. 26, 2004, p. 3.
65 EIA(4), Vol. 4, pp. 1-24 – 1-26 and 2-20 – 2-25.
66 SEIC, TEO-C, Vol. 3, Book 9, Sec.3.3.2, p. 3-11.
67 EIA(4), Vol. 4, Table 1.2, pp. 1-16 – 1-19 (also discussed in VI.4.[a], above). The nine segments, from north to south, are numbered 1, 8, 6, 9, 2, 3, 4, 5 and 7; the table presents the segments in sequential rather than geographic order.
68 SEIC explains its out-of-sequence segment numbering and cumbersome pipeline kilometer post numbering system in this way: "These segments and KP numbers have been inherited from work undertaken during project development, and as such the numbering does not follow a sequential system. Nevertheless, using Figure 1.3 as a key map, geographical locations can be derived along the pipeline route" (EIA[4], Vol. 4, p. 1-2).
69 Estimated from EIA (3) Fig. 1-29 (Fig. VI.3 below).

significant increase in the seismic hazard rating for the pipeline route:

(1) The southeast limit of the 9_2 seismic intensity rating zone in the Map of Geotechnical Zoning and Hazards extends further south than shown in EIA(3) Figure 1-29; this change raises the seismic hazard rating for nearly 20 kilometers of the northern pipeline segment and a similar portion of the southern segment from 8 to 9 on the MSK scale.[70] (See Figs. VI.4, VI.5, VI.6.)

(2) At more than 20 places on the pipeline route, geotechnical review apparently determined that relatively short segments of the pipeline route have a seismic hazard rating one increment higher than the general area. Altogether, these adjustments would raise the seismic hazard rating for approximately 108 kilometers of the pipeline as follows: [a] 61 kilometers from 8 to 9; [b] 46 kilometers from 9 to 10; and [c] one kilometer from 8 to 10. (See Appendix D.)

(b) SEIC's PSTS for onshore project design states that the pipeline route "is characterized with high seismicity from 8 to 9 points Richter scale. In some areas seismicity exceeds 9 points depending on ground conditions."[71] Earthquakes of that magnitude are generally regarded as catastrophic and liable to destroy buildings and underground pipelines. But there is a significant disparity between the PSTS estimate of Sakhalin's seismicity and the somewhat lower (but still significant) seismicity intensity ratings shown on SEIC's 2002 maps of seismic zoning, which indicate seismic intensity ratings of 8 to 10 on the MSK scale. An earthquake with force of 6.2 to approximately 7.3 on the Richter scale is liable to produce an intensity rating of 8 to 10 on the MSK scale – severe, but not catastrophic (see Sec. III.10).

(c) EIA(4) describes the geologic conditions of the pipeline segment in the vicinity of Makarov as "favorable."[72] However, in this segment of the route the pipelines will cross steep coastal ramparts and five active faults, threading its way through a series of hills and steep valleys whose stability is threatened by landslides, mudslides and avalanches.[73] The TEO-C states that this segment of the pipeline is the "most complex" part of the route due to the mountainous terrain.[74]

(d) At various times in the last 18 months, SEIC has described its plan for fault crossing burial (then for crossing 24 faults) in official documents as follows:

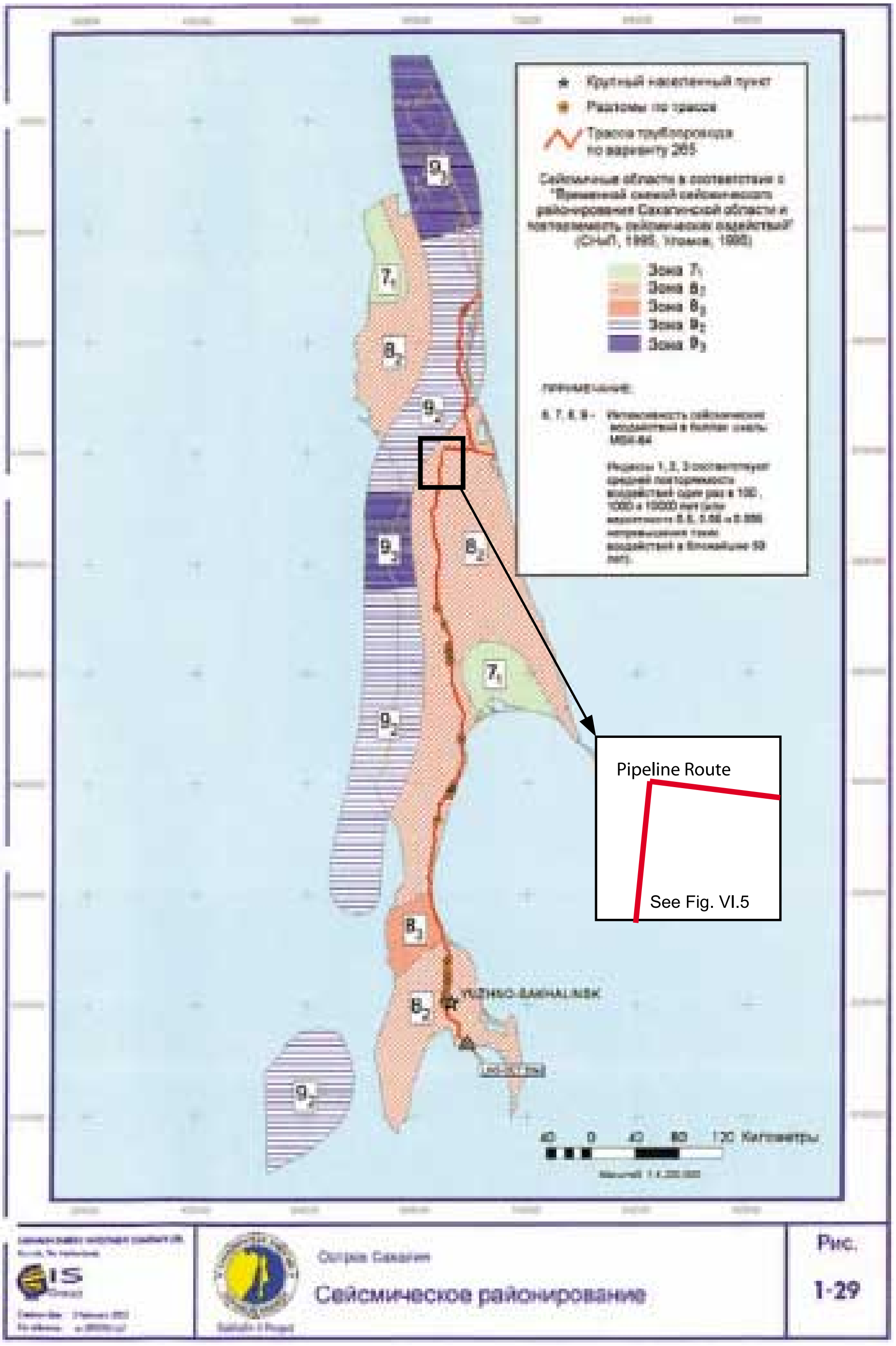
EIA(3): 24 –"choosing a certain trench configuration and specifying selected loose granular backfill."[75]

TEO-C: 12 – standard trench, friable granulated backfill
2 – standard trench with sand
7 – widened trenches with flat slopes
3 – widened trenches, flat slopes and geotextile facing.[76]

EIA(4): 23 – standard trench, foam with geotextile material
1 – standard trench with sand.[77]

70 Estimated from Map of Geotechnical Zoning and Hazards.
71 PSTS, p. 9.
72 EIA(4), p. 2-21. (Using SEIC's nomenclature, this is pipeline Segment 4.)
73 See: Map of Geotechnical Zoning and Hazards, sheets 56-61.
74 EIA(4), pp. 1-17 (Table 1.2), p. 2-22 (Table 2.14); TEO-C, Vol. 3, Book 8, Part 2.1 , Sec. 4.3.2.1, p. 4-108 ("Evaluation of Seismic and Tectonic Danger") and Vol. 3, Book 9, Sec. 3.3.2, Item 1, p. 3-11 ("Earthquakes, Landslide and Karstic phenomena").
75 EIA(3), Chapter 3, p. 3-43.
76 TEO-C, Vol. 3, Book 8, Part 2.1, Section 4.4.1, pp. 117-118 (preliminary translation).
77 EIA(4), Vol. 4, p. 2-22.

Figure VI.4 Russian EIA(3) Figure 1-29 Highlighting Argi-Pagi Area



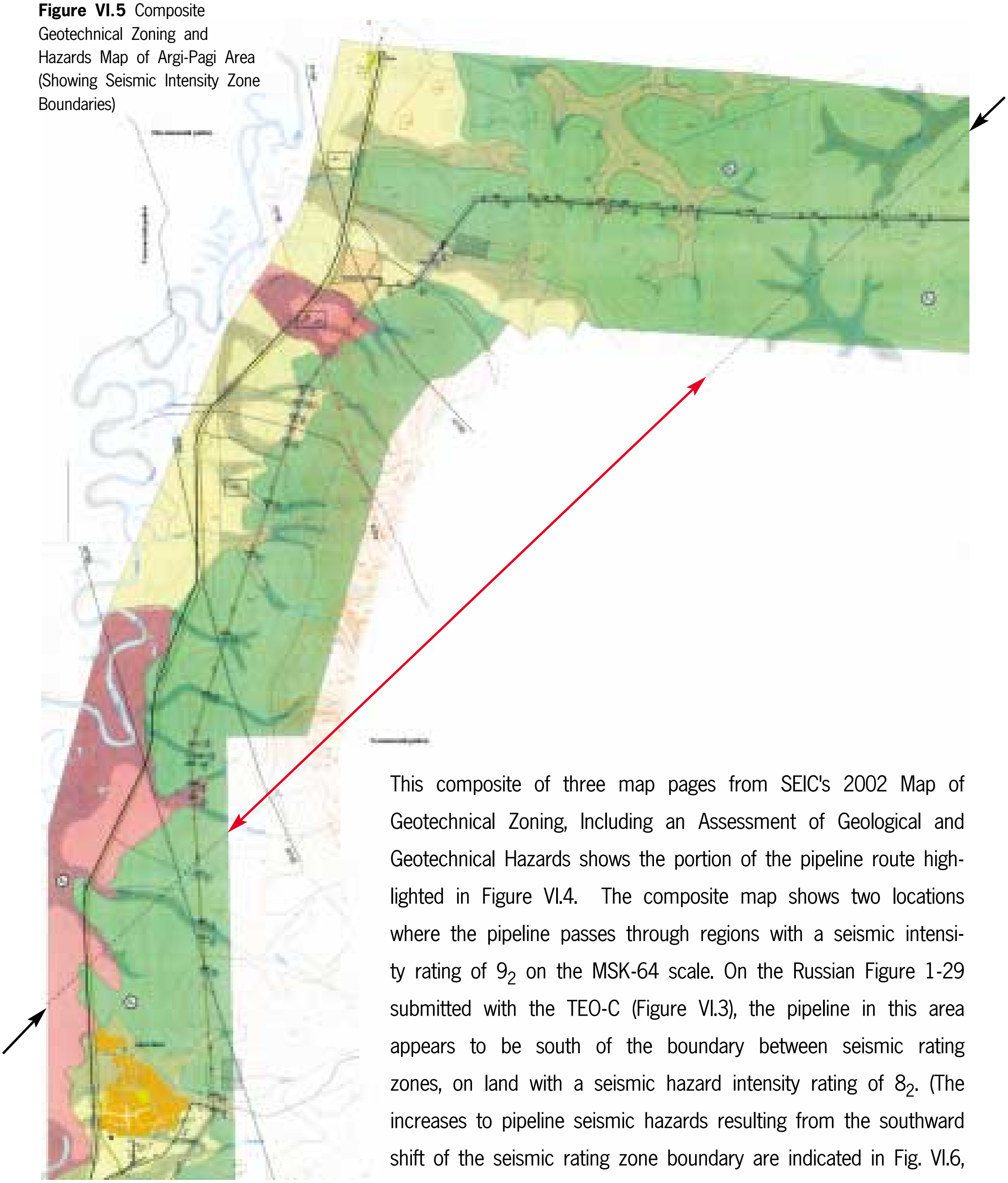


Figure VI.5 Composite Geotechnical Zoning and Hazards Map of Argi-Pagi Area (Showing Seismic Intensity Zone Boundaries)

This composite of three map pages from SEIC's 2002 Map of Geotechnical Zoning, Including an Assessment of Geological and Geotechnical Hazards shows the portion of the pipeline route highlighted in Figure VI.4. The composite map shows two locations where the pipeline passes through regions with a seismic intensity rating of 9_2 on the MSK-64 scale. On the Russian Figure 1-29 submitted with the TEO-C (Figure VI.3), the pipeline in this area appears to be south of the boundary between seismic rating zones, on land with a seismic hazard intensity rating of 8_2. (The increases to pipeline seismic hazards resulting from the southward shift of the seismic rating zone boundary are indicated in Fig. VI.6, discussed in Sec. VI.6[a] and supported by Appendices D and E. (The red arrow joining the endpoints of the two seismic intensity zone boundary segments is an inference.)

We presume that SEIC has devoted some consideration to the ability of buried pipelines to withstand sudden large ground movements caused by the potential earthquakes and related phenomena that might be expected in Sakhalin.

Nevertheless, EIA(3), EIA(4) and other documents reviewed for this report do not provide substantive information regarding those studies or the means by which SEIC has validated the effectiveness of the proposed design.

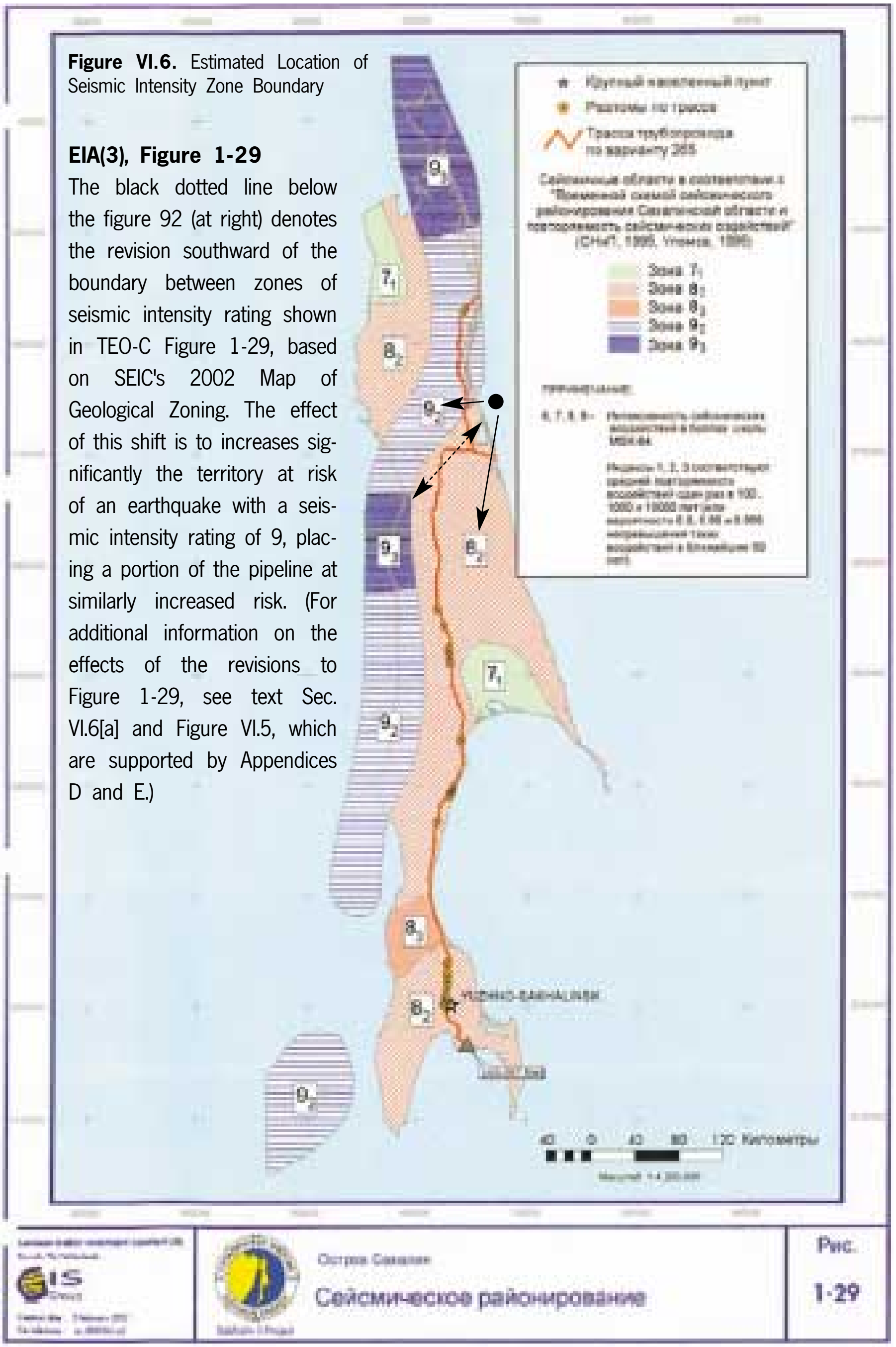


Figure VI.6. Estimated Location of Seismic Intensity Zone Boundary

EIA(3), Figure 1-29

The black dotted line below the figure 92 (at right) denotes the revision southward of the boundary between zones of seismic intensity rating shown in TEO-C Figure 1-29, based on SEIC's 2002 Map of Geological Zoning. The effect of this shift is to increases significantly the territory at risk of an earthquake with a seismic intensity rating of 9, placing a portion of the pipeline at similarly increased risk. (For additional information on the effects of the revisions to Figure 1-29, see text Sec. VI.6[a] and Figure VI.5, which are supported by Appendices D and E.)

VII. COMPARISONS TO EXPERIENCE WITH THE TRANS-ALASKA PIPELINE (TAPS)

A. Background

1. Alaska's experience with oil and gas development and the Trans-Alaska Pipeline System (TAPS) are frequently used as benchmarks for discussion of Sakhalin oil development projects.[78]

2. TAPS was built between 1974 and 1977 by a consortium of eight major oil companies. At its peak in 1988 TAPS carried approximately 2.0 million bpd from Alaska's North Slope 800 miles (1,290 kilometers) to the ice-free port of Valdez.[79] Betweeen 2000 and 2003, TAPS carried approximately 1.0 million bpd.[80]

Figure VII.2 Alaska Pipeline on Beams Embedded in a Gravel Berm

Figure VII.1 Alaska Pipeline Elevated on Vertical Supports

Figure VII.3 Damage to TAPS Support System Caused by Nov. 2003 Earthquake at Denali Fault

B. Above-Ground Fault Crossings on TAPS

1. In discussing the Sakhalin-II Phase 2 onshore pipelines, SEIC officials frequently suggest that TAPS was placed above ground at three active fault crossings due to permafrost – not seismic – considerations.[81]

2. Approximately 420 miles of TAPS is elevated. In general, TAPS was placed above ground in order to prevent heat from the pipeline from causing thawing and settlement of permafrost.[82] (Fig. VII.1.)

3. TAPS also uses an elevated support system to cross active fault zones. (Fig.VII.2.) The following authoritative sources confirm that seismic concerns – not permafrost – are the reason that TAPS was built above ground at fault crossings:

(a) According to the TAPS design basis manual, "[a]t the Denali Fault crossing, the pipeline is sup-

78 SEIC, The Trans Alaska Pipeline System (TAPS) and Comparisons with the Sakhalin II Pipeline Transportation System (briefing paper; http://www.sakhalinenergy.com/documents/doc_38_taps.pdf). Before participating in the financing of Phase I of the Sakhalin-II project, the European Bank for Reconstruction and Development (EBRD) reported that the project environmental action plan "specifies that the Company will meet or exceed World Bank environmental standards and that Alaskan offshore environmental/health and safety (EHS) guidelines have been used to develop standards for the project. The Bank's consultants have confirmed that Alaskan standards exceed applicable European Union standards" (European Bank of Reconstruction and Development, "Standards," in Project Summary Document for Sakhalin II [Phase 1] Project, Russian Federation, circa 1997 (http://www.ebrd.com/projects/psd/psd1997/94sakhal.htm).

79 Alyeska Pipeline Service Co., Trans Alaska Pipeline System FACTS, 2003, pp . 6, 26-27 and 30. Since inception, major oil companies BP, ExxonMobil and ConocoPhillips (or their predecessors) have owned more than 90% of TAPS.

80 Alaska Department of Revenue, Fall 2003 Revenue Sources Book, December 2003, p. A5.

81 Most recently, SEIC's Julian Barnes reflected this opinion in his Jan. 26, 2004 letter to the author of this report (Appendix C). In a meeting in Yuzhno-Sakhalinsk with SEIC officials November 4, 2003, Mr. James Robinson, head of SEIC's environmental program, also expressed this opinion.

82 Trans Alaska Pipeline System FACTS, pp. 79, 84-89.

ported above the ground surface on beams in gravel berms in order to accommodate the anticipated large ground movements and to prevent excessive pipeline strains."[83]

(b) According to the 1977 Alyeska document compiled specifically to record the construction mode for each stretch of the pipeline and documented the reasons for that selection, for the 1,900-foot (0.6 km) section of the pipeline spanning the Denali Fault, "[a]n elevated support system . . . was chosen for this segment, rather than the otherwise equally suitable conventional burial mode, in order to provide more flexibility for the pipe to accommodate possible ground motion on the Denali Fault." At both ends of the fault crossing, the pipeline enters discontinuous permafrost and returns to normal elevated design used for crossing permafrost.[84]

(c) TAPS is described in the Earthquake Engineering Handbook as a "classic example" of a pipeline that traverses a fault area above the ground so that "potential fault movement can be accommodated without overstressing the pipe."[85]

4. Defending its contention that TAPS is elevated at the Denali Fault crossing due to permafrost, SEIC recently stated that its position "is illustrated in the photo attached by the presence of heat exchangers on the top of the pile supports."[86] (See Appendix C.) Careful examination reveals that SEIC's photo and comments are irrelevant to the question: the two above-ground support structures in the photograph SEIC provided do not lie within the 1,900-foot Denali Fault crossing zone; rather, these supports are located in the discontinuous permafrost that begins on the hill immediately to the north of the crossing zone.[87] Moreover, it is the pilings themselves that indicate the need for elevating TAPS – not the heat exchangers, as asserted by SEIC.[88]

5. According to the TAPS design basis document, the Denali fault crossing was designed to accommodate potential pipeline movements of approximately 6.0 meters (20 feet) horizontally and 1.5 meters (five feet) vertically. By comparison, normally buried TAPS pipe in a soil ditch was expected to survive a two foot by two foot fault movement.[89]

6. According to the seismic design criteria for TAPS, a major earthquake "could possibly lead to damage requiring repair. . . . (but) there should be no structural collapse or release of crude oil or hazardous substances, and functionality of essential control, communications, and emergency systems should be maintained without interruption."[90]

83 Alyeska Pipeline Service Co., Design Basis Update DB-180, June 18 2002 [4th ed., Rev. 2], p. 1-26.
84 Alyeska Pipeline Service Co., "ETSCAD [Environmental and Technical Stipulation Compliance Assessment Document] Mode Justification," May 17, 1977, Alignment Sheet 37.
85 See excerpt from Earthquake Engineering Handbook, p. 23-33, in box accompanying Section III.12, above.
86 Barnes letter to Fineberg, Jan. 26, 2004, p. 4.
87 "ETSCAD Mode Justification," Alignment Sheet 37. Although the piling location numbers stencilled onto each vertical support are not visible in the photograph SEIC provided, from the topography and the visible pipeline structures, it is clear that the vertical support structures in this photograph are the second and third supports south of Anchor No. 3107921 on current TAPS Alignment Sheet no.105 (author's identification, based on on-site inspection and photographs).
88 According to a TAPS system description manual, "[T]hawing permafrost could cause differential settlement of the soil in which the pipe is buried and could result in bending the pipe. . . . The pipeline is constructed aboveground in areas where heat from a buried pipeline might melt the permafrost and create soil stability problems. . . . To prevent thawing around the vertical support members, thermal devices (heat pipes) are installed inside many of the vertical supports." (Alyeska Pipeline Service Co., Trans Alaska Pipeline System Description Manual (Document No. SD-26; revised June 1977), pp. 3-2 – 3-3. Approximately 30,500 of the 39,000 above ground support structures on the TAPS line have heat exchangers (FACTS, pp. 83-84). In sum, heat exchangers are a design feature of many of the vertical support structures, but it is the elevated goalpost structure itself that indicates the presence of permafrost.
89 Design Basis Update DB-180, p. 1-23.
90 Design Basis Update DB-180, p. 1-13.

C. TAPS Performance in the Denali Fault Earthquake (November 2002)

1. When an earthquake of 7.9 magnitude (Richter Scale) occurred on the Denali Fault November 3, 2002, seismic specialists familiar with TAPS credited the specially designed above-ground support structure with successfully allowing the pipeline to handle ground movement at the pipeline crossing of approximately 5.5 meters (18 feet) horizontally and 1.5 meters (5 feet) vertically.[91]

2. Although most observers were complimentary of the way in which TAPS handled the Denali Fault earthquake,[92] several issues deserve further consideration. For example:

(a) The specially designed fault crossing system, approximately 1,900 feet (0.6 kilometers) in length, suffered limited damage but absorbed the motion and shaking of the earthquake. However, at both ends of the fault crossing, immediately past where the pipeline returned to normal above-ground supports, the vertical support crossbeams dropped to the ground, leaving the pipeline unsupported. In all, eight crossbeams fell.[93] (Fig. VII.3.) Although official statements maintain that this kind of damage was expected, the pipeline design basis document does not include crossbeam failure in the description of anticipated structural failures during a major earthquake.[94]

(b) Although the pipeline's automatic earthquake alarms ordered immediate shutdown of the pipeline, the controllers overrode that command and oil continued to flow for an hour after the quake.[95] Various explanations have been given for the failure to shut down immediately when the earthquake occurred.[96]

(c) According to credible but unofficial reports, after the Denali Fault earthquake TAPS personnel were worried that portions of the buried pipeline may have been ruptured.[97] To assure that there was no damage and that oil was not leaking, a buried valve near the fault had to be excavated for inspection.[98]

91 Steve P. Sorensen and Keith J. Meyer, "Effect of the Denali Fault Rupture on the Trans-Alaska Pipeline," August 2003, p. 8 (http://www.alyeska-pipe.com/Inthenews/techpapers/2-TAPS%20Fault%20Crossing%20Denali%20EQ.pdf). According to the authors (the current TAPS engineering coordinator and an Alaska consultant), "[I]nitial field estimates of the ground faulting at the fault scarp indicated displacements of approximately 2.3 m strike slip and 0.8 m vertical. GPS and geodetic surveys initiated within one week after the earthquake determined the fault displacement to be larger: 5.5 m horizontal and 1.5 m vertical distributed over a zone of approximately 200 m."

92 According to one trade publication account: "On Nov. 3 [2002], a 7.9 magnitude earthquake struck Alaska's interior, producing a 145-mile-long crack across the landscape and sending boats bobbing on lakes more than 3,000 miles away. . . . But the 48-inch Alaska pipeline . . . survived just as designed – damaged but not ruptured, said Doug Nyman, the pipeline's seismic design coordinator from 1973 to 1977. . . .If anything, the strongest oearthquake ever recorded on the Denali fault showed the pipeline could have withstood more, Nyman said. . . . "Compared to what happened, we still have a lot of capacity there," Nyman said. . . (Alexander's Gas & Oil Connections [News & Trends in North America], Vol. 7, issue #23, Nov. 27, 2002).

93 Alyeska Pipeline Service Co., "Fact Sheet: MP 588 – Earthquake Damage Assessment Update No. 3," Nov. 4, 2003.

94 Design Basis Update B-180 discusses above ground support structures designed to collapse to absorb the force of an earthquake but does not identify the vertical support crossbeams as a sacrificial component or suggest the possibility of crossbeam failure. (Design Basis Update DB-180, p. 1-13).

95 Diana Campbell, "How oil pipeline officials handled the 'big one' of 2002," Fairbanks Daily News-Miner, Nov. 20, 2002, p. A1.

96 Operating instructions for the TAPS pipeline controller at the Valdez Marine Terminal's Operations Control Center warn the operator that an earthquake alarm will shut down the pipeline automatically if not overridden manually. However, review of the relevant manuals reveals that the instructions are vague as to when and under what circumstances the controller should re-issue the shutdown command. An example of that vagueness is the instruction to go to the Earthquake Monitoring System (EMS) console, turn it on and "wait five or ten minutes." Another possible reason given for the shutdown delay is that if the operators initiated a shut down they would not be able to determine whether the earthquake had caused a leak because flow conditions would no longer be stable enough to permit the leak detection system to operate.

97 Interviews with TAPS field workers.

98` "How oil pipeline officials handled the 'big one' of 2002."

D. Pipe Wall Thickness and Corrosion in Buried Pipelines

1. According to SEIC, heavier (thicker) pipe may be used to mitigate the risk of seismic damage at faults.[99]

2. In reviewing the Denali Fault earthquake, informed TAPS engineers concluded that if TAPS had been buried "in a special fault crossing trench (loose backfill and sloped sides), it would have required much heavier wall pipe and local buckling likely would have occurred, hence requiring pipe repair and more extended downtime."[100]

3. Corrosion, which reduces pipe wall thickness, is one of the major risks to buried pipelines and a major causes of pipeline leaks.[101]

4. Three significant factors that contribute to a corrosive soil environment are moisture, high acid content and the presence of other buried metal in the vicinity of a pipeline.[102]

5. According to EIA(4), "In general, soils [along the Sakhalin-II Phase 2 pipeline route] tend to be boggy, fragile and podzolized."[103]

6. SEIC plans to bury a natural gas pipeline in the same right-of-way, generally separated by a distance of eight to 15 meters.[104]

7. SEIC notes that although statutory corrosion protection requirements vary, "it is necessary to adopt such a procedure that would insure reliable protection against corrosion for 30-year operating life cycle at minimum cost."[105]

8. The following experience on TAPS is noteworthy in this regard:

   (a) In 1975, a TAPS spokesman assured the author that corrosion would not be a problem on TAPS. According to the TAPS representative, "[t]he pipe is essentially inert and the Alaska environment is not hostile to the pipe. We don't have many corrosive contaminants."[106]

   (b) In 1988, significant corrosion was discovered on buried portions of TAPS. Since then, the TAPS owners have had to spend more than $1 billion to weld short repair sleeves around patches of corrosion at more than 100 locations and replace more than eight miles of mainline pipe.[107]

99 In EIA(3), SEIC states that [t]he pipelines will use pipe with varying wall thickness, based on safety classifications. In general, pipe wall thickness is increased at river, road and railway crossings, near to settlements and facilities and at seismic fault crossings (EIA[3], p. 3-19). However, EIA(4) states that "[f]or onshore pipelines, wall thickness and pipe selection has been carefully considered for sections that cross rail, road, water, pipelines and electrical lines" (EIA[4], Vol. 4, p. 2-24).

100 "Effect of the Denali Fault Rupture on the Trans-Alaska Pipeline," p. 9.

101 See: W. Kent Muhlbauer, Pipeline Risk Management Manual (Gulf Publishing Company, 1993), pp. 53-105.

102 Muhlbauer, pp. 79-82.

103 EIA(4), Vol. 4, p. 1-14 (for a summary description of Sakhalin soils, see also pages 1-14 through 1-23). Podzolic soils are often severely leached and highly acid (The Columbia Encyclopedia, Sixth Ed., 2001).

104 EIA(3), Ch. 3, p. 3-19.

105 SEIC, Technical Design Specifications (TDS) for Integrated Corrosion Protection of Onshore and Offshore Pipelines, Sakhalin II Project (Doc. No. 10000-S-990-01-S-1505-00-01), 2002, p. 16.

106 Memo from Larry Carpenter (TAPS community liaison), Sept. 23, 1975 (author's files).

107 U.S./Alaska Joint Pipeline Office, "TAPS Corrosion History Report," June 22, 2000 (Report No. JPO-00-E-021, attached to memo from Robert Krenzelok to Jim Lusher), p. 1. In 1991, Alyeska estimated that it would spend approximately $800 million on corrosion repairs through 1993 (Alyeska Pipeline Service Co., Alyeska Reports, Summer 1991, p. 5); in 1997, corrosion repairs were running at an estimated $40 to $60 million annually (Alyeska Pipeline Service Co., Trans Alaska Pipeline System Briefing Document, Oct. 23, 1997, p. 10).

(c) The ability of corrosion to significantly reduce pipe wall thickness is indicated by the fact that in 2001 there were: [1] at least eight locations on TAPS where corrosion had eaten through more than 40 per cent of the pipeline wall; [2] 30 locations within three inches of a mainline girth weld where pipeline wall loss at specific corrosion pockets ranged between 30% and 39%; and [3] approximately 10 locations per year where anti-corrosion teams were digging up the pipeline to assess and repair corrosion damage to buried mainline pipe.[108]

(d) Buried pipelines are significantly more susceptible to corrosion than above ground lines.[109]

9. The presence of conditions conducive to corrosion cited above – such moist soils, acidic soils and metal in the ground – indicate the importance of careful review of (a) SEIC decisions for the on the Sakhalin-II pipeline route regarding pipe wall thickness[110] and (b) SEIC's pipe coating, anti-corrosion and corrosion inspection plan.

E. Pipeline Control Systems

1. EIA(4) acknowledges that the principal technical parameters influencing the magnitude of a spill include control system elements such as leak detection system performance, pump shutdown time and valves shut-off time after pump shutdown.[111]

2. SEIC's statements regarding its still undeveloped leak detection system capabilities have been inconsistent.

(a) According to EIA(4), "[w]hilst the design of the pipeline leak detection system has yet to be detailed, it will incorporate features such as "state of the art leak system, which is estimated to have leak detection rates of around 1% of flow in any section of the pipeline."[112]

(b) More recently, SEIC has stated that the specifications for the oil pipeline leak detection system requires that for steady state conditions, the minimum detectable leak rate is 0.5% of the flow rate at that time.[113]

(c) At expected throughput (195,000 bpd), the leak detection system could not detect any leak smaller than 975 bpd (133 tonnes).[114] If SEIC realizes its hopes to increase throughput to 400,000 bpd,[115] the minimum detectable leak would double.

3. The TAPS experience demonstrates that existing leak detection systems may allow leaks to continue undetected below the ground for extended periods of time.[116]

(a) The TAPS builders originally promised the United States Congress and the public that they would

108 U.S./Alaska Joint Pipeline Office, 2001 Maintenance CMP Report, pp. 17-20; "TAPS Corrosion History Report;" and "Trans-Alaska Pipeline System Corrosion Control and Monitoring," Nov. 2, 2000 (Report No. JPO-00-E-028, from Bob Krenzelok to Jim Lusher).

109 The vast majority of TAPS corrosion inspection and repair work has been performed on buried portions of TAPS.

110 EIA(4) mentions increased pipe wall thickness in populated areas and near highway and rail crossings but does not discuss pipe wall thickness in relation to seismic considerations.

111 EIA(4), Vol. 4, p. 3-46.

112 EIA(4), Vol. 1, p. C-7.

113 Barnes letter to Fineberg, Dec. 10, 2003. (Barnes does not specify how often, nor in what circumstances oil pipeline operations will depart from steady-state conditions.)

114 195,000 x 0.005 = 975.

115 EIA(4), Vol. 1, p. 5-7.

116 For example, when TAPS lost 5,000 barrels of oil over a several day period in the mountainous Atigun Pass region in the spring of 1979, the leak went two to four days without triggering an alarm at the pipeline operations control center (Alaska Pipeline Office report, August 20, 1979).

develop a leak detection system that would meet or exceed industry standards and would be able to detect small leaks immediately and shut down promptly.[117]

(b) In the late 1990's, pressure from the United States Congress and the public forced TAPS to develop an improved leak detection system capable of detecting line loss between 0.2% and 0.5% of throughput under steady flow conditions.[118]

(c) TAPS has experienced seven spills larger than 1,000 barrels; the pipeline's automatic leak detection system has never detected a leak.[119]

4. Although critical, leak detection is only one aspect of the many control systems essential to safe pipeline operations. SEIC's plan to bury the Sakhalin pipelines significantly increases the importance of assuring the careful design and integration of the pipeline control systems.

F. TAPS Construction Experience

1. Although the TAPS builders had several years to prepare for construction, field changes to construction plans resulted in confusion, delays and the necessity to go back and do the same job over again. According to historian Robert Douglas Mead, unexpected conditions encountered during the construction of TAPS played a critical role in these difficulties.

Building the Trans-Alaska Pipeline

1975: *In late March 1975 actual pipeline work could begin. . . . The place chosen was . . . about 70 miles north of Valdez. By April 1976, the first 1,400-foot string of pipe had been welded together, lowered into its ditch and angled below the stream bed, and covered over; and presently floated and had to be reset. It was a preview of . . . the trials that were to come. . . . when you opened the ground, that the soil was not what you expected or had predicted; another engineering euphemism. The practical effect was, repeatedly, the wrong equipment in the wrong place at the wrong time, crews of men (at a base rate of about $10 each per hour) drawing time while engineers and surveillance personnel argued out a design change.*

1976: *A.P. Rollins, the head federal monitor, commented: "We got forty-five days," he said, "before we really get cranked up for this summer's work, because once we get in the summer it's going to be the day-by-day field problems – we had 'em last summer and they called in every day and they've encountered something, well, they're going to have to make a field change. And then be ready, and people in the field, to answer the problems when we come up with a remoding situation: we get in there and we find that we've got frozen material that we didn't anticipate . . . or they encounter a condition that wasn't intended, so they've got to make a field change."*

Robert Douglas Mead, Journeys Down the Line: Building the Trans-Alaska Pipeline (New York: Doubleday, 1978), pp. 228-229, 283-284.

117 Alyeska Pipeline Service Co., "Alyeska lays detailed plans to combat leaks or pipeline spills," Alyeska Reports, October 1977, pp. 18-20.
118 See: U.S. Joint Pipeline Office, Evaluation of the Alyeska Pipeline Service Company's Operation of the Trans-Alaska Pipeline 1999/2000, April 2001, pp. 12-13.
119 U.S. General Accounting Office, Trans-Alaska Pipeline: Regulators Have Not Ensured That Government Requirements Are Being Met (report no. GAO/RCED-91-80), July 1991, p. 27.

2. The history of TAPS demonstrates the importance of establishing clear construction plans and standards before construction begins.

3. In view of the complexity of the regulatory framework in Russia (see Section II, above), it may be difficult for government monitors to assure the establishment and implementation of appropriate design and construction standard.

VIII. SUMMARY

The following conclusions and observations, based on the documentary record on the Sakhalin-II Phase 2 project presented in the preceding sections and comparison with TAPS, are limited to (a) the seismic hazards associated with the SEIC project and (b) the company's presentation of its plans for dealing with the problems associated with broad spectrum of seismic-related hazards.

1. Assessment of seismic hazards is characterized by a high degree of uncertainty.
2. Sakhalin is an island of recognized high seismicity.
3. The Sakhalin-II Phase 2 pipeline route lies entirely within areas whose seismic intensity rating is 8 or higher on the MSK-64 scale. (A level-8 earthquake, generally understood to be severe, might cause houses to shift on foundations, chimneys to twist and fall and ground water levels to change.)
4. Our review of SEIC data indicates than 25 percent of the pipeline route is to be buried in ground that bears a seismic intensity rating of 9 or higher on the MSK-64 scale. (A level-9 earthquake is liable to result in considerable damage to buildings and reservoirs, ground cracking and some underground pipes broken.)
5. The Sakhalin-II Phase 2 pipeline route will cross 22 identified active faults in buried mode, as well as 33 faults that SEIC apparently has classified as inactive.
6. Although seismic issues have been a primary concern of individuals and nongovernmental organizations, SEIC's presentation of information on these issues has frequently been fragmented, less than clear, internally contradictory, out of date, vague and lacking in clear links to the technical support or foundations for the company's approach to important questions.
7. The Trans-Alaska Pipeline System (TAPS) crosses three active faults. At the Denali Fault, the pipeline was placed above ground and engineered to handle displacement of at least 20 feet laterally and five feet vertically.
8. In contrast, TAPS engineers expect a normally buried pipeline to withstand ground displacement of two feet horizontally and two feet vertically without rupturing.
9. One reason that TAPS survived the November 2003 earthquake without leaking is that the above-ground fault crossing design enabled the pipeline to move as much as 18 feet laterally and five feet vertically during the quake.
10. We have been unable to locate substantive analytical supporting documentation for SEIC's assertion

that buried pipelines can be engineered and constructed in a manner that will effectively mitigate Sakhalin's high seismic risks.

IX. SEISMIC HAZARDS AND SEIC'S ONSHORE PIPELINES: UNANSWERED QUESTIONS

This report addresses an significant and straightforward question: What are the seismic risks associated with the proposed Sakhalin-II Phase 2 onshore pipelines? To the exact degree that these risks are serious, the following question takes on immediate importance: Has SEIC demonstrated that it can safely bury pipelines on Sakhalin?

Sections II, III and IV of this report describe the legal and regulatory framework in which this project is being conducted, the uncertain science of earthquakes and their effects and the seismicity of Sakhalin. As noted in Section V, the seismic challenges on the Sakhalin-II Phase 2 pipeline route are indeed formidable. Over much of the proposed pipeline route, the intense ground movement associated with an earthquake, or its associated phenomena – particularly landslides or mudslides – are liable to cause large and sudden ground movement or permanent ground deformation that could damage a pipeline, resulting in an oil spill with attendant environmental harm. It is not surprising, therefore, that some members of the public have expressed concern over the manner in which SEIC has assessed the seismic risks on Sakhalin and has made plans to mitigate them.

As documented in Section VI, SEIC has not responded to these concerns with a clear or convincing presentation of information on seismic issues affecting the Sakhalin-II onshore pipelines. In fact, SEIC's public information on this subject can be characterized as conflicting, confusing, incomplete and vague. Based on our review of SEIC's public communications on this important subject, we conclude that there is simply no way to put aside concerns about the long-term environmental risks posed by buried pipelines on this island, with its pronounced seismic volatility and boggy, acidic soils. It is difficult to reconcile SEIC's current assertions about the safety of the project with facts that support the findings and conclusions of this report.

One reason for questioning SEIC's proposals arises from comparison with Alaska's experience with the Trans-Alaska Pipeline System (TAPS), discussed in Section VII. How is it that the same considerations that led engineers on that project to elevate that pipeline when crossing active faults do not obtain on Sakhalin? When it is generally agreed in the pipeline industry that TAPS proved the effectiveness of its above-ground design for fault crossings during the Denali Fault earthquake of November, 2002, what specific factors lead SEIC's engineers and planners to believe that they can safely cross 22 active faults with buried pipelines?

Review of the operating history of TAPS suggests that in the case of buried pipelines it is especially important to ensure that pipeline components not normally associated with earthquakes, such as control systems and corrosion prevention and detection systems, are designed and implemented to the highest standards.

Consider, for example, this scenario: Could an ongoing oil spill below the leak detection system alarm threshold result from earthquake-related phenomena that put the pipeline under stress at a location – perhaps not on an identified, active fault – where corrosion had significantly weakened the wall of the proposed pipeline?

In discussions about the Sakhalin-II Phase 2 project on Sakhalin last November, SEIC officials expressed their interest in resolving public concerns about the risks associated with buried onshore pipelines. The issues raised in this report suggest that public seismic concerns have not been addressed. The mass of technical literature used internally by SEIC may be appropriate for a large corporate entity engaged in a sizable project, but the information those documents contain is effectively inaccessible to most concerned citizens. It has been our privilege – with SEIC's cooperation – to go further into this record than most. In doing so, we have been unable to locate a document or set of documents that present a comprehensive picture of SEIC's assessment of seismic hazards on Sakhalin or the relative risks those hazards pose to buried or above-ground pipelines. More troubling, perhaps, are the inconsistencies and unanswered questions enumerated in this report.

In order to ensure that SEIC's onshore pipelines will be provide maximum feasible protection from seismic risks, SEIC must address the seismic issues discussed in this report. We commend SEIC for its recent addition of seismic concerns to the the issues the company intends to address in its addendum to EIA(4), planned for release in March 2004. However, in view of the project's tight schedule, the shortcomings in SEIC's previous presentations and the difficulties we have encountered obtaining clear and comprehensive information on seismic issues, we are not confident that SEIC's belated promise to discuss the subject again in its addendum to EIA(4) will fulfill the imperative need for timely and usable public information regarding seismic concerns. We therefore propose the following:

1. To meet its commitment to addressing public concerns, SEIC should craft a summary report that provides clear and unequivocal answers to the questions raised by this report regarding the safety of burying pipelines on Sakhalin, with a detailed presentation of the reasons that SEIC believes the seismicity of Sakhalin does not require above-ground construction.
2. SEIC's report should be one that can successfully be used by the average citizen to locate the documents necessary to evaluate the relevant engineering inputs and design considerations.
3. Since we have been unable to obtain the inputs and assumptions SEIC has used to determine seismic risks, we urge SEIC to include site-specific data reflecting a current assessment of seismic hazards on the island and the kinds and degrees of risk posed by these conditions. This document, too, should present a transparent picture that outside evaluators can use to understand the processes by which SEIC has arrived at its decision to bury the Sakhalin-II Phase 2 onshore pipelines.
4. SEIC's report should discuss the seismic design and operating experience of the TAPS. In addition to seismic design and construction, the history of TAPS also makes clear the importance of ancillary features such as pipeline control systems and the corrosion prevention, monitoring and remediation programs. Because underground problems can go undetected for extended periods, the report should con-

sider systems such as these to ensure that they are designed and can be operated to effectively minimize the broad spectrum of seismic risks.

5. In light of the complexity of the problems associated with seismic risk and the necessity for objectivity, we recommend that SEIC establish an independent review panel that includes expert earth scientists not associated with the oil industry, pipeline experts and representatives of interested NGOs, and that the NGO representatives be allowed to name at least 25% of the expert membership.

6. SEIC's assessment of seismic hazards directly affects plans for the imminent construction of the Sakhalin-II Phase 2 onshore pipelines. Therefore, the SEIC report and the subsequent expert review should be completed and made available to interested parties as soon as practicable. In the interim, we believe that construction plans should be put on hold until the review is complete and public concerns about the seismic risks to the proposed Sakhalin-II Phase 2 onshore pipelines are satisfactorily addressed.

Appendix A - Letter of December 10, 2003 from Julian Barnes, SEIC

SAKHALIN ENERGY INVESTMENT COMPANY LTD.

[illegible]

[illegible]

10 December 2003

Ref. # 08-898

Richard Fineberg
PO Box 416
Ester, Alaska
United States 99725

Dear Mr Fineberg

Further to your recent letter please find attached responses to the outstanding questions from your letter.

1. Already addressed.

2. **Does the TEOC contain *site-specific* risk analyses performed to assess the possible effects of earthquakes on on-shore facilities, including the planned oil and gas pipelines at specific locations in the planned pipeline corridor?**

Sakhalin Energy have undertaken a risk analysis for all facilities to be constructed.

The platforms and offshore structures are all designed to meet the ISO International code. All offshore structures have been designed to withstand a "Ductility Level Earthquake" which is the highest design category.

The onshore plants have been designed in accordance with international standards and verified against existing Russian codes. All onshore facilities will be able to withstand an earthquake that would occur once in every 1000 years, some critical facilities have been designed for even more rare events.

Specifically for the onshore pipelines, the risk analysis is contained within Book 9 of Volume 3 of the TEOC. It only considers risks to people in accordance with Russian requirements.

The Risk Analysis (which was prepared by the specialized Russian Institute TAU) does indeed consider the effects of seismic activity on the pipeline in line with the design basis return frequency for onshore pipelines of 200 years for Strength Level and 1000 years for ductility level events.

For the analysis the oil and gas pipelines were each divided into 44 sections. Each section was selected to capture the significant risk features along the pipeline route including where the pipeline crosses active faults. Furthermore, each set of faults constitutes a specific section considered within the Analysis (refer to Tables 6.3 & 6.4 in TEOC Volume 3, Book 9).

In order to accurately identify their location surveys have been undertaken to map all active faults crossed along the proposed route of the Sakhalin II Onshore Pipelines by the Russian Institute Rosstroiiskaniya (RSIS) during 1999. (Active faults are defined as those which have displaced the surface of the ground within the last 10,000 years.)

This fault identification process included classification of fault slip type and estimated slip displacements and reoccurrence intervals. The RSIS data was reviewed and validated by EQE International during 2000.

The data was used to propose the optimum crossing designs for the oil and gas pipelines that will provide "sufficient fault displacement capacity" for the pipelines to withstand rupture in the event of fault movement.

The RSIS / EQE work identified 41 crossings of faults from the original table-top routing plan for the pipelines. Indeed many of the faults were crossed in several places. A series of pipeline re-routes were then engineered to avoid as many of the crossings as possible. This resulted in a remaining 24 crossings to be evaluated in more detail.

Additional re-routing studies in 2001 and 2002 removed a further three crossings, leaving a total number of fault crossings of 21. An additional major re-route in 2001, the Northern Nysh Bypass, introduced one new fault crossing at Imchinsky that post dates the original survey work. This will be evaluated in a similar way during detailed design. The total fault crossings are now 22 as shown in Table 1.

Table 1 below lists the current fault crossings for the onshore pipelines:

Count	Crossing ID (Nyman)	Fault	KP (approx Old System)	Crossing Angle (°)	Pipeline
1	34	Piltun	19.28	+86	20" Oil / 20" Gas
2	33	Piltun	19.69	+81	20" Oil / 20" Gas
3	N/A	Imchinsky	142.0	TBA	20" Oil / 20" Gas
4	32	Central Sakhalin	154.0	+38	24" Oil / 48" Gas
5	31	Central Sakhalin	169.9	-65	24" Oil / 48" Gas
6	30	Central Sakhalin	192.3	<35	24" Oil / 48" Gas
7	29	Pobedino	196.7	-72	24" Oil / 48" Gas
8	28	Pobedino	199.5	-22	24" Oil / 48" Gas
9	27	Pobedino	200.8	<10	24" Oil / 48" Gas
10	25	Central Sakhalin	207.4	-30	24" Oil / 48" Gas
11	23	Central	282.4	+25	24" Oil / 48"

OS F101 (2000). This approach is similar to that taken by the BTC Pipeline currently being constructed by BP and others. Further details can be found at www.azer.com/aiweb/categories/magazines/ai112_folders/112_articles/112_btc.html).

3. Can you provide a course syllabus and sample course materials (such as training manuals and information brochures) for the current oil spill response program covering Phase 1 operations and Phase 2 construction? By what means does SEIC plan to verify participation in oil spill training and response exercises?

Please find attached course outline for Phase 1 oil spill response training. Phase 2 materials will be available shortly.

4. Can you tell me where to find specific information on petroleum flow control systems, including (a) valve type and closure times, (b) whether valves can be closed simultaneously or must be closed in sequence to avoid overpressuring of the pipe and (c) additional information on the SCADA system and leak detection systems planned for the oil pipeline

(a) The valves that will be installed as part of the onshore pipeline systems are ball valves manufactured in accordance with API 6D (American Petroleum Institute- the internationally recognized manufacturing standard for pipeline valves).

The valve closure times have been calculated using hydraulic surge analysis such that the closure of the valves does not cause pressure waves along the pipeline. This closure time has been determined as one second per inch diameter giving a closure time for a 24" oil block valve of 24 seconds and 48 seconds for a 48" gas block valve. Closure time is the time taken for the valve to travel from the full open to the fully closed following the signal to close being initiated.

Valve closure is an operator-initiated event. The operator will be alerted to an event via the pipeline operation and management system (POMS) which allows the operator to select individual or groups of valves for closure and transmits the signal to close via the Supervisory Control & Data Acquisition (SCADA) system to the selected valve sites. The valve actuators are specified to provide the necessary torque and speed of closure to ensure that no hydraulic surges outside the operating envelope of the pipeline are possible. Typically the pumps or compressors at the production installations would be shut down before the pipeline valves are closed in order to prevent trips following pipeline shut down.

There is no intention to install check valves at river crossings. The oil block valves have been sited as far as possible to minimize the loss of fluid in the event of a leak at the low point of the pipeline, i.e. where it crosses a sensitive water body.

It should be noted that the block valves will only be effective in the event of a leak in the pipeline within the area protected by that valve and the valves at river crossings are required to be installed under Russian Specifications to minimize leakage from pipelines at river crossing locations.

Statistically the majority of leakage from pipelines is due to third party interference and is most prevalent near areas of habitation where, for example, pipelines are damaged during excavation for other utilities, road works and the like.

		Sakhalin			Gas
12	22	Makarovsky	326.1	+57	24" Oil / 48" Gas
13	21	Makarovsky	330.6	+58	24" Oil / 48" Gas
14	19A	Makarovsky	334.8	+72	24" Oil / 48" Gas
15	18	Makarovsky	335.0	+54	24" Oil / 48" Gas
16	17	Zagrobka Creek	367.9	+95	24" Oil / 48" Gas
17	13	Aprelovsky	520.6	+44	24" Oil / 48" Gas
18	5	Aprelovsky	550.0	<15	24" Oil / 48" Gas
19	4	Aprelovsky	550.7	+34	24" Oil / 48" Gas
20	3	Aprelovsky	551.8	-62	24" Oil / 48" Gas
21	2	Aprelovsky	552.0	-42	24" Oil / 48" Gas
22	1	Aprelovsky	552.3	-42	24" Oil / 48" Gas

The Seismic Design Premise for Sakhalin Pipeline, authored by D.J. Nyman & D.G. Honegger, February 2001, provides the criteria for implementation of seismic design to be used by the design contractor.

It addresses the major seismic hazards that can affect the pipelines including fault movement, liquefaction, landslides, seismic wave propagation and ground shaking. The basis of the document with regard to fault crossing design is that pipelines are designed to accept comparatively large strains in the case of permanent ground deformation (PGD). The basis of the design is that in the case of large PDG the strain levels in the pipeline will be above yield but below the levels typically associated with rupture. This strain based approach is consistent with engineering practice worldwide for similar pipeline projects. (Additional background to this approach can be found on the website for the Multidisciplinary Centre for Earthquake Engineering Research: http://mceer.buffalo.edu/default.asp)

Survey work, currently ongoing, again by RSIS, will identify the exact point on the pipeline route where the faults are crossed and finalisation of the seismic micro zoning to confirm the parameters of the 200 and 1000 year return seismic events.

This data will be utilized in detailed design to produce site-specific designs and mitigation for the onshore pipelines. For fault crossings, the specific designs will include replacement of the trench backfill with specially engineered non freezing materials to allow ground movements to be transferred around the pipelines in line with the selected strain criteria for critical tensile deformations (bending) and compressive failure / wrinkling which are based on the calculation methodology and limits contained in DnV

While check valves can be effective in preventing back flow, again they are only useful if a leak is downstream (in pipeline flow terms) of the valve, where the check valve prevents backflow of oil towards the leak. There are no regulatory requirements that require the installation of check valves in addition to block valves in pipeline systems.

In addition to the Leak Detection System (LDS), the pipeline route will be monitored during operation by land based patrols and regular overflights by fixed and / or rotary wing aircraft. The patrols and overflights will be able to observe any potential leakage not identified by the LDS.

Regular monitoring of the pipeline cathodic protection system and intelligent internal inspection in line with the pipeline operation and maintenance philosophy will also ensure that the pipelines are safeguarded from internal and external corrosion. Specific inspections will be made at areas of high risk (faults, landslides) in addition to the environmental monitoring measures identified in TEOC Volume 3 Book 6.

(b) As noted above, valve closure is an operator –initiated event. The operator will be alerted to an event via POMS which allows the operator to select individual or groups of valves for closure and transmits the signal to close via the SCADA system to the selected valve sites. The valve actuators are specified to provide the necessary torque and speed of closure to ensure that no hydraulic surges outside the operating envelope of the pipeline are possible. Typically the pumps or compressors at the production installations would be shut down before the pipeline valves are closed in order to prevent trips following the pipeline shutdown. The SCADA system has been designed to close either a single or a group of valves at the same time. Sakhalin Energy has configured these valves around river crossings and fault zones to close complete sections of the pipeline at the same time.

(c) The LDS is currently being designed by ATMOS International. The LDS functional requirements are detailed in the "Leak Detection System:User Requirements specification"

The specification provided to ATMOS includes parameters consistent with those detailed in API 1155 Performance standards for pipeline models as the base specification.

The performance requirements are detailed in the LDS specifications for sections of the oil and gas pipeline systems. Generally, for the oil pipelines, the specifications requires that for steady state conditions (i.e the pipeline is flowing at a constant rate) the minimum detectable leak rate is 0.5% of the flow rate at the time of leak. A leak of 5% (rate/time specification rather than overall sensitivity) of the flow must be detectable within 50 minutes of the leak occuring. Specific requirements for the gas pipeline are 1% (minimum detectable leak) and 5% flow in 60 minutes respectively. This has to be done with less than two false alarms per year. The mass balance system will display two levels of balance, a one hour balance and a 24 hour balance of the pipeline systems. The LDS will also use a statistical model of the pipelines to determine if there are any leaks on the pipeline.

It is noted that the two alarms are only allowed under transient conditions. It also sets the requirements for the leak location and volume of the leak. These specifications are the common industry ways to describe the performance of a LDS. Sakhalin Energy has specified the same levels of protection that other pipelines like Trans Alaska Pipeline System (TAPS) have used.

Detailed design of the LDS system has just commenced with the intention to fully model the pipeline systems, verify the performance, the predicted sensitivity of the model with performance curves and any equipment or operational changes that can improve the performance of the system.

The pipeline SCADA system will connect all pipeline facilities to a central control room located at the Onshore Processing Facility. Signals to and from the pipeline facilities will be transmitted via fibre optic cable that Sakhalin Energy is installing parallel to the pipelines. The fibre optic system has various features to ensure redundancy including separation and duplication of the repeater stations, armouring of the cable and additional security measures. Back-up monitoring and control facilities will be located in the LNG control room.

Please feel to contact Rachele Sheard should you have any further queries.

Yours sincerely

Julian Barnes
External Affairs Manager

Appendix B. Letter from Richard A. Fineberg (Research Associates) to Ms. Rachele Sheard (SEIC), Dec. 29, 2003

From the desk of Richard A. Fineberg P.O. Box 416 Ester, Alaska 99725 Phone /Fax: (907) 479-7778 E-mail: fineberg@alaska.net

December 29, 2003

Ms. Rachele Sheard
Head of Issues and Stakeholder Management
Sakhalin Energy Investment Company LTD. (SEIC)
35, Dzerzhinskogo Str.
Yuzhno-Sakhalinsk, 693020, Russia

Dear Ms. Sheard:

Questions Regarding SEIC Seismic Risk Assessment and Mitigation Measures

Thank you for the information you and Sakhalin Energy Investment Company (SEIC) have provided to date regarding the on-shore pipeline portion of Phase 2 of the Sakhalin-II project. This letter requests additional information regarding the seismic risks associated with buried pipelines on Sakhalin Island.

Despite our mutual best efforts, I am unable to find answers to significant questions concerning the manner in which SEIC has assessed and intends to address seismic risks. With project construction plans proceeding at a rapid pace, there is a little time between completion of engineering design and the initiation of field construction. Therefore, to expedite your clarification of the record I have formulated a set of questions designed to obtain the best possible information regarding SEIC's approach to seismic hazards.

These questions are based on observation and interviews during my November 2003 visit to the pipeline right-of-way, information SEIC provided subsequent to my meeting with you and James Robinson in Yuzhno-Sakhalinsk November 4 and my follow-up letter of November 9 and discussions with various parties, including seismic research experts, engineers on the Trans-Alaska Pipeline System (TAPS) and others with specialized knowledge. These questions focus on the following documents: SEIC's Technical Economic Substantiation of Construction submissions (TEO-C), the third revision to SEIC's Environmental Impact Assessment, completed in 2002 as part of the TEO-C (identified here as EIA[3]) and the fourth Environmental Impact Assessment (identified here as EIA[4]).[1]

The questions posed here cover the following seismic-related subjects: (1) missing fault crossing and seismic zone information; (2) reported ground movement on Sakhalin; (3) definition of active and inactive faults; (4) identification of fault crossings; (5) determination of zones of seismic risk on Sakhalin; (6) SEIC's seismic design premise; (7) SEIC's risk analysis of pipeline seismic hazards; and (8) implementation of construction standards and practices for earthquake hazard mitigation. In view of the importance of seismic issues and SEIC's compressed schedule, I hope you will respond quickly. To facilitate your response, I have provided references to the documents on which these questions are based.

I. Missing Fault Crossing and Seismic Zone Information

According to SEIC's 2003 ESHIA *Environmental Impact Assessment* (EIA[4]), "[t]here are 24 locations where the pipeline crosses seismic faults, as shown in Table 1.2. These are also shown in Figure 1.10 along with the seismic zones of Sakhalin Island." While Table 1.2 of this document does include a list of 24 fault crossings

1 Sakhalin Energy Investment Company's two Environmental Impact Assessments are: Technical and Economic Substantiation of Construction, Environmental Impact Assessment, Vol. 7, Book 1, July 2002 (EIA[3]); and Environmental Impact Assessment (SEIC phase II Development), Vols. 1 through 7, 2003 (EIA[4]). According to SEIC, EIA(4), released in early 2003 and available on-line, is the company's fourth revision of its EIA "but is the only EIA that has been carried out to international best practice standards" (EIA[4], Vol. 1, p. 1-9).

by kilometer post, Figure 1-10 shows neither fault crossings nor seismic zones.[2]

1. Does EIA(4) contain a map that shows fault crossed by the Sakhalin-II Phase 2 onshore pipelines?

In SEIC's predecessor EIA, submitted to Russian authorities as part of its formal Technical Economic Substantiation of Construction (TEO-C) in 2002, Figure 1-29 is captioned "Seismic Zoning and Fault Crossings Along the Pipeline Route." Contrary to its title, however, the English EIA(3) CD shows only broad seismic zones but does not show either the pipeline route or fault locations.[3]

2. Does the English-language EIA(3) contain a map that shows the Sakhalin-II Phase 2 onshore pipeline route and fault crossings?

II. Reported Ground Movement at Faults

EIA(4) reports that for approximately three-quarters of the pipeline route (600 kilometers) the typical annual ranges of ground movement at faults exceed 67 mm horizontally and 15 mm vertically.[4] Several seismic experts who informally reviewed the EIA(4) text for this report commented that these were unusually large numbers.[5] However, they felt that neither EIA(4) nor the additional information they reviewed enabled them to understand the meaning or significance of these numbers.

1. Please provide SEIC's understanding and interpretation of these data, as well as the reviews or reports on which SEIC's interpretation is based.

EIA(4) also reports that North Sakhalin generally exhibits tectonic (plate) tilting resulting in regional subsidence of up to –5.0 mm yr along the eastern coast, while middle Sakhalin is generally stable north of Poronaysk; south of Poronaysk, vertical movement of –4.0 mm/yr is occurring, increasing to 7.2 mm yr near Yuzhno-Sakhalinsk.[6]

2. Please provide SEIC's understanding and interpretation of these data and the reviews or reports on which SEIC's interpretation is based.

III. Definition of Active and Inactive Faults

According to Mr. Julian Barnes' letter of December 10, 2003, SEIC's risk analysis of faults considered "all active faults crossed by the proposed route. . . . (Active faults are defined as those which have displaced the surface of the ground within the last 10,000 years.)"

According to the California Geological Survey, "[t]he investigation of sites for the possible hazard of surface fault rupture is a deceptively difficult geologic task. Many active faults are complex . . . . the evidence for identifying active fault traces is generally subtle or obscure and the distinction between recent active and long-inactive faults may be difficult to make. . . . . . . faults of known historic activity during the last 200 years, as a class, have a greater probability for future activity than faults classified as Holocene age (last 11,000 years), and a much greater probability of future activity than faults classified as Quaternary age (last 1.6 million years). However, it should be kept in mind that certain faults have recurrent activity measured in tens or hundreds of

2 Sakhalin Energy Investment Company, Environmental Impact Assessment (SEIC phase II Development), Vol. 4, 2003, pp. 1- 4, 1-5, 1-25 and 1-26.

3 Each of four CD copies of the English-language EIA(3), including a copy I received from SEIC in December 2003, were examined; on each disk, Figure 1-29 lacked the pipeline route and fault crossings. (Figure 1-29 of the Russian-language EIA[3] does show the pipeline route and fault crossings.)

4 EIA(4), Vol. 4, pp. 1-24 and 1-25. Specifically, EIA(4) reports the following typical fault movements in the northern 200 kilometers of the pipeline, "[h]orizontal, 88 mm yr1; vertical, 17 mm yr1 (since the Neftegorsk Earthquake, 1995)," while fault movement given for the southern 400 kilometers is "[h]orizontal, 67 mm yr1; vertical, 15 mm yr1." (The footnotes referenced in the text of EIA[4] could not be found.)

5 Over a 100-year period, this average movement at faults would equate to movement of 6.7 meters horizontally and 1.5 meters of vertically – far greater movement than that typically exhibited by large earthquakes.

6 EIA(4), Vol. 4, p. 1-25. (Again, the data contain a footnote "1," but the footnote information could not be found.)

years whereas other faults may be inactive for thousands of years before being reactivated."[7] Large earthquakes can and do occur on faults classified inactive. For example in October 1999, a major earthquake at Hector in California's Mojave Desert created a 40-meter-long surface rupture with as much as five meters of slip on a fault that had not broken in at least 5,000 years and was classified as inactive.[8] According to a veteran seismic engineer, in 1994 a major earthquake struck Northridge, California "on a blind thrust fault that had not been identified as a potential seismic source," producing ground motions that were about 50% stronger than expected and causing economic losses estimated at about $30 billion. One year later, the Kobe (Japan) earthquake, which killed 6,000 people, "occurred on a relatively inactive fault in a region that conventional wisdom (and governmental policy) had grown to regard as "being of low seismic risk."[9] From the foregoing, it appears that although an inactive fault can be defined as one that has not moved in 10,000 years, some analysts and authorities require a significantly longer period of inactivity to consider a fault inactive.[10]

1. Please provide any analyses that SEIC has performed to assure that the definition of active and inactive faults SEIC is using is compatible with the complex geological conditions on Sakhalin.
2. Please provide an explanation of the methodology SEIC has used to calculate risk to the pipelines from permanent ground deformation, including liquefaction, landslides, mud flows and avalanches at (a) faults classified as active (b) faults classified as inactive and (c) elsewhere on the pipeline route.

IV. Identification of Fault Crossings

Mr. Barnes' letter of December 10, 2003 identifies 22 fault crossings on the pipeline route identified as "active," based on the 1999 work of the Russian Institute Rosstroiizyskaniya (RSIS), validated in 2000 by EQE International.[11] SEIC's 2002 Map of Geotechnical Zoning, Including An Assessment of Geological and Geotechnical Hazards indicates at least 33 additional fault crossings on the SEIC pipeline route.[12]

1. Please explain the differences between (a) faults intersecting the pipeline route presented in the Figure 1-29 of EIA(3) and the updated list in Mr. Barnes' letter of December 10, 2003 and (b) the Map of Geotechnical Zoning and Hazards, which indicates that the pipeline route intersects approximately 33 additional fault crossings.
2. Please indicate whether the Map of Geotechnical Zoning and Hazards was: (a) used in establishing the criteria for construction standards for pipeline route fault crossings; (b) used in determining the application of those standards to the pipeline route; and/or (c) submitted as part of the TEO-C.

7 California Geological Survey, Guidelines of Evaluating the Hazard of Surface Fault Rupture (Note 49) 2002 (http://www.consrv.ca.gov/CGS/information/publications/cgs_notes/note_49/note_49.pdf).

8 See: "Hector Mine, 1999" at http://www.goldenstatemuseaum.org/gehector.htm and seminar materials of Dr. Thomas Rockwell, Department of Geological Sciences, San Diego State University (http://www.geology.sdsu.edu/activities/seminar/fall99/rockwell/text.html).

9 Paul G. Somerville, "Implications of the Northridge and Kobe Earthquakes for the National Earthquake Hazard Reduction Program," September/October 1997 (opinion; Seismological Society of America; at http://www.seismosoc.org/publications/SRL/SRL_68/srl_68-5_op.html).

10 While many seismic specialists regard 10,000 years as an appropriate period to define inactivity, the Nevada's earthquake safety council identifies an inactive fault as one that has not moved in 1,600,000 years (Nevada Earthquake Safety Council, Guidelines for Evaluating Potential Surface Fault Rupture/Land Subsidence Hazards in Nevada [http://www.nbmg.unr.edu/nesc/guidelines.htm]).

11 According to Mr. Barnes, re-routing studies in 2001 and 2002 removed three fault crossings and introduced one new fault crossing at Imchinsky, reducing the total active fault crossings from 24 to 22.

12 SEIC, Map of Geotechnical Zoning, Including An Assessment of Geological and Geotechnical Hazards (Environmental Centre IFPA, Moscow, 2002). The 33 additional fault crossing markings, with their approximately location by SEIC kilometer post ("KP") and map sheet number ("sh.") are: Garomaysky Fault (upthrust – shift), KP 39 (sh. 5); Tymsky Fault (thrust), KP 122.5 (Sh. 13); Zmeinogorsky Fault, KP 65.6 (sh. 30); Zmeinogorsky Fault (thrust), KP 67.9 (sh. 30); Zmeinogorsky Fault (thrust), KP 73.9 (sh. 31); Zmeinogorsky Fault (thrust), KP 74.8 (sh. 31); unnamed thrust fault, KP 102.5 (sh. 33); Novaya-Vostok Fault, KP 294.7 (sh. 53); unnamed fault, KP 339.9 (sh. 58); unnamed fault (upthrow), KP 341.1 (sh. 59); Zaradnotroskský Fault (upthrow), KP 349.1 (sh. 60); unnamed fault at Berzhny Cr., KP 371.43 (sh. 61); fault (shift), KP 374.5 (sh. 62); fault (shift), KP 379.4 (sh. 62); Central Sakhalin fault (fragment), KP 387.5 (sh. 63); unnamed fault, KP 431.0 (sh. 67); Arcentevsky Fault, KP 435.1 (sh. 67); Sezzro-Mylvsky Fault, KP 440.5 (sh. 67); fault, KP 441.2 (sh. 68); unnamed fault, KP 460.8 (sh. 69); Pokrovsky Overthrust, KP 466.4 (sh. 70); Pokrovsky Overthrust, KP 467.6 (sh. 70); Kyrzhnensky fault, KP 478.9 (sh. 71); Pokrovsky Overthrust, KP 483.0 (sh. 71); Pokrovsky Overthrust, KP 485.7 (sh. 72); Pokrovsky Overthrust, KP 486.0 (sh. 72); Pokrovsky Overthrust, KP 492.0 (sh. 72); Pokrovsky Overthrust, KP 497.0 (sh. 73); Pokrovsky Overthrust, KP 503.0 (sh. 73); Pokrovsky Overthrust, KP 509.0 (sh. 74); Zapadnokhrutschevsky Fault, KP 594 (sh. 83); Shugochny Fault, KP 595.6 (sh. 83); and Mereysky Fault, KP 596.8 (sh. 83). (This list excludes all ambiguous markings possibly associated with faulting, as well as the Aprolovsky fault crossings at KP 539.4 [sh. 77] and 543.2 [sh. 78], which appear to be the two faults avoided by the re-routes Mr. Barnes mentioned.)

V. Determination of Zones of Seismic Risk on Sakhalin

EIA(3) states that the pipeline route crosses "territories with a seismic intensity equal to:

7-8 (repeated every 100 years);

8-9 (repeated every 500-1000 years);

10 (repeated every 5000 years)."

Additionally, this section of EIA(3) states that "Figure 1-29 illustrates the seismic zoning within Sakhalin Island."

However, EIA(3) Figure 1-29 displays a zoning scheme different from that of the text of EIA(3) quoted above (Figure 1-29 does not show any areas on Sakhalin with a seismic intensity of 10; average occurrence intervals shown on Figure I-29 are for 100, 1000 and 10000 years).[13]

1. Please explain why the seismicity ratings in EIA(3) differ from those in Figure 1-29 of that document.
2. Please provide the source documents that explain the bases for the seismic zoning depicted in EIA(3) Figure 1-29.

According to EIA(4), "[s]ince the Neftegorsk earthquake in 1995 the seismicity rating of much of the route has been raised from the occurrence of one magnitude 6 to 7 event every one thousand years to one magnitude 8 to 9 event every one thousand years."[14]

3. Please explain why the seismicity ratings in EIA(3), as submitted in 2002, differ from those of EIA(4), released less than one year later.

The severity of an earthquake can be expressed in terms of both magnitude and intensity. These two terms, frequently confused, have different meanings and therefore should be distinguished.[15]

и 4. Please clarify whether the raised seismicity rating in EIA(4) refers to an intensity scale (such as the MSK-64 scale used in other SEIC documents), or to a magnitude rating (as indicated).

In discussing fault movement risk, EIA(4) describes the pipeline segment along the coast in the vicinity of Makarov as "favorable."[16] However, in this 126-km segment, the pipeline route leaves the coast and goes inland, crossing a series of active faults and traversing steep valleys to thread its way through hills prone to landslides, mudslides and avalanches, where earthquake intensity is occasionally raised.[17] This segment of the pipeline is

crossed by five of the 22 faults SEIC identifies as active;

the only pipeline segment threatened by landslides, mudslides and avalanches;

contains two of the seven planned sites for seismometer installation to provide instant identification of local ground movement;

described by the TEO-C as the "most complex" part of the route due to the mountainous terrain.[18]

5. Please explain and document the basis for describing the geology in this pipeline segment as "favorable."
6. Please reconcile the description of this segment as geologically "favorable" in EIA(4) to the description of potential geologic and tectonic hazards listed above.

The seismic zoning in the Russian-language EIA(3) Figure 1-29 indicates that approximately 100 kilometers of the pipeline traverses areas in which an earthquake of an intensity of 9 on the MSK-64 scale is possible; according to this chart, the remaining 700 kilometers of the pipeline are located in areas where the largest earthquake

13 EIA(3), Chapter 1, p. 1-54 and Figure 1-29.
14 EIA(4), Vol. 4, p. 1-25.
15 "Magnitude" is a measurement of the energy released by an earthquake at its hypocenter within the earth; "intensity" describes the perceived effects of an earthquake. Unlike magnitude, intensity may differ from location to location. See: U.S. Geological Survey, "The Severity of an Earthquake," p. 2 (U.S. Government Printing Office: 2000-(575-347); and Charles Scawthorn, "Earthquakes: Seismogenesis, Measurement, and Distribution," p. 4-8 (chapter 4 in Wai-Fah Chen and Charles Scawthorn [eds.], Earthquake Engineering Handbook [Boca Raton: CRC Press, 2003]).
16 EIA(4), p. 2-21.
17 See: Map of Geotechnical Zoning and Hazards, sheets 56-61.
18 EIA(4), pp. 1-17 (Table 1.2), p. 2-22 (Table 2.14); TEO-C, Vol. 3, Book 8, Part 2.1 , Sec. 4.3.2.1, p. 4-108 ("Evaluation of Seismic and Tectonic Danger") and Vol. 3, Book 9, Sec. 3.3.2, Item 1, p. 3-11 ("Earthquakes, Landslide and Karstic phenomena").

would register 8 on this scale. But the more detailed mapping shown in SEIC's Map of Geotechnical Zoning and Hazards, referenced above, shows significantly a significantly higher earthquake intensity rating at many places on the pipeline route. For example, analysis of the Map of Geotechnical Zoning and Hazards reveals:

approximately 50 kilometers (more than 6% of the pipeline route) in the zone rated at "9" actually appears to be at risk of an earthquake with intensity rated at "10" on the MSK-64 scale;[19]

the seismic intensity rating for approximately 55 kilometers (an additional 6% of the pipeline route) shown in the "8" zones of the pipeline route has actually been increased to "9;"[20]

the "9(2)" zone shown in Figure I-29 extends further southeast than shown in Figure 1-29, covering sections of the pipeline as far south as four kilometers north of the town of Argi-Pagi.[21]

6. Please indicate whether the SEIC intends to construct the Sakhalin-II Phase 2 pipelines to withstand the seismic risks indicated by the Map of Geotechnical Zoning and Hazards or those indicated by EIA(3) Figure 1-29.
7. If SEIC has evaluated what changes in construction specifications (if any) would be necessary to provide protection against a major earthquake in the portions of the pipeline route where the Map of Geotechnical Zoning and Hazards indicates a seismic rating of 10, please provide that discussion, as well as sources of information SEIC regards as relevant.

VI. SEIC's Seismic Design Premise

According to Mr. Barnes' letter of December 10, 2003, the seismic design premise for the Sakhalin-II pipelines by D.J. Nyman & D.G. Honegger (February 2001) provides criteria for fault crossing for implementation by the project's design contractor. Also according to that letter, the design premise addresses "the major seismic hazards that can affect pipelines including fault movement, liquefaction, landslides, seismic wave propagation and ground shaking. The basis of the document with regard to fault crossing design is that pipelines are designed to accept comparatively large strains in the case of permanent ground deformation (PGD)."

1. Please provide all reports Nyman and/or Honegger prepared for SEIC.[22]
2. Please identify and provide the field studies, reports on Sakhalin geotechnical hazards and fault listings on which Nyman and Honegger relied to determine the design premises for the Sakhalin-II pipelines.
3. Please identify and provide theoretical calculations and/or reports on physical tests employed to verify the appropriateness of the SEIC seismic design premise.

Mr. Barnes also states that specific construction criteria and techniques are similar to those used on the Baku-Tbilisi-Ceyhan Pipeline, presently under construction in Azerbaijan, Georgia and Turkey. According to a BTC publication, DJ Nyman & Associates has also been retained on the BTC project to design and evaluate fault crossings.[23]

5. Please identify the construction criteria and techniques used on the BTC project that will be applied to the Sakhalin-II project.
6. Please provide any reports or field tests on which SEIC has relied to assure that geologic and construction criteria developed for BTC are appropriate to the site-specific conditions anticipated on the Sakhalin project.
7. Because DJ Nyman & Associates has been retained on the BTC project to design and evaluate fault crossings, please specify Mr. Nyman's involvement in preparation of any of the materials provided in response to questions VI.5. and VI.6., above.

19 In the Map of Geotechnical Zoning and Hazards, areas along the pipeline route with "seismic intensity increment (increased) by 1 point" over the general rating of 9(2) are indicated on sheets 1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12 and possibly 13, 14, 17 and 24.
20 In the Map of Geotechnical Zoning and Hazards, areas along the pipeline route with "seismic intensity increment (increased) by 1 point" over general area ratings of 8(2) or 8(3) are indicated on sheets 27, 28, 30, 31, 32, 36, 37, 40, 41, 44, 50, 51, 54, 55, 56, 68, 72, 73, 74, 75, 79, 80 and 83.
21 Map of Geotechnical Zoning and Hazards, sheets 23 and 25.
22 For example, TEO-C cites three reports by Nyman and Honegger at Vol. 3, Book 8, Part 2.1, Sec. 4.4.1, p. 117.
23 BTC, "Dealing with Earthquakes," in "Progress on the Baku-Tbilisi-Ceyhan Pipeline Project," June 2003 (on-line at http://www.azer.com/aiweb/categories/magazine/ai112_folder/112_articles/112_btc.html).

For additional background regarding the seismic design premises for Sakhalin-II pipelines, Mr. Barnes directed me to the web site for the Multidisciplinary Center for Earthquake Engineering Research (MCEER).[24] That center conducts research on the vulnerability of pipelines to seismic effects and explores ways to deal with this problem. MCEER conducts research on seismic risks to pipelines and construction techniques to mitigate those risks. However, using the search tool provided by MCEER at its web site, I found no entries for Sakhalin.

9. If MCEER researchers have evaluated the SEIC design premises and planned construction techniques, please provide these documents.

10. If specific concepts or construction techniques developed or analyzed by MCEER being applied on Sakhalin-II project, please provide that information, as well as the reports or field tests on which SEIC has relied to assure the applicability of those concepts construction techniques to site-specific conditions anticipated on the Sakhalin-II pipeline route.

VII. SEIC's Risk Analysis of Pipeline Seismic Hazards

SEIC's pipeline risk analysis "only considers risk to people in accordance with Russian requirements."[25] But the SEIC pipelines will pass through remote areas, where human population is relatively sparse and dispersed. Even in sparsely populated areas, an oil spill could cause significant environmental harm, as well as injury to salmon and other fish and wildlife, with serious consequences to the people who depend on these resources to feed their families, or for commercial livelihood.

1. How has SEIC assured that its seismic design and construction standards will mitigate earthquake risks to salmon, other fish and wildlife and their habitat?

In response to my November 9, 2003 request for detailed information regarding site-specific analyses of seismic risks, Mr. Barnes responded on December 10 that "each set of faults constitutes a specific section considered within the [SEIC risk] Analysis (refer to Tables 6.3 & 6.4 in TEO-C, Volume 3, Book 9)." These tables appear to summarize SEIC's analysis of the likelihood of line break resulting from all contingencies – risks that include not only earthquakes, but also factors having nothing to do with earthquakes, such as lightning, corrosion, damage caused by third parties. While aggregate analysis of all risks reported in the summary tables 6.3 and 6.4 contains useful information for response planning purposes, this information does not indicate how SEIC determined the site-specific seismic risks the SEIC pipelines will encounter, the strategies to mitigate those risks or measures of their effectiveness.

2. Please provide information on the data SEIC used to determined seismic risk and hazards, including but not limited to [a] description of the geological conditions, [b] geographic factors affecting these conditions, [c] quantitative assumptions summarizing these conditions and factors, [d] mitigating strategies and [e] assumed effectiveness of these strategies.

Sakhalin Environmental Watch has provided information from TEO-C regarding seismic conditions on Sakhalin and dangers to the proposed Sakhalin-II Phase 2 pipeline routes. This information does not appear to answer the questions raised here. Nevertheless, these sections provide more detailed information on subjects that include seismic characteristics of Sakhalin, evaluation of seismic factors, disjunctive tectonics, fault classifications, fault zoning according to frequency, neo-tectonics and fault crossing methods.[26]

3. Please provide an English-language copy of TEO-C, Vol. 3, Book 8, Part 2.1, Sections 4.2.2.3 through 4.4.5, along with relevant appendices and referenced documents.

24 On-line at: http://mceer.buffalo.edu/default.asp.
25 EIA(4), Vol. 4, p. 2-22; Barnes letter to R. Fineberg, Dec. 10, 2003, p. 1.
26 SEIC, TEO-C, Vol. 3, Book 8, Part 2.1, Sections 4.2.2.3 through 4.4.5.

VIII. Implementation of construction standards for earthquake hazard mitigation

In EIA(3), SEIC proposes that fault crossings "will be designed to accommodate the expected loads by choosing a certain trench configuration and specifying selected loose granular backfill around the pipelines."[27] This description differs from the more detailed description of fault crossings in the TEO-C itself, which indicates that 24 faults will be crossed as follows: 12 with standard trench with friable granulated backfill; 2 with standard trench and sand; 7 with widened trenches with flat slopes; 3 with widened trenches, flat slopes and geotextile facing.[28] A third description of planned fault crossings is presented in EIA(4), in which SEIC states plans to use sand at one seismic crossing and "foam with geotextile materials" at 23 other sites.[29]

1. Please provide information regarding the current plans for fault crossings, along with discussion of factors leading to these design decisions, including (but not limited to) any changes in SEIC's seismic risk assessment and/or seismic design premises.
2. Please indicate whether SEIC intends to apply special seismic construction techniques to fault crossings other than the list of 22 fault crossings identified as "active" in Mr. Barnes' letter of December 10, 2003.

According to EIA(3), "[t]he pipelines will have varying wall thickness based on safety classifications. In general pipe wall thickness is increased at river, road and railway crossings, near to settlements and facilities and at seismic fault crossings."[30]

3. Please indicate (a) the locations with thicker pipe, (b) the methodology by which those locations were (or will be) determined and (c) the locations at which pipe thickness varies from the thickness assumed in risk analysis calculations.

The pipeline route passes Yuzhno-Sakhalinsk at a distance between 0.45 and 4.5 km. In this 32-kilometer stretch, the route crosses five active faults. According to EIA(4), "steps must be taken to further reduce the risks to people within this area . . . this is to be carried out at the next stage of engineering design."[31]

4. Please indicate whether SEIC intends to apply special seismic construction techniques, including but not limited to thicker pipe, foam and geotextile block backfill, to the faults near Yuzhno-Sakhalinsk or other sites on the pipeline route.
5. Please indicate whether SEIC intends to apply special seismic construction techniques to sections of the pipeline near but not on a fault that may be subject to seismic effects, including liquefaction, mudflows, landslides avalanches in the event of an earthquake.

During construction of the Trans-Alaska Pipeline System (TAPS), field changes to approved plans were frequently necessary to deal with unexpected circumstances.[32] In light of the complexity of the geology on Sakhalin,[33] the Sakhalin-II onshore pipelines construction teams are liable to encounter unanticipated conditions that will require field modifications to design plans.

6. Please describe the process by which decisions on possible field changes to construction plans resulting from subsequent analysis or unexpected conditions encountered during construction will be made, validated, implemented and monitored.

While discussing the subject of seismic hazard mitigation I would like to offer two additional comments:

As you may recall, at our meeting in Yuzhno-Sakhalinsk, Mr. Robinson of SEIC expressed the opinion, based on his experience in Alaska, that the fault crossings on the Trans-Alaska Pipeline System (TAPS) were placed

27 EIA(3), Chapter 3, p. 3-43.
28 TEO-C, Vol. 3, Book 8, Part 2.1, Section 4.4.1, pp. 117-118.
29 EIA(4), Vol. 4, p. 2-22 (Table 1.13).
30 EIA(3), Chapter 3, p. 3-19.
31 EIA(4), Vol. 4, p. 2-25.
32 Robert Douglas Mead, Journeys Down the Line: Building the Trans-Alaska Pipeline (NY: Doubleday, 1978), pp. 228-229 and 283-284.
33 SEIC, "Design Concepts of Building or Structures in Regions with High Seismicity in Combination with Other Adverse Loads," May 2002 (DC 1000-S-90-01-S-1506-00), p. 10.

above ground due to permafrost – not seismic – considerations.[34] Review of relevant documents and discussion with seismic specialists on TAPS indicates that the three TAPS fault crossings were in fact built above ground in order to avoid potential damage to the pipe from seismic effects.[35]

It is not necessary to take a position on whether a pipeline should be buried or above ground to recognize that above ground mode would permit easier access, thereby improving operating control over of a range of functions that include leak detection and supervisory systems, valve operation and corrosion maintenance. Two reports from the November 3, 2002 earthquake on the Denali Fault in central Alaska will underscore this point: (1) After the quake, TAPS continued to operate for more than an hour instead of shutting down, raising significant questions about the emergency shutdown system. (2) After the quake, workers had to dig up a buried mainline valve near the fault to ensure that it had not been damaged and was not leaking.[36]

The conclusions one can draw from the Denali Fault earthquake can be debated. What is not in dispute is the fact that TAPS – above ground at the fault Denali Fault crossing – absorbed major impact from the November 2002 quake without a spill. In any event, in Alaska and on Sakhalin consideration of seismic issues clearly demonstrates the importance of establishing accurate factual bases for informed decisions. I believe the seismic issues raised by the questions in this letter are paramount to assuring the safety of the Sakhalin-II Phase 2 pipeline system. Therefore, in the interest of obtaining relevant information on seismic issues in a timely manner I will not discuss questions about other aspects of the pipeline portion of the project at this time.

In closing, I want to thank you for the information you and Mr. Barnes have provided to date. The materials I have reviewed have enabled me to gain a much better understanding of the Sakhalin-II Phase 2 project. At the same time, without clear, consistent and comprehensive summary information on important subjects such as the assessment and mitigation of seismic conditions, it is difficult to regard the manner in which SEIC is proceeding with confidence. For this reason, I look forward to your prompt response to these questions.

With best wishes for the New Year, I am

Sincerely,

Richard A. Fineberg

Cc:
Mr. Dmitry Lisitsyn, Sakhalin Environmental Watch
Mr. Vassily Spiridonov, WWF – Ru
Ms. Naomi Kanzen, Friends of the Earth Japan
Mr. David K. Gordon, Pacific Environment
Mr. Doug Norlen, Pacific Environment
Mr. Misha Jones

34 Approximately 420 miles (675 kilometers) of the 800-mile (1290-kilometer) pipeline was elevated to isolate the hot-oil pipeline from permafrost that might become unstable if thawed. At issue here is whether three fault crossings – totaling less than two kilometers – were elevated for the same reason, or due to seismic considerations.

35 See, for example, the TAPS design basis, which states that "[a]t the Denali Fault crossing, the pipeline is supported above the ground surface on beams in gravel berms in order to accommodate the anticipated large ground movements and to prevent excessive pipeline strains" (Alyeska Pipeline Service Company, Design Basis Update DB-180, June 18 2002 [4th ed., Rev. 2], p. 1-26).

36 Diana Campbell, "How oil pipeline officials handled the 'big one' of 2002," Fairbanks Daily News-Miner, Nov. 20, 2002, p. A1.

Appendix C. Letter from Julian Barnes (SEIC) to Richard A. Fineberg (Research Associates), Jan. 26, 2004 (with Research Associates comment)

Sakhalin Energy Investment Company LTD.
35 Dzerzhinskogo st., Yuzhno-Sakhalinsk, 693020 Russia
(Copmpany emlem and phone numbers deleted)

26 January 2004

Ref. # 08-08
Mr. Richard A. Fineberg
P.O. Box 416 Ester, Alaska 99725

Dear Mr Fineberg,

Thank you for your recent correspondence regarding the pipeline development. In March 2004 Sakhalin Energy will be releasing an addendum to its Environmental Impact Assessment which will address in further detail issues such as seismic design and pipeline crossings. In advance of this document being made publicly available we have addressed your questions contained in your letter. In connection with a number of points raised in your letter with respect seismic matters it should generally be assumed that EIA (4) is the lead document and supercede previous documentation on this subject.

I. Missing fault crossings and seismic zone information

1) A copy of the map has been attached in Appendix Two.
2) Please see map supplied above.

II. Reported ground movement faults

1) These general statements in the EIA are provided as background information. Sakhalin Energy has had specific reports commissioned by DJ Nyman where the important specific engineering numbers relevant to the faults being crossed are contained. Further information on this point will be available in the EIA Addendum.

2) Sakhalin Energy has used the regional movements as background information only; as such they have not played a principal role in the development of pipeline design with respect to seismic design. Other factors, such as the type of each fault crossed and the projected movements specific to each fault, have instead played a more critical role in the development of the pipeline design.

III. Definition of active and inactive faults

1) In development of the pipeline with respect to seismic conditions Sakhalin Energy has drawn heavily from local experts from the RSIS and in particular Dr Alexei Ivaschenko from the Institute of Marine Geology and Geophysics, who is a consultant to the RSIS. Dr Ivaschenko is a resident on the island and an expert in local geological and seismic conditions. This work formed part of the wider design work conducted by Sakhalin Energy, including the commissioning of DJ Nyman who has played a principal role in the design development for the pipelines.

2) All of the potential hazards listed here have been recognized and will be designed against in detail design phase of the pipeline. Briefly, liquefaction uses buoyancy control, for landslides and mudflows by optimized routing and stabilization measures and for avalanches via appropriate burial depth.

IV. Identification of fault crossings

1) The number of pipeline fault crossings is 22. The figure from EIA (3) has been superceded by subsequent re-routings. The original figure was 24 but this was reduced to by two fault crossings in 2002, and the Big Southern Nysh by-pass avoids an additional fault. The Imchinsky is new to the original list to due to its presence on a re-route leading to a total of 22. The activity of the Imchinsky fault is being investigated and may well prove to be inactive. A re-route to avoid fault #9 may reduce the total to 21. Please see Table of Fault Crossings, Appendix One and Maps Appendix Two.

2) The construction follows the design standards which meet international and Russian standards. The Map of Geotechnical Zoning and Hazards was a step along the way in the process towards identifying faults and ensuring that pipeline design takes their presence into account.

V. Determination of zones of seismic risk on Sakhalin

1) In the case of conflict between EIA (3) and EIA (4) on the same subject please refer to EIA (4) as this was prepared later than EIA (3) and is the latest version which takes into account changes made up until a later stage in project development.

2) The Russian Standard SniP II-7-81-2000 was used as the basis for the seismic zoning depicted in EIA (#) Figure 1-29. Please note that the TEO-C referenced a 1995 version.

3) The differences are the result of a refinement of the seismic environment as the development of the project proceeded.

4) The seismic rating in EIA (4) refers to an intensity scale.
The route selected through Makarov is the most favourable for the conditions in that section of the route.

5) See response to item 5).

6) Design has moved on to EIA (4) and Nyman's recommendations with respect to construction of the pipeline. Both references in your question were steps along the way in designing the pipeline.

7) See response to item 7).

SEIC's seismic design premise

1) These reports will be forwarded to you in due course. The reports to be made available are the design premise, liquefaction, landslides and fault crossings.

2) See response to item 1)

3)The purpose of the premise is to set out how the design will be carried out and does not include calculations.

4) The BTC reference is number 23. Extracted from Ref 23 "These mitigation measures could include reducing the pipeline/fault-crossing angle to help promote tension and reduce compression in the pipe. Special material properties can also be designated for pipe that is used in fault-crossing areas. Where the fault / pipeline alignment results in a degree of lateral pipe/soil movement, a trapezoidal trench design will be used to reduce soil resistance either side of the pipe to allow it to move more freely-an essential measure if large ground movements are to be absorbed safely.

Another possible mitigation measure is the use of granular material for backfill and, in some cases, the inclusion of a geo-textile membrane to enhance the mobility of the pipe/trench material. A maximum trench depth is usually specified which must not be reduced by vehicular traffic. Other preventative measures include avoiding sharp changes in direction within the fault zone."

All of these are considered in SEIC designs as appropriate to the particular fault. All fault crossing angles have been optimized.

5) See below item:

6) Copies of all Nyman's reports (listed below) will be supplied in due course. No specific comparisons have been made with BTC however the principles used to design both projects are the same.

Evaluation of Fault Crossings Sakhalin Pipeline - DJ. Nyman and D.G.Honegger, December 2000

- Doc.No: 1000-S-00-Z-T-0083-00-P1 - in file: 1 hardcopy

Seismic Design Premise for Sakhalin Pipeline - DJ. Nyman and D.G.Honegger, February 2001

- Doc.No: 5600-S-36-55-T-6669-00-AFU - in file: 1 hardcopy

7) MCEER has not been involved in the evaluation of the design premises and planned construction techniques, this reference was provided to you for background information purposes only with respect to seismic issues.

8) Please see response in item 7)

VII. SEIC's Risk analysis of pipeline seismic hazards

1) The design is based on no rupture for the specified loads.

2) Please see response to item 1)

3) Copy to be forwarded in due course.

VIII. Implementation of construction standards for earthquake hazard mitigation

1) Detailed design in currently underway for the pipeline. The risk assessment and design premises remain unchanged.

2) The pipeline construction will apply the special seismic construction techniques to the 22 active faults. Inactive faults do not require special construction techniques.

3) The locations of the thicker pipeline will be supplied to the contractor on alignment sheets, which provide in depth detail of the type of pipe to be used, where etc. The methodology for choosing which location will have thicker pipe is as referenced in your question "at river, road and railway crossings, near to settlements and facilities and at seismic fault crossings".

4) The following special seismic techniques will be used as appropriate:

Trapezoidal trench design, use of granular material for backfill, inclusion of a geo-textile membrane to enhance the mobility of the pipe/trench material, placement of heat-insulating material over the trench to prevent soil freezing, drainage system installation to prevent water accumulation in the trench and subsequent freezing.

Listed techniques will be specified for the particular fault crossing during detail design.

5) These will be taken into account in detailed design as previously stated.

6) Sakhalin Energy has performed significant engineering survey work. Prior to the Alignment Sheets preparation, additional survey work will be conducted to verify proposed design solutions. The additional surveys will minimize the need for changes during the course of construction.

In accordance with the Russian requirements all changes from the design solutions shall be agreed and approved by the Design Contractor prior construction commencement. Significant design changes of the Project will require the Russian Supervisory Authorities approval.

Representatives from the Company, Engineering Contractor, Third Party Inspection and various Russian Supervisory Authorities will control the compliance of the construction with the design solutions.

With respect to your comments regarding the Denali Fault area, in the first instance TAPS is above ground due to permafrost, this is illustrated in the photo attached by the presence of heat exchangers on the top of the pile supports in the foreground. See Appendix Three. Outside of the permafrost area TAPS is largely below ground.

Sakhalin Energy believes that the burying of the pipeline is the safest manner in which to build the pipeline on Sakhalin Island for a variety of reason, including security.

The Sakhalin Energy pipeline differs from TAPs because we do not have permafrost to consider.

We hope that this addresses the questions raised in your letter and will ensure that the EIA Addendum is made available to you as soon as possible to further assist you with your work.

Yours sincerely,

Julian Barnes
External Affairs Manager

CC: Mr. Dmitry Lisitsyn, Sakhalin Environmental Watch
Mr. Vasily Spiridonov, WWF – Ru
Ms. Naomi Kanzen, Friends of the Earth Japan
Mr. David K. Gordon, Pacific Environment
Mr. Doug Norlen, Pacific Environment
Mr. Misha Jones

Appendix C. Onshore Pipeline Fault Crossings

Count	Crossing ID Nyman)	Fault	KP (approx Old System)	Crossing Angle (º)	Pipeline
1	34	Piltun	19.28	+86	20” Oil / 20” Gas
2	33	Piltun	19.69	+81	20” Oil / 20” Gas
3	N/A	Imchinsky	142.0	TBA	20” Oil / 20” Gas
4	32	Central Sakhalin	154.0	+38	24” Oil / 48” Gas
5	31	Central Sakhalin	169.9	-65	24” Oil / 48” Gas
6	30	Central Sakhalin	192.3	<35	24” Oil / 48” Gas
7	29	Pobedino	196.7	-72	24” Oil / 48” Gas
8	28	Pobedino	199.5	-22	24” Oil / 48” Gas
9	27	Pobedino	200.8	<10	24” Oil / 48” Gas
10	25	Central Sakhalin	207.4	-30	24” Oil / 48” Gas
11	23	Central Sakhalin	282.4	+25	24” Oil / 48” Gas
12	22	Makarovsky	326.1	+57	24” Oil / 48” Gas
13	21	Makarovsky	330.6	+56	24” Oil / 48” Gas
14	19A	Makarovsky	334.8	+72	24” Oil / 48” Gas
15	18	Makarovsky	335.0	+54	24” Oil / 48” Gas
16	17	Zagrobka Creek	367.9	+95	24” Oil / 48” Gas
17	13	Aprelovsky	520.6	+44	24” Oil / 48” Gas
18	5	Aprelovsky	550.0	<15	24” Oil / 48” Gas
19	4	Aprelovsky	550.7	+34	24” Oil / 48” Gas
20	3	Aprelovsky	551.8	-62	24” Oil / 48” Gas
21	2	Aprelovsky	552.0	-42	24” Oil / 48” Gas
22	1	Aprelovsky	552.3	-42	24” Oil / 48” Gas

Figure C.1 Onshore Pipeline Fault Crossings

Appendix C. Map of Fault Findings

Figure C.2
Map of Fault Findings

Appendix C. Untitled Photo of TAPS Denali Fault Crossing

Figure C.3 Untitled Photo of TAPS Denali Fault Crossing

Heat exchangers

Research Associates' Response to Appendix Three to Julian Barnes' Letter

Re: TAPS Denali Fault Crossing

In his letter of January 26, 2004 (p. 4, above), Julian Barnes of SEIC asserts that, "regarding the Denali Fault area, in the first instance TAPS is above ground due to permafrost, this is illustrated in the photo attached by the presence of heat exchangers on the top of the pile supports in the foreground. See Appendix Three." That appendix is the photograph of TAPS on the preceding page, which shows TAPS descending a hill to cross the seismically active Denali Fault on long beams that can accommodate the potential large ground movements of an earthquake (the crossing itself is also shown in Figure VII.2). In the foreground, two vertical support structures (similar to those shown in Figure VII.1) can be seen; in the distance, at the end of the fault zone (approximately 1,900 feet [0.6 km] to the south), the unique fault crossing beams end and the pipeline returns to normal vertical supports.

On TAPS, vertical support structures like those at both ends of the Denali Fault carry TAPS for approximately 420 miles of its 800-mile length. ATAPS manual describes the function of the elevated pipe supports as follows: "The pipeline is constructed aboveground in areas where heat from a buried pipeline might melt the permafrost and create soil stability problems. . . . To prevent thawing around the vertical support members, thermal devices (heat pipes) are installed inside many of the vertical supports."[1] Approximately 30,500 of the 39,000 elevated support structures on the TAPS line have heat exchangers.[2] In other words, it is the support structure itself - not the heat exchangers identified by SEIC - that indicate the presence of permafrost.

But the photograph fails to prove Mr. Barnes' point for another reason: permafrost on most of the TAPS route is discontinuous; that is to say, it suddenly starts and stops.[3] That's why TAPS pops up, then goes back underground again literally hundreds of times on its 800-mile (1290-km) journey across Alaska. A closer reading of TAPS documents confirms that the SEIC photograph captures one of those transitions. According to a company geotechnical assessment of the pipeline route, at the Denali Fault it was not necessary to elevate TAPS to avoid permafrost; rather, "[a]n elevated support system . . . was chosen for this segment, rather than the otherwise equally suitable conventional burial mode, in order to provide more flexibility for the pipe to accommodate possible ground motion on the Denali Fault."[4]

In sum, the SEIC photo and comments are irrelevant to the discussion of the reasons that TAPS is elevated at the Denali Fault crossing because the vertical supports in the photograph lie outside the 1,900' Denali Fault crossing zone.[5]

Confusion about the TAPS Denali Fault crossing demonstrates the importance of basing conclusions about pipeline design and construction on accurate, site-specific considerations.[6]

1 Alyeska Pipeline Service Co., Trans Alaska Pipeline System Description Manual (Document No. SD-26; revised June 1977), pp. 3-2 - 3-3.

2 Alyska Pipeline Service Co., Trans Alaska Pipeline System FACTS, 2003, pp. 83-84.

3 FACTS, p. 87.

4 Alyeska Pipeline Service Co., "ETSCAD [Environmental and Technical Stipulation Compliance Assessment Document] Mode Justification," May 17, 1977, Alignment Sheet 37.

5 Although the piling location numbers stencilled onto each vertical support are not visible in the photograph SEIC provided, from the topography and the visible pipeline structures, it is clear that the vertical support structures in this photograph are the second and third supports south of Anchor No. 3107921 on TAPS Alignment Sheet no.105 (author's identification, based on on-site inspection and photographs).

6 Parenthetically, it should be noted that the detailed information necessary to such decisions requires a clear numbering system for identifying specific locations on the pipeline route. As discussed in Section VI.5(c), above, the Sakhalin-II Phase 2 pipeline route lacks this kind of numbering system.

Appendix D. SEIC's Map of Geotechnical Zoning, Including An Assessment of Geological and Geotechnical Hazards

Inactive Faults

On this 85-sheet map of the pipeline route, completed in 2002, the faults identified by SEIC as active are shown in red; the 33 additional fault crossing marking are in blue. The latter fault crossings, with their approximately location by SEIC kilometer post ("KP") and map sheet number ("sh.") are: Garomaysky Fault (upthrust - shift), KP 39 (sh. 5); Tymsky Fault (thrust), KP 122.5 (Sh. 13); Zmeinogorsky Fault, KP 65.6 (sh. 30); Zmeinogorsky Fault (thrust), KP 67.9 (sh. 30); Zmeinogorsky Fault (thrust), KP 73.9 (sh. 31); Zmeinogorsky Fault (thrust), KP 74.8 (sh. 31); unnamed thrust fault, KP 102.5 (sh. 33); Novaya-Vostok Fault, KP 294.7 (sh. 53); unnamed fault, KP 339.9 (sh. 58); unnamed fault (upthrow), KP 341.1 (sh. 59); Zaradnotrosksky Fault (upthrow), KP 349.1 (sh. 60); unnamed fault at Berzhny Cr., KP 371.43 (sh. 61); fault (shift), KP 374.5 (sh. 62); fault (shift), KP 379.4 (sh. 62); Central Sakhalin fault (fragment), KP 387.5 (sh. 63); unnamed fault, KP 431.0 (sh. 67); Arcentevsky Fault, KP 435.1 (sh. 67); Sezzro-Mylvsky Fault, KP 440.5 (sh. 67); fault, KP 441.2 (sh. 68); unnamed fault, KP 460.8 (sh. 69); Pokrovsky Overthrust, KP 466.4 (sh. 70); Pokrovsky Overthrust, KP 467.6 (sh. 70); Kyrzhnensky fault, KP 478.9 (sh. 71); Pokrovsky Overthrust, KP 483.0 (sh. 71); Pokrovsky Overthrust, KP 485.7 (sh. 72); Pokrovsky Overthrust, KP 486.0 (sh. 72); Pokrovsky Overthrust, KP 492.0 (sh. 72); Pokrovsky Overthrust, KP 497.0 (sh. 73); Pokrovsky Overthrust, KP 503.0 (sh. 73); Pokrovsky Overthrust, KP 509.0 (sh. 74); Zapadnokhrutschevsky Fault, KP 594 (sh. 83); Shugochny Fault, KP 595.6 (sh. 83); and Mereysky Fault, KP 596.8 (sh. 83).

This list excludes all ambiguous markings possibly associated with faulting, as well as the Aprolovsky fault crossings at KP 539.4 (sh. 77) and 543.2 (sh. 78), which appear to be the two faults avoided by recent re-routes.

Increased Seismicity

These maps also identify specific areas of increased seismicity, indicating that a major earthquake is liable to have effects one point higher on the MSK scale than the general area rating. Sheets on which the pipeline route traverses an area with a seismicity rating of 10 instead of 9 (all on the northern leg of the pipeline route) are: 1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 and 17 (approximate total = 47.1 kilometers). Sheets on which the pipeline route traverses an area with a seismicity rating of 9 instead of 9 are: 27, 28, 30, 31, 32, 36, 37, 40, 41, 44, 50, 51, 54, 55, 56, 68, 72, 73, 74, 75, 79, 80 and 83 (approximate total = 58.5 kilometers).

Source: SEIC, Map of Geotechnical Zoning, Including An Assessment of Geological and Geotechnical Hazards (Environmental Centre IFPA, Moscow, 2002). Analysis by Research Associates, Ester, Alaska.

Appendix E. SEIC Geotechnical Zoning and Hazards Map

Figure E.1 SEIC Geotechnical Zoning and Hazards Map

Сахалин Энерджи Инвестмент Компани, Лтд.

Проект Сахалин II

Этап 2

Стадия ТЭО-С

КАРТА ИНЖЕНЕРНО-ГЕОЛОГИЧЕСКОГО РАЙОНИРОВАНИЯ С ОЦЕНКОЙ ОПАСНОСТИ ОТ ГЕОЛОГИЧЕСКИХ И ИНЖЕНЕРНО-ГЕОЛОГИЧЕСКИХ ПРОЦЕССОВ

Масштаб 1:25000

НПФ "Экоцентр МТЭА"

Москва, 2002

Figure E.2 SEIC Geotechnical Zoning and Hazards Map

Sakhalin Energy Investment Company Ltd.

Sakhalin II Project

Phase 2

TEO-C Stage.

MAP OF GEOTECHNICAL ZONING, INCLUDING AN ASSESSMENT OF GEOLOGICAL AND GEOTECHNICAL HAZARDS

Scale 1:25000

Environmental Centre IFPA

Moscow, 2002

Figure E.3 SEIC Geotechnical Zoning and Hazards Map

Figure E.4 SEIC Geotechnical Zoning and Hazards Map

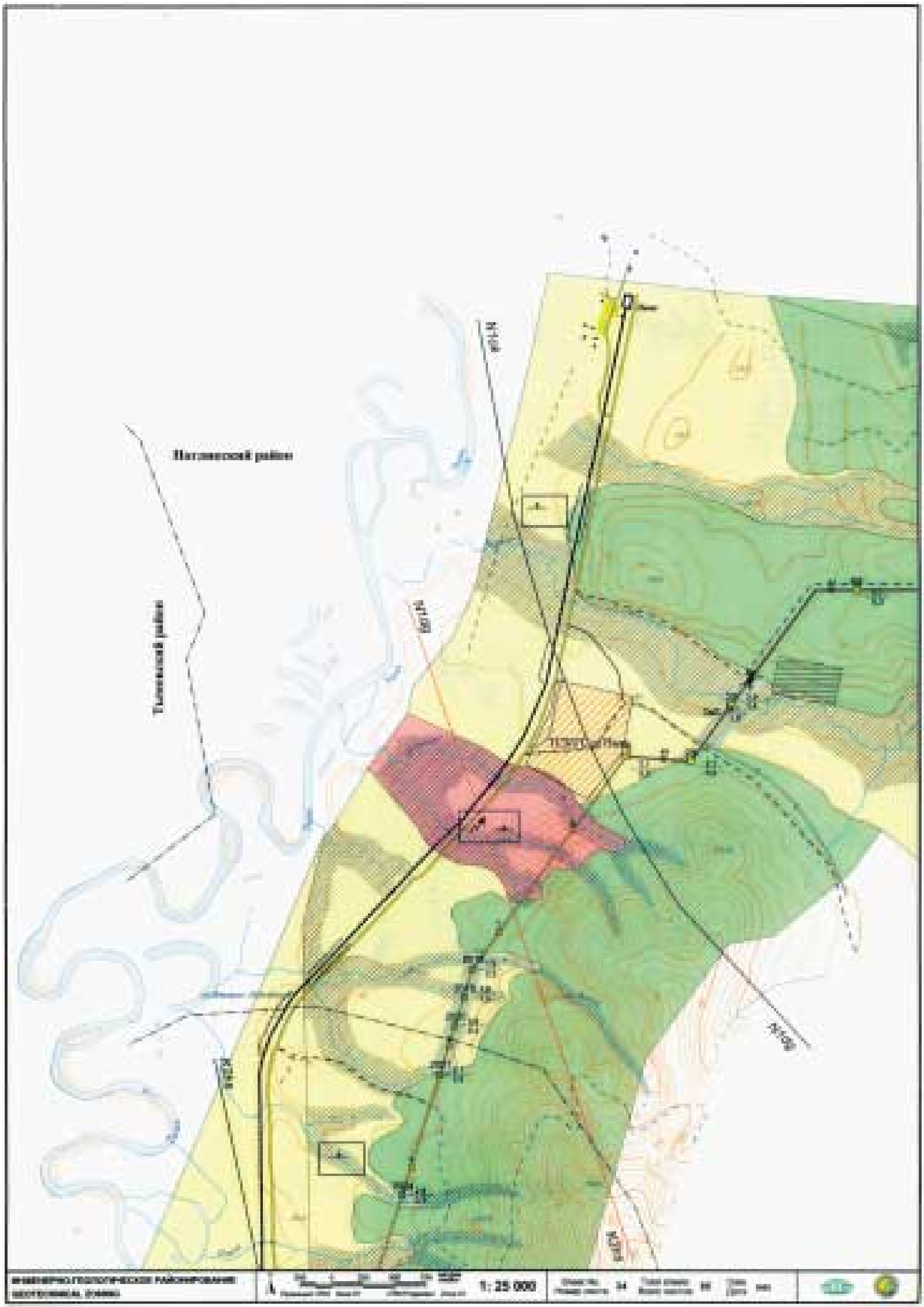


Figure E.5 SEIC Geotechnical Zoning and Hazards Map

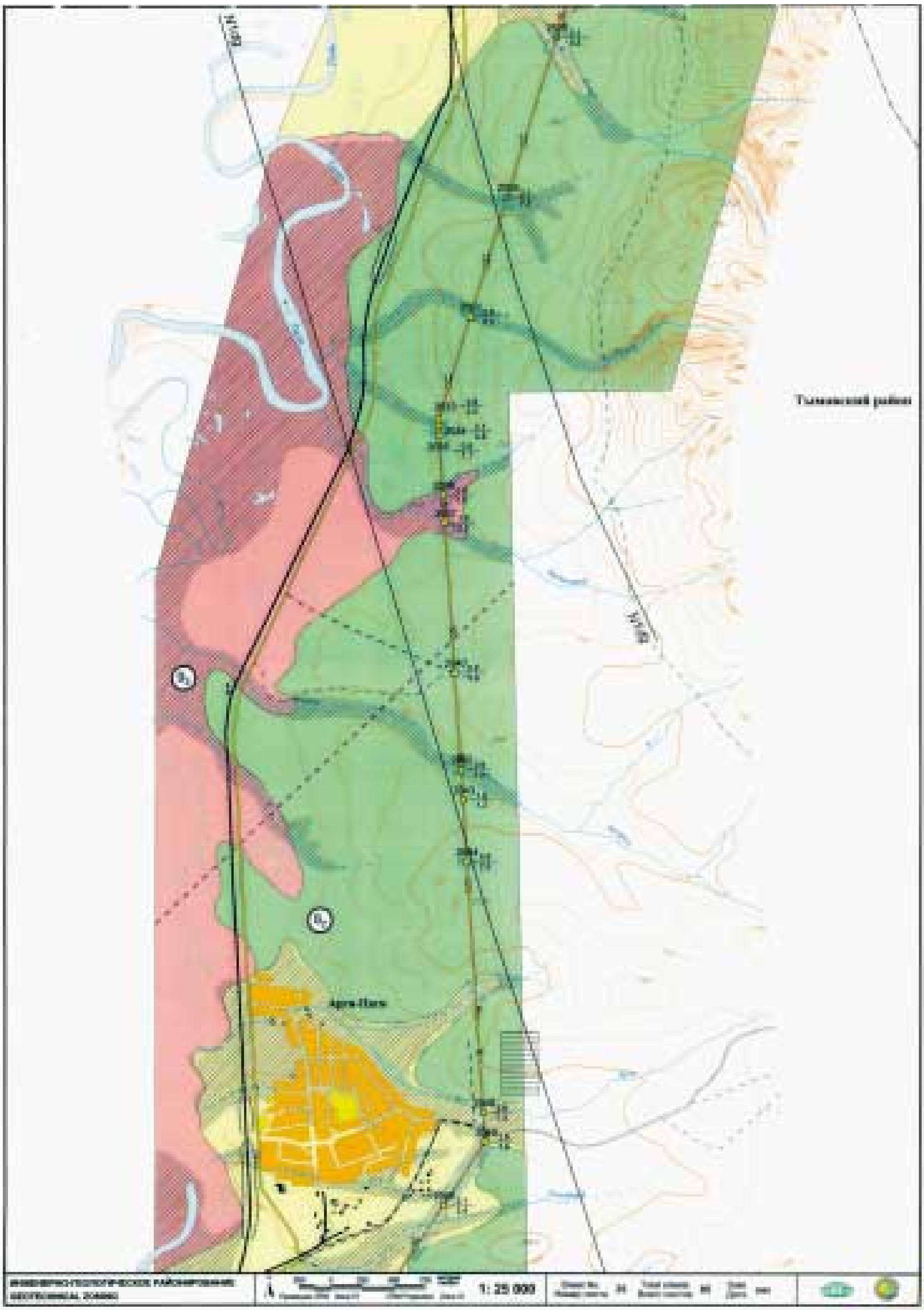


Figure E.6 SEIC Geotechnical Zoning and Hazards Map

MAP OF GEOTECHNICAL ZONING, INCLUDING AN ASSESSMENT OF GEOLOGICAL AND GEOTECHNICAL HAZARDS

LEGEND

GEOTECHNICAL ZONING

Relief forms		Relief		Lithology	Exogenic geological processes	Seismicity	Index
Regions of I order	Regions of II order	Areas	Relief forms				
East Sakhalin anticlinorium	Nabil syncline zone	Coastal belt of North Sakhalin plain	Flat and slightly undulating surfaces of marine terraces	Sands and peat	Liquification of sands, swamping, thermokarst	[illegible]	[illegible]
		Tym' valley	Slightly undulating surfaces of high terraces above the flood plain	Sands, loams and peat	Underflooding, swamping, erosion	[illegible]	[illegible]
	Medium massif of East Sakhalin anticlinorium	Northern arms of Nabil ridge	Gently undulating surfaces in proluvial-alluvial and deluvial deposits	Loams, and aleurolite and sandstone grues	Landslides, hillside waste, mud streams, erosion	[illegible]	[illegible]
	Superposed Cenozoic depression	Korsakov plateau	Slightly dissected gentle slopes covered with talus	Grues and chippings of argillites, aleurolites and sandstones	Erosion, abrasion and pile-up waves	[illegible]	[illegible]
Central Sakhalin synclinorium	Tymovsk and Onor syncline zones	Tym' valley	Slightly undulating surfaces of high terraces above the flood plain	Sands, pebble-beds, peat	Underflooding, swamping, erosion	[illegible]	[illegible]
		Tym'-Poronay watershed divide	Gently undulating surfaces in lake alluvial deposits	Sands, loams, peat	Underflooding, swamping	[illegible]	[illegible]
	Poronay superposed depression	Poronay valley	Slightly undulating surfaces of high terraces above the flood plain	Sands, loams, peat	Underflooding, swamping	[illegible]	[illegible]
	Susunay syncline zone	Susunay lowland	Flat surfaces of terraces above the flood plain	Sands, loams, peat	Underflooding, swamping	[illegible]	[illegible]
West Sakhalin anticlinorium	Anticlinal zone	Kamyshovyi and Dolinskyi ridges of West Sakhalin mountains	Heavily dissected steep slopes covered with talus and eluvium	Argillite and aleurolite grues and chippings	Landslides, hillside waste, avalanches, mudflows, erosion, shifts along the faults	[illegible]	[illegible]
		Coast of Terpenia Bay	Slightly undulating surfaces of marine terraces and lake alluvial plains	Sands and argillite and aleurolite chippings	Swamping, abrasion	[illegible]	[illegible]

Boundaries of the regions and provinces selected by tectonic and geomorphologic features and prevailing lithological rock types bedding on the surface

a/ boundaries of the regions

b/ boundaries of the provinces

TYPOLOGICAL ZONING

areas with the weak development of geological and geotechnical processes

areas of possible activation of geological and initiation of geotechnical processes

areas with active development of geological and geotechnical processes

floodplain terraces and low terraces of the river valleys

Figure E.7 SEIC Geotechnical Zoning and Hazards Map

Initiative for Social Action and Renewal in Eurasia (ISAR)'s mission is to strengthen the ability of citizens and social change organizations in Eurasia and their colleagues in the US to influence decision-making, advance social justice and promote environmentally sound stewardship of the Earth and its resources.

ISAR
1601 Connecticut Avenue, NW, Suite 301, Washington, DC 20009
tel: 202-387-3034, fax: 202-667-3291, http://www.isar.org,

Pacific Environment protects the living environment of the Pacific Rim by strengthening democracy, supporting grassroots activism, empowering communities, and redefining international policies.

311 California, Suite 650, San Francisco, CA 94104, USA
tel: 415/399.8850, fax: 415/399.8860, **info@pacificenvironment.org**

Friends of the Earth Japan is an international NGO which deal with environmental problems at the global level. As a member of Friends of the Earth International, we have worked in Japan since 1980. FoEJ tackles problems such as global warming, deforestation, and development aid to the Third World.
Our ultimate goal is to create a world in which all people may live peacefully and equitably. While generously supporting international finance institutions (IFIs), Japan provides huge amount of bilateral official development finance through the Japan Bank of International Cooperation (JBIC), the world largest financial source. Development Finance and Environment Program at FOEJ is working to improve the funding policies of the JBIC and other IFIs and advocates for greater transparency and accountability in development finance.

Friends of the Earth Japan
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"Sakhalin Environment Watch" is an independent non-political nongovernment organization, whose goal is protection of the natural ecosystems of Sakhalin Region. SEW was created in 1995 as unformal group of citizens and in 1997 it was officially registered. The SEW's main goals are: protection of environment and defence of nature of Sakhalin Region; conducting of public environment control; defence of ecological rights and law's interests of citizens; organization and realization of public environment expertiza (review).

The main directions of SEW's activity are:

– to preserve the forests of Sakhalin Region;
– to increase the ecological security of Sakhalin's off-shore oil and gas projects.

Office 301, 27a, Kommunisticheskiy st., Yuzhno-Sakhalinsk, 693007 Russia,
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WWF is one of the world's largest and most experienced independent conservation organizations, with almost 5 million supporters and a global network active in more than 90 countries. WWF's mission is to stop the degradation of the planet's natural environment and to build a future in which humans live in a harmony with nature, by:

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– ensuring that the use of renewable natural resources is sustainable
– promoting the reduction of pollution and wasteful consumption.

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