3. TOPOGRAPHY, GEOLOGY, AND SOILS

This chapter describes topography, geology, soils, permafrost and seismic hazards anticipated to be encountered during construction and operation of the proposed Port MacKenzie Rail Extension. Section 3.1 describes the regulatory setting and Section 3.2 describes the study area. Sections 3.3 through 3.6 describe analysis methods, the affected environment (existing conditions), and potential environmental consequences (impacts) related to topography, geology and soils, permafrost, and seismic hazards.

3.1 Regulatory Setting

There are no Federal, State of Alaska, or Matanuska-Susitna Borough (MSB) regulations regarding the protection of or minimization of impacts to topography, geology, or permafrost that either exist or would apply to the proposed rail line extension. Federal codes and design guidelines, such as the Uniform Building Code, which the MSB has adopted under the Borough Code for buildings and structures, address structure earthquake resistance. The American Association of State Highway Transportation Officials provides guidelines for the seismic design of highway bridges, which could apply to the construction of bridge crossings along the proposed rail line extension. The American Railway Engineering and Maintenance-of-Way Association has developed recommended guidelines and standards for the seismic design of new railroad structures and embankments.

Regarding the protection of soils, Congress enacted the Farmland Protection Policy Act of 1981 in response to substantial decreases in the amount of open farmland resulting from the high rate of conversion to other uses. The Act's purpose is to minimize the extent to which Federal programs contribute to the unnecessary and irreversible conversion of farmland to nonagricultural uses. The Act addresses prime and unique farmland and farmland of statewide or local importance (7 U.S. Code [U.S.C.] 4201(c)(1)(A), (B), and (C)). However, there are no prime farmlands in Alaska because soil temperatures do not meet the prime farmland threshold established by Congress. No unique farmlands or farmlands of statewide importance have been designated in Alaska, however, the MSB has adopted criteria for Farmlands of Local Importance for lands within its boundaries (USDA, undated).

3.2 Study Area

The proposed Port MacKenzie Rail Extension would be between the Susitna River to the west, the Knik Arm to the south and east, and the Talkeetna Mountains to the north. It would lie within the Susitna Lowland, which is the landward extension of the Cook Inlet Depression. The depression is a structural basin that contains the lowland basins of the Susitna River, its tributaries, and several other rivers that flow directly into the head of Cook Inlet. This area has been subjected to several glacial advance and retreat cycles, and the resulting gently undulating landforms consist primarily of glacial moraines, outwash deposits, and organic and bog soils.

3.3 Topography

3.3.1 Analysis Methodology

The objective of the topographic analysis was to identify and compare the extent to which the proposed rail line alternatives would require modifications to the current topography to meet project design objectives. The proposed rail line would be designed to meet Federal Railroad Administration Class 4 track standards to facilitate 60-mile-per-hour freight operations. Grade changes are typically kept to a minimum to maximize fuel efficiency and lessen long-term maintenance costs. ARRC's design objectives for the proposed rail line alternatives would limit grades to a maximum of 1 percent to maintain consistency in train components and reduce the need for additional facilities for helper locomotives. The topographic analysis study area consists of the 200-foot-wide right-of-way (ROW) corridor of the individual proposed rail line segments and segment combinations.

3.3.2 Affected Environment

The terrain in the study area is relatively flat. Most of the area lies between 150 and 200 feet in elevation, with a few locations having elevations as high as 450 feet. Topographic relief is present in the form of scattered gently rolling landforms. There is no extreme or rugged topography in the study area.

There are several topographic sub-areas in the study area. The Point MacKenzie Agricultural Area is a flat, gently sloping plain at the southern end of the study area. To the north and east of Big Lake, the land undulates significantly more than other areas. North and west of Big Lake, to the ridge west of Red Shirt Lake, the terrain is flat and has relatively persistent marshy areas. Terrain to the north and west of this ridge is relatively flat, with isolated areas of high ground.

3.3.3 Environmental Consequences

3.3.3.1 Proposed Action

Common Impacts

Spatial analysis of topography was completed using 50-foot contours available on U.S. Geological Survey 1:63,360 scale series topographic maps encompassing the entire study area. Slopes were determined using Geographic Information System software. Each proposed alternative was bisected at the intersection of a contour line to create numerous segments and segment combinations. A "from" and "to" elevation was recorded for the end points of each segment. The difference between these two elevations was calculated and divided into the length of each segment to obtain percent slope. Because ARRC's geometric design goals include grades limited to 1 percent, the software was used to identify slopes by band widths (less than or equal to 1 percent, greater than 1 percent to 5 percent, and greater than 5 percent) to identify areas where topography would be a concern and associate a relative degree of concern. Table 3-1 lists this information.

Table 3-1
Slope Analysis of Alternative Segments and Segment Combinations

Segment/Segment Combination	Percent Slope Less Than or Equal to 1 Percent (linear feet)	Percent Slope Greater Than 1 to 5 Percent (linear feet)	Percent Slope Greater than 5 Percent (linear feet)
Mac West-Connector 1	93.3 (82,300)	6.7 (5,900)	0.0 (0)
Mac West-Connector 2	94.4 (77,900)	5.6 (4,600)	0.0 (0)
Mac East-Connector 3	91.2 (77,600)	8.3 (7,100)	0.5 (400)
Mac East	86.9 (50,100)	12.3 (7,100)	0.7 (400)
Willow	93.7 (148,300)	5.9 (9,300)	0.4 (700)
Big Lake	79.4 (88,400)	15.3 (17,000)	5.4 (6,000)
Houston-Houston North	94.6 (94,600)	3.8 (3,800)	1.6 (1,600)
Houston-Houston South	93.1 (95,900)	5.3 (5,500)	1.6 (1,600)

Steeper terrain would require a greater amount of either fill or cut and fill during rail line construction than flatter terrain, and would therefore have a greater impact on topography. Normally, the steeper the terrain is, the greater the impact.

From Table 3-1 it can be seen that all segments and segment combinations would be relatively flat, with most having approximately 90 to 95 percent of their total lengths on ground with a slope of less than or equal to 1 percent, and approximately 4 to 12 percent of their lengths on ground with a slope between 1 and 5 percent. A notable exception is the Big Lake Segment, which would cross ground with a slope of 1 percent or less along only about 80 percent of its length. This segment would also cross the highest percentage of slopes between 1 and 5 percent (15.3 percent of its length), slopes greater than 5 percent (5.4 percent of its length), and would cross ground with the highest maximum slope (27 percent). The Mac East Segment has the second steepest conditions, with 12.3 percent of its length crossing ground with slopes between 1 and 5 percent, and 0.7 percent of its length crossing ground with slopes greater than 5 percent.

Construction Impacts

Temporary impacts would consist of cuts for the construction of railroads that would be needed for construction access or for temporary facilities such as construction staging areas, material laydown/stockpile areas and temporary camp/emergency facilities. If such areas were regraded to match the original topography after they were no longer needed, there would be no permanent impact.

There would be permanent physical impacts to topography wherever the terrain would be reshaped during construction to meet railroad design objectives. With ARRC's objective to construct the rail line with a grade of 1 percent or less, fill or cut and fill earthwork would be needed along most of the alternatives. Ditches and other drainage structures would also be cut into the terrain along the proposed rail line to prevent storm water or snow melt runoff from damaging the railbed. Other construction activities, such as those for associated facilities, bridge approaches, communication towers, access roads, and drainage structures, would also permanently alter topography. In areas of temporary construction activities, impacts would be permanent if restoration did not occur.

Operations Impacts

Proposed rail line operations would not result in impacts to topography. Any excavation or filling required for maintenance activities would be temporary.

Summary of Impacts to Topography by Alternative

Table 3-2 summarizes the potential topographical impacts of each proposed rail line alternative.

Table 3-2
Slope Analysis of Proposed Port MacKenzie Rail Extension Alternatives

Alternative	Length (linear feet) with Slope Less Than or Equal to 1 Percent	Length (linear feet) with Slope Greater Than 1 to 5 Percent	Length (linear feet) with Slope Greater than 5 Percent
Mac West-Connector 1-Willow	230,600	15,200	700
Mac West-Connector 1-Houston-Houston North	176,900	9,700	1,600
Mac West-Connector 1-Houston-Houston South	178,200	11,400	1,600
Mac West-Connector 2-Big Lake	166,300	21,600	6,000
Mac East-Connector 3-Willow	225,900	16,400	1,100
Mac East-Connector 3-Houston-Houston North	172,200	10,900	2,000
Mac East-Connector 3-Houston-Houston South	173,500	12,600	2,000
Mac East-Big Lake	138,500	24,100	6,400

From Table 3-2 it can be seen that, except for the two alternatives that include the Big Lake Segment, most alternatives would be relatively flat, which minimize cut and fill requirements. The two alternatives with the Big Lake Segment (i.e. Mac West-Connector 2-Big Lake and Mac East-Big Lake) would also cross the greatest lengths of ground sloping at more than 5 percent.

3.3.3.2 No-Action Alternative

Absent the proposed rail extension, there could be other, non-project-related impacts to topography. Natural processes such as erosion and seismic activity would continue to shape the topography of the area.

3.4 Geology and Soils

3.4.1 Analysis Methodology

The objective of the geology analysis was to identify areas of bedrock that would need to be removed to construct the proposed rail line. Existing project geotechnical reconnaissance reports (Shannon & Wilson, 2003; 2007a; 2007b; 2007c) include information regarding geological conditions in the study area.

The objectives of the soils analyses included identification of: soils that would be unsuitable for construction and would need to be compacted or removed and replaced with suitable imported materials; highly erodible soils; and soils that MSB considers to be of local importance for agricultural uses and that would no longer be available if the rail line were constructed. The geology and soils analysis study area consists of the 200-foot-wide ROW of the individual proposed rail line segments and segment combinations.

The U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) has classified and mapped soils in the Matanuska-Susitna Valley (USDA, 1998). Forty-one separate soil units, exclusive of organic and peat soils, have been identified along proposed rail line alternatives (USDA, 1998). Based on soils mapping data, soils within the 200-foot-wide ROW were classified as either good, moderate, or poor regarding their usability for construction of the rail line. The soils mapping data were also used to determine the susceptibility of soils to wind erosion or to sheet and rill erosion by water. Soils classification is based on information regarding the drainage characteristics of individual soil units, the amount of gravel and sand present, and frost susceptibility (USDA, 1998). Unsuitable soils were further identified based on data from peat probes (Shannon & Wilson, 2007a) in delineated bog sections along each proposed rail line segment.

The Point MacKenzie Agricultural District and some parcels along the Willow Segment contain soils the MSB has designated as Farmlands of Local Importance, protected under the Farmland Protection Policy Act. The Board's Section of Environmental Analysis (SEA) has coordinated with NRCS to determine the potential acres of impact to farmland soils, as required by the Farmland Protection Policy Act. Section 3.4.3.1 describes the results of this consultation.

3.4.2 Affected Environment

The alternatives would cross areas dominated by glacially-derived landforms. The area has been subject to several glacial advance and retreat cycles that have completely or partially covered the landscape with glacial ice (Shannon & Wilson, 2007a). The most recent glacial advance, known as the Naptowne Glaciation, created and shaped many of the landforms visible today. This advance transported rock debris from the Chugach and Talkeetna Mountains, and left behind unconsolidated moraine and glaciofluvial outwash deposits. In the project vicinity, these glacial and glaciofluvial deposits are overlain by soils consisting largely of well-drained silt loams and poorly drained mucky silt loams and peats (Shannon & Wilson, 2003).

Moraine deposits in the study area tend to be dense, unstratified, and composed of material ranging in size from clay and silt to boulders. These moraine deposits are commonly found in and beneath topographically high areas. Outwash deposits are typically less dense than moraine deposits, are composed of relatively clean sand and gravel, and can be found in broad, low-lying areas at the southwestern end of the study area. In addition to the moraine and outwash deposits, there is a region of low-lying bogs with indeterminate underlying geology within the study area (Shannon & Wilson, 2007b, 2007c). This region abuts the moraine deposits, is roughly triangular, and is in the northeastern portion of the study area. Figure 3-1 shows the approximate extents of these three general deposit types in the vicinity of the project alternatives.

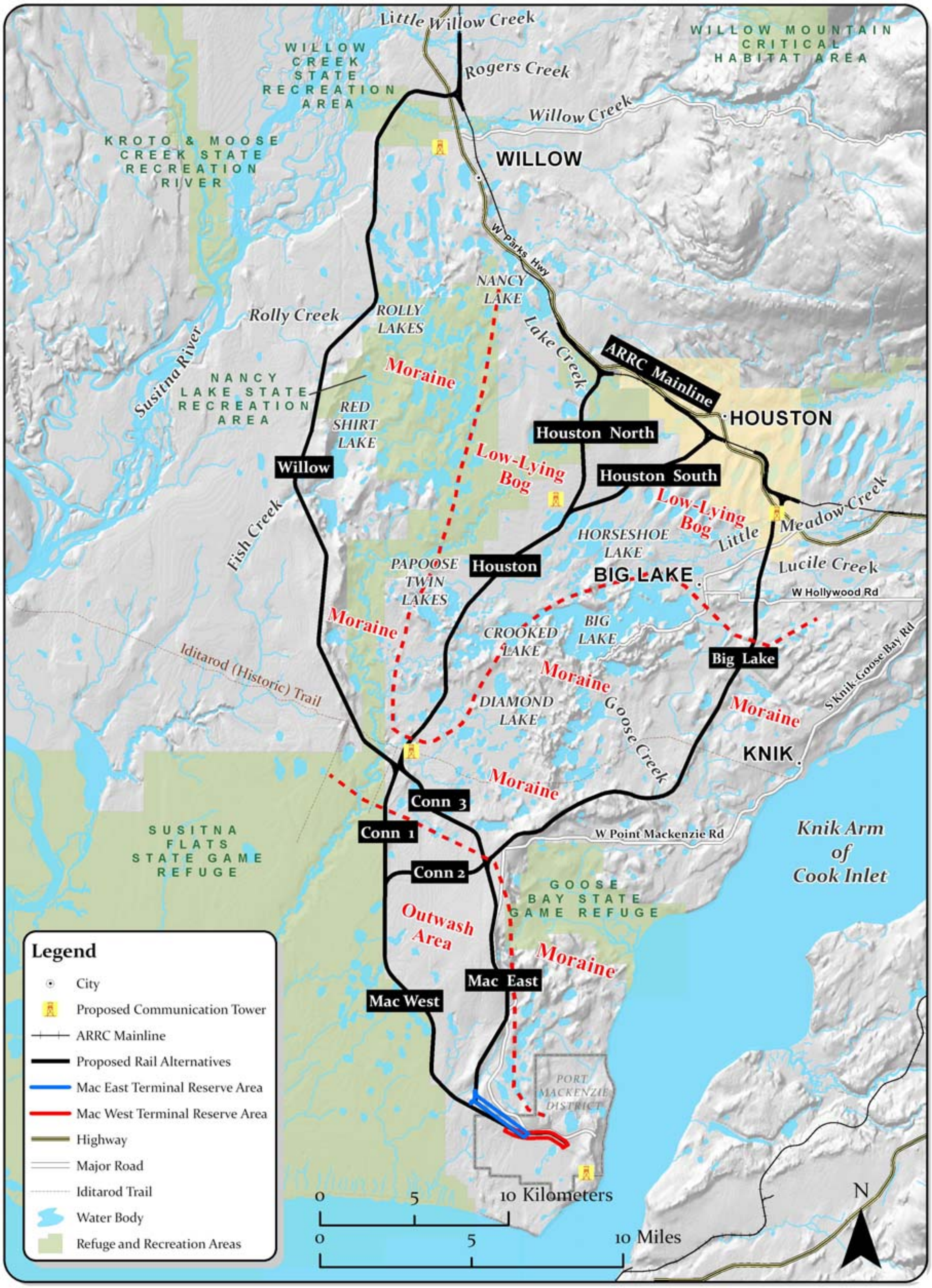

Figure 3-1. Terrain Along the Proposed Port MacKenzie Rail Extension Segments

Surface soils in the study area consist of reworked glacial and glaciofluvial deposits, and soils deposited by wind and volcanic activity. These soils consist of silt loams, gravels, and sands.

Soft, compressible organic and peat soils are common in low-lying areas, along the margins of streams, and within closed depressions. These deposits can be dozens of feet thick (Shannon & Wilson, 2003). The amount of fine-grained particles influences the susceptibility of a soil to erosion, with finer-grained soils having a higher susceptibility to wind and water erosion (USDA, 1998). Table 3-3 summarizes the soil units in the soils analysis study area.

Table 3-4 lists the soils the MSB considers locally important for agricultural uses and protected under the Farmland Protection Policy Act explained in Section 3.1.

3.4.3 Environmental Consequences

3.4.3.1 Proposed Action

Common Impacts

Construction Impacts

Outcroppings of bedrock are rare or absent throughout the study area, and bedrock should not be encountered in any cuts required for rail line construction. Therefore, there would be no impacts to geologic resources.

Construction activities would affect soils unsuitable for rail line construction because these soils would need to be removed and replaced with imported, well-draining soils. Soft, compressible organic and peat soils, present in wetland areas, would also have to be compacted or removed and replaced. At some locations along the proposed rail line, a segment could encounter hills or slopes where soils would need to be cut away, potentially affecting the stability of the slope. Furthermore, wind and water erosion would be a concern where slopes were cut in erodible soils. Larger cut slopes would have greater potential for erosion.

In some locations, the railroad would be constructed on soils the MSB considers locally important for agricultural purposes. This loss of soil use would apply to the full width of the rail line ROW. SEA coordinated with NRCS to determine the potential acres of impact to these locally important farmland soils, as required by the Farmland Protection Policy Act. SEA, in coordination with NRCS, assessed non-soil-related criteria, such as the potential for impacts to the local agricultural economy if the land were converted to non-farm use and compatibility with existing agricultural use. In conjunction with NRCS, SEA made scoring decisions in the context of each proposed alternative by examining the alternative, the surrounding area, and the programs and policies of the state or local unit of government in which the alternative would be located. The computed score enabled SEA to identify the effects of the proposed project on farmland. All of the alternatives received a score of less than 160; therefore, according to the Farmland Protection Policy Act, they do not need to be given further consideration for protection and no additional alternatives need to be evaluated. Chapter 13, Land Use, describes potential impacts to agricultural lands.

Table 3-3
Natural Resources Conservation Service Mapped Soils Units in the Study Area[a]

Soil Unit	Description	Usability for Construction	Erodibility
101, 103	Benka Silt Loam	Moderate	Not Highly
114	Chilligan	Poor	Not Highly
116	Cryaquepts	Poor	Not Highly
120	Cryods	Poor	Highly
122	Deception Silt Loam	Poor	Potentially Highly
123, 124	Deception Silt Loam	Poor	Highly
125	Deception Silt Loam	Poor	Not Highly
126	Delyndia Silt Loam	Good	Not Highly
128	Disappoint Very Cobbly Mucky Silt Loam	Poor	Not Highly
131, 132, 133, 134	Estelle Silt Loam	Poor	Highly
135, 136	Estelle	Poor	Highly
141	Histosols	Poor	Not Highly
147, 148, 149	Kashwitna Silt Loam	Good	Highly
150	Keba Silt Loam	Poor	Not Highly
151	Kichatna Silt Loam	Good	Not Highly
152, 153	Kichatna Silt Loam	Good	Highly
154	Kichatna Silt Loam	Good	Potentially Highly
155	Kichatna-Deception Complex	Good	Highly
156	Kichatna-Deception Complex	Moderate	Highly
157	Kichatna-Deception Complex	Good	Potentially Highly
158	Kichatna-Delyndia Silt Loams	Good	Not Highly
163	Killey and Moose River Soils	Good	Not Highly
169	Liten Silt Loam	Moderate	Potentially Highly
171	Nancy Silt Loam	Good	Not Highly
172	Nancy Silt Loam	Good	Highly
185	Susitna Silt Loam	Good	Not Highly
186	Susvivar-Moose River Complex	Poor	Not Highly
203	Typic Cryaquents	Poor	Not Highly
208	Whitsol Silt Loam, Silty Substratum	Poor	Not Highly
209	Whitsol Silt Loam, Silty Substratum	Poor	Potentially Highly
216	Yohn Silt Loam	Poor	Potentially Highly
218	Yohn-Delyndia Complex	Poor	Potentially Highly

[a] Source: USDA, 1998.

Table 3-4
Locally Important Agricultural Soils in the Study Area[a]

Soil Unit	Description
101	Benka Silt Loam, 0- to 3-Percent Slopes
103	Benka Silt Loam, Undulating
114	Chilligan, Undulating-Cryaquepts Complex
134	Estelle Silt Loam, Undulating
147	Kashwitna Silt Loam, 0- to 3-Percent Slopes
149	Kashwitna Silt Loam, Undulating
150	Keba Silt Loam, Undulating
171	Nancy Silt Loam, 0- to 3-Percent Slopes
185	Sustina Silt Loam, 0- to 2-Percent Slopes
208	Whitsol Silt Loam, Silty Substratum, 0- to 7-Percent Slopes

[a] Source: USDA, undated.

Operations Impacts

There would be no impacts to geology or soils from proposed rail line operations as long as erodible soils were stabilized and revegetated following construction.

Impacts to Soils by Alternative Segment and Segment Combination

Table 3-5 lists the percentages of soils classified as good, moderate, and poor (NRCS classifications for usability for construction, see Section 3.4.1), and percentages of soils the MSB considers locally important for agricultural purposes by segment or segment combination. Table 3-6 lists the percentages of highly or potentially highly erodible soils.

From Table 3-5 it can be seen that southern segment and segment combinations (Mac West-Connector 1, Mac West-Connector 2, Mac East-Connector 3, and Mac East) would cross a higher percentage of good soils and much shorter lengths of peat and organic soils than northern segments, but would cross a much higher percentage of soils considered to be of local importance for agricultural purposes.

From Table 3-6 it can be seen that all segments and segment combinations have soils classified as highly or potentially highly erodible along more than a quarter of their lengths, with the greatest (64 percent) being present along the Big Lake Segment.

Table 3-5
Construction Impacts to Soils by Segment and Segment Combination

Segment/Segment Combination	Good (percent)	Moderate (percent)	Poor (percent)	Agricultural Soils (percent)	Peat and Organic Soils along the Segment (of ROW feet)	Peat and Organic Soils along the Segment (acres)
Mac West-Connector 1	28	0	72	41	20,400	94
Mac West-Connector 2	33	0	67	49	12,600	58
Mac East-Connector 3	46	0	54	59	9,100	42
Mac East	32	0	68	62	4,900	23
Willow	25	15	60	38	25,300	116
Big Lake	28	4	68	6	16,900	78
Houston-Houston North	26	3	71	13	52,400	241
Houston-Houston South	33	3	64	16	34,600	159

Table 3-6
Erodibility of Soils by Segment and Segment Combination

Segment/Segment Combination	Not Highly Erodible Soils (percent)	Highly or Potentially Highly Erodible Soils (percent)
Mac West-Connector 1	73	27
Mac West-Connector 2	67	33
Mac East-Connector 3	55	45
Mac East	68	32
Willow	58	42
Big Lake	36	64
Houston-Houston North	63	37
Houston-Houston South	64	36

Southern Segments/Segment Combinations

Mac West-Connector 1 Segment Combination

This segment combination would primarily cross outwash deposits, but would also cross moraine deposits on the northern 1 to 2 miles of its length. Table 3-5 lists the percentages of soils classified as good, moderate, and poor, and percentages of soils the MSB considers locally important for agricultural purposes along this segment. Peat and organic soils, which range from 3 to 10 feet thick, would be encountered along this segment, as listed in Table 3-5. Highly or potentially highly erodible soils are present along 27 percent of this segment, as listed in Table 3-6. This segment has the lowest erosion potential of all segments and segment combinations.

Mac West-Connector 2 Segment Combination

This segment combination would cross outwash deposits along its entire length. Table 3-5 lists the percentages of soils classified as good, moderate, and poor, and percentages of soils the MSB considers locally important for agricultural purposes along this segment. This segment combination would cross agricultural soils of local importance along 49 percent of its length, which is the second highest percentage among all segments and segment combinations. Peat and organic soils, which range from 3 to10 feet thick, would be encountered along this segment, as listed in Table 3-5. Table 3-6 lists the percentage of highly or potentially highly erodible soils along this segment.

Mac East-Connector 3 Segment Combination

The Mac East portion of this segment combination would cross outwash deposits and the Connector 3 Segment portion would cross moraine deposits. Table 3-5 lists the percentages of soils classified as good, moderate, and poor, and percentages of soils the MSB considers locally important for agricultural purposes along this segment. This segment combination would cross good soils along 46 percent of its length, which is the highest percentage among all segments and segment combinations. The Mac East-Connector 3 Segment Combination would cross agricultural soils of local importance along 59 percent of its length, the second highest percentage among all segments and segment combinations. Peat and organic soils, which range from 3 to 15 feet thick, would be encountered along this segment combination, as listed in Table 3-5. With the exception of the Mac East Segment, this segment combination would cross the shortest length (9,100 feet) of peat and organic soils. Highly or potentially highly erodible soils are present along 45 percent of this segment combination, as listed in Table 3-6. This segment combination has the second highest erosion potential of all segments and segment combinations.

Mac East

The Mac East Segment would cross outwash deposits along its entire length. Table 3-5 lists the percentages of soils classified as good, moderate, and poor, and percentages of soils the MSB considers locally important for agricultural purposes along this segment. This segment would cross good soils along 32 percent of its length. Mac East would also cross agricultural soils of local importance along 62 percent of its length, the highest percentage among all segments and segment combinations. Peat and organic soils, which range from 3 to 15 feet thick, would be encountered along this segment, as listed in Table 3-5. This segment would cross the shortest length (4,900 feet) of peat and organic soils among all segments and segment combinations. Highly or potentially highly erodible soils are present along 32 percent of this segment, as listed in Table 3-6.

Northern Segments and Segment Combinations

Willow Segment

This segment would cross moraine deposits for its entire length. Table 3-5 lists the percentages of soils classified as good, moderate, and poor, and percentages of soils the MSB considers locally important for agricultural purposes along this segment. Peat and organic soils, which range from 3 to 15 feet thick, would be encountered along this segment, as listed in Table 3-5. Table 3-6 lists the percentage of highly or potentially highly erodible soils along this segment.

Big Lake Segment

This segment would cross moraine deposits along much of its length, but would cross low-lying bog deposits along the northern 5 to 6 miles of the segment. Table 3-5 lists the percentages of soils classified as good, moderate, and poor, and percentages of soils the MSB considers locally important for agricultural purposes along this segment. This segment would cross poor soils along 68 percent of its length, the second highest percentage among all segments and segment combinations. The segment would cross agricultural soils of local importance along 6 percent of its length, the lowest percentage among all segments and segment combinations. Peat and organic soils, which range from 3 to 15 feet thick, would be encountered along this segment, as listed in Table 3-5. Highly or potentially highly erodible soils are present along 64 percent of this segment, as listed in Table 3-6. This segment has the highest erosion potential of all segments and segment combinations.

Houston-Houston North Segment Combination

This segment would cross low-lying bog deposits except the southern 1 to 2 miles of this segment, which would cross moraine deposits. Table 3-5 lists the percentages of soils classified as good, moderate, and poor, and percentages of soils the MSB considers locally important for agricultural purposes along this segment. This segment would cross poor soils along 71 percent of its length, the second highest percentage among all segments and segment combinations. Peat and organic soils, which range from 3 to more than 20 feet thick, would be encountered along this segment, as listed in Table 3-5. This segment would cross the greatest length (52,400 feet) of peat and organic soils among all segments and segment combinations. Table 3-6 lists the percentage of highly or potentially highly erodible soils along this segment.

Houston-Houston South Segment Combination

Like the Houston-Houston North Segment Combination, most of this segment combination would cross low-lying bog deposits, except for the southern 1 to 2 miles, which would cross moraine deposits. Table 3-5 lists the percentages of soils classified as good, moderate, and poor, and percentages of soils the MSB considers locally important for agricultural purposes along this segment. Peat and organic soils, which range from 3 to 15 feet thick, would be encountered along this segment, as listed in Table 3-5. This segment would cross the second greatest length (34,600 feet) of peat and organic soils among all segments and segment combinations. Table 3-6 lists the percentage of highly or potentially highly erodible soils along this segment.

Impacts to Soils by Alternative

Table 3-7 lists the percentages of soils classified as good, moderate, and poor, and percentages of peat and organic soils the MSB considers locally important for agricultural purposes along each rail line alternative. Table 3-8 lists highly or potentially highly erodible soils along each alternative.

Table 3-7
Construction Impacts to Soils by Rail Line Alternative

Alternative	Classification (percent) Good	Moderate	Poor	Agricultural Soils (percent)	Agricultural Soils (acres)	Peat and Organic Soils along the Alternative (feet)	Peat and Organic Soils along the Alternative (acres)
Mac West-Connector 1-Willow	27	8	65	40	510	45,600	209
Mac West-Connector 1-Houston-Houston North	28	1	71	29	297	72,800	334
Mac West-Connector 1-Houston-Houston South	30	1	69	30	312	54,900	252
Mac West-Connector 2-Big Lake	30	2	68	29	317	29,500	135
Mac East-Connector 3-Willow	33	8	59	47	608	34,300	157
Mac East-Connector 3-Houston-Houston North	35	1	64	39	390	61,500	282
Mac East-Connector 3-Houston-Houston South	38	1	61	40	406	43,600	200
Mac East-Big Lake	28	2	70	33	322	21,800	100

Table 3-8
Erodibility of Soils by Rail Line Alternative

Alternatives	Classification: Highly Erodible or Potentially Highly Erodible Soils (percent)
Mac West-Connector 1-Willow	35
Mac West-Connector 1-Houston-Houston North	31
Mac West-Connector 1-Houston-Houston South	31
Mac West-Connector 2-Big Lake	47
Mac East-Connector 3-Willow	41
Mac East-Connector 3-Houston-Houston North	39
Mac East-Connector 3-Houston-Houston South	38
Mac East-Big Lake	47

Table 3-7 shows that the Mac West-Connector 1-Houston-Houston North Alternative would contain both the greatest percentage of poor soils and the greatest length of peat and organic soils. The table also shows that the Mac East-Connector 3-Willow Alternative would have the greatest impact to soils the MSB considers locally important for agricultural purposes. Table 3-8 shows that the greatest amount of highly erodible or potentially highly erodible soils would be found along the Mac East-Big Lake and Mac West-Connector 2-Big Lake alternatives, because both these alternatives would include the Big Lake Segment.

3.4.3.2 No-Action Alternative

Absent the proposed rail extension, there could be other, non-project-related impacts to geology and soils. Natural processes such as erosion and seismic activity would continue to shape the geology and soils of the area.

3.5 Permafrost

Permafrost is defined as earth (soil) materials that remain continuously frozen (temperature lower than 32 degrees Fahrenheit) for at least 2 years. Permafrost zonation in the northern hemisphere is defined by the percentage of surface underlain by permafrost. The four defined zones are Continuous (90 to 100 percent), Discontinuous (50 to 90 percent), Sporadic (10 to 50 percent), and Isolated Patches (0 to 10 percent) (U.S. Arctic Research Commission Permafrost Task Force, 2003).

3.5.1 Analysis Methodology

No formal field investigations have been performed to determine the presence or absence of permafrost along the proposed rail alternatives. Geotechnical investigations completed to date consist only of surface observations and subsurface probing to determine the depth of soft surficial soils. No permafrost was identified during these investigations. Using available Geographic Information System data, analyses were performed by SEA to infer the presence of permafrost through identification of physical surface features that are typically indicative of frozen ground, specifically, scrub black spruce forests and steep north-facing terrain that limits ground exposure to sun and its warming effects. The permafrost analysis study area consists of the 200-foot-wide ROW of the individual proposed rail line segments and segment combinations. The analyses consisted of the determination of areas within the ROW of each alignment where evergreen forests are present on north-facing slopes steeper than 20 percent.

3.5.2 Affected Environment

Various permafrost studies and references classify the area of the Susitna Lowland plain (the location of the proposed rail line) as either isolated patch permafrost, or as an area that is generally free of permafrost. There have been no formal field investigations to specifically identify permafrost along the proposed rail line segments and segment combinations, however, the presence of permafrost has been documented in the study area.

The degree to which permafrost affects the physical environment depends on its type, depth, and extent. Massive permafrost influences overlying vegetation and soil characteristics, runoff, and to a limited extent, topography. Left undisturbed and in a stable state, permafrost has little effect on the physical environment. However, environmental or human disturbances can cause irreversible thawing and degradation of permafrost, which can produce changes to the ground surface and disruption of infrastructure.

The maintenance of permafrost depends on climate and disturbance activities. Mean annual temperatures throughout Alaska have shown a warming trend that, if it continues, would reduce the extent of permafrost. A reversal in this trend could cause an increase in the extent of permafrost. Human disturbance has much more immediate effects.

For areas within the ROW of each alternative where evergreen forests are present on north-facing slopes steeper than 20 percent, the Geographic Information System analyses identified only two very small areas where this combination exists (<1 acre along the Houston Segment and <1 acre along the Big Lake Segment). This analysis was conservative because slopes providing shade to harbor permafrost generally need to be much steeper, and the evergreen forest Geographic Information System data represent a much more diverse community of vegetation than the scrub black spruce forest of concern. With the exception of the small areas noted above, there are essentially no areas along the proposed rail alternatives that have a combination of the two conditions that would indicate a high probability of underlying permafrost. Although permafrost could be present in the study area, the physical characteristics of the area (gently rolling terrain with mixed deciduous and evergreen forests) are indicative of sporadic to nonexistent permafrost zonation.

3.5.3 Environmental Consequences

3.5.3.1 Proposed Action

In the absence of identified locations or types of permafrost in the study area, it is not possible to correlate impacts to individual rail line segments or segment combinations. Therefore, the following discussion of impacts to permafrost is common to all segments and segment combinations.

Construction Impacts

Any disturbances during construction activities that cause permafrost to degrade would result in a permanent change. Upon completion of construction, the condition of the affected permafrost would either not change or continue to degrade with the passage of time until it reached thermal equilibrium.

Although permafrost is the predominant and most serious cause of engineering problems that affect the Alaska Railroad in Interior Alaska, it is not reported to be a problem along the portions of the existing railroad system south of the Alaska Range. Clearing, disruption of vegetative cover, placement of fill materials, and other construction activities would disturb thermal equilibrium in the subgrade. If permafrost was present, these activities would induce thawing, which could result in subsidence of the ground surface. Significant amounts of subsidence could severely disrupt infrastructure such as roads, bridges, buildings, culverts, and utilities. The extent of settlement and resulting damage would be directly related to the amount of ice present in the permafrost that melted before thermal equilibrium was reached.

Construction of the railbed would remove or reduce the insulating vegetative layer and also reduce the surface albedo (reflectance of solar energy), which would cause an increase in ground surface temperature in summer. These conditions would increase thaw penetration below the natural depth of thaw. If the soils were thaw-unstable (high ice content in combination with silty soils), the embankment and its shoulders would settle as the ice melted and the water drained out of the soil. If the railbed was constructed on permafrost with a high potential for subsidence, the rate of thaw could be slowed by the use of insulating mats and gravel embankments of increased thickness to keep frozen substrates frozen, and therefore load bearing.

Specific construction methods that would be employed in areas of permafrost, if present, would greatly depend on the permafrost and site conditions encountered. Because areas of permafrost in the study area are expected to be few and small, minor shifts of the rail alignment could avoid or minimize impacts to permafrost. Therefore, impacts to permafrost during rail line construction would be expected to be low.

Operations Impacts

During rail line operations, temperature changes in the railbed related to compaction and friction produced by equipment using the railbed could cause impacts to permafrost, if present; however, these impacts would be expected to be low.

3.5.3.2 No-Action Alternative

Because permafrost was not identified as likely to be present in the project area, any potential impacts would be limited. Nevertheless, natural processes such as climate change and any potential alternative development activities that could occur in place of the proposed rail extension could impact permafrost if it was present.

3.6 Seismic Hazards

3.6.1 Analysis Methodology

Seismic hazard analyses were performed by reviewing scientific and engineering literature regarding seismicity in Southcentral Alaska, and reviewing maps of probabilistic seismic hazards in the study area. Assessments of seismic potential and hazard can be evaluated to estimate the probabilities that various levels of earthquake ground motion would be exceeded at a site in a period of time. Such evaluations use three inputs – seismic source, seismicity, and a ground motion attenuation function (a function of earthquake magnitude and distance) (DOI, 2002). The resulting evaluation of seismic hazard can be used to produce maps of probabilistic seismic hazard.

Probabilistic seismic hazard maps of Alaska were prepared in 1999 (Wesson, 2007). In 2005, an effort to revise and extend the maps was initiated, taking into account new and improved information about the earthquake hazard in the region and improvements in methodology. The most significant development since preparation of the 1999 maps was the occurrence of the November 3, 2002, Denali earthquake (moment magnitude 7.9), the epicenter of which was about 50 miles south of Donnelly, Alaska, approximately 150 miles north-northeast of the project area. Ground motion was felt most strongly north of the Alaska Range. This was the largest earthquake recorded in Interior Alaska (USGS, 2006; Trans-Alaska Pipeline System Owners, 2001). Because of high seismic activity in the proposed Port MacKenzie Rail Extension study area, seismic events could affect all alternatives. Due to the regional nature of seismic hazards, the seismic hazards study area covers a broad geographic area including essentially all of Southcentral Alaska and the Alaska Range.

3.6.2 Affected Environment

The Upper Cook Inlet Basin is a very tectonically active region, characterized by numerous potentially active fault-cored folds (folded layers of rock with faults that run through the center of the folds) between two major linear faults and underlain by the subduction zone (the area where one plate is forced beneath another) between the North American and Pacific Plates. Seismicity in the region comes from three sources (see Figure 3-2) – megathrust earthquakes associated with the subduction zone, strike-slip earthquakes associated with the surficial transformation boundary (the area at the Earth's surface where one plate moves against another) between plates, and shallow crust earthquakes within the North American Plate (PND Engineering Inc., 2006).

The megathrust subduction zone is the dominant source of seismicity capable of producing earthquakes of magnitude 9 or greater. Earthquakes of this magnitude are capable of lasting for minutes and having an extreme number of ground motion cycles; thus, they have a greater probability of causing damage. Shallow crustal earthquakes and strike-slip fault earthquakes have much shorter durations and less extreme motion cycles.

The Castle Mountain Fault is an active strike-slip (horizontal movement of plates along a fault line) fault, the western part of which runs through the vicinity of the project. This western part of the fault has a 38-mile-long Holocene fault scarp (surface feature that has occurred within the last 12,000 years). Two earthquakes have been recorded on this fault – a magnitude 5.7 earthquake in 1983 and a magnitude 4.5 earthquake in 1996. Both earthquakes occurred on the eastern part of the fault (not within the study area) and neither resulted in surface displacement. Characteristics of the Castle Mountain Fault were recently revised in USGS Report 2007-1043 (Wesson *et al.*, 2007). New data and analysis suggest slip rates higher than those previously determined, and earthquakes of a reduced magnitude (7.1 versus 7.5) with a recurrence interval of 730 years.

3.6.3 Environmental Consequences

3.6.3.1 Proposed Action

Seismic impacts on the study area would most likely be common to all segments and segment combinations. Seismic impacts would be the same during rail line operation and maintenance, and proportionally less during rail line construction, depending on when a seismic event occurred. The most likely impact on the rail line from seismic activity would be misalignment or damage to the tracks, railbed, or access road. This could be caused by ground shaking, offset lateral movement, or soil subsidence. If strong enough, ground shaking could also cause trains to derail.

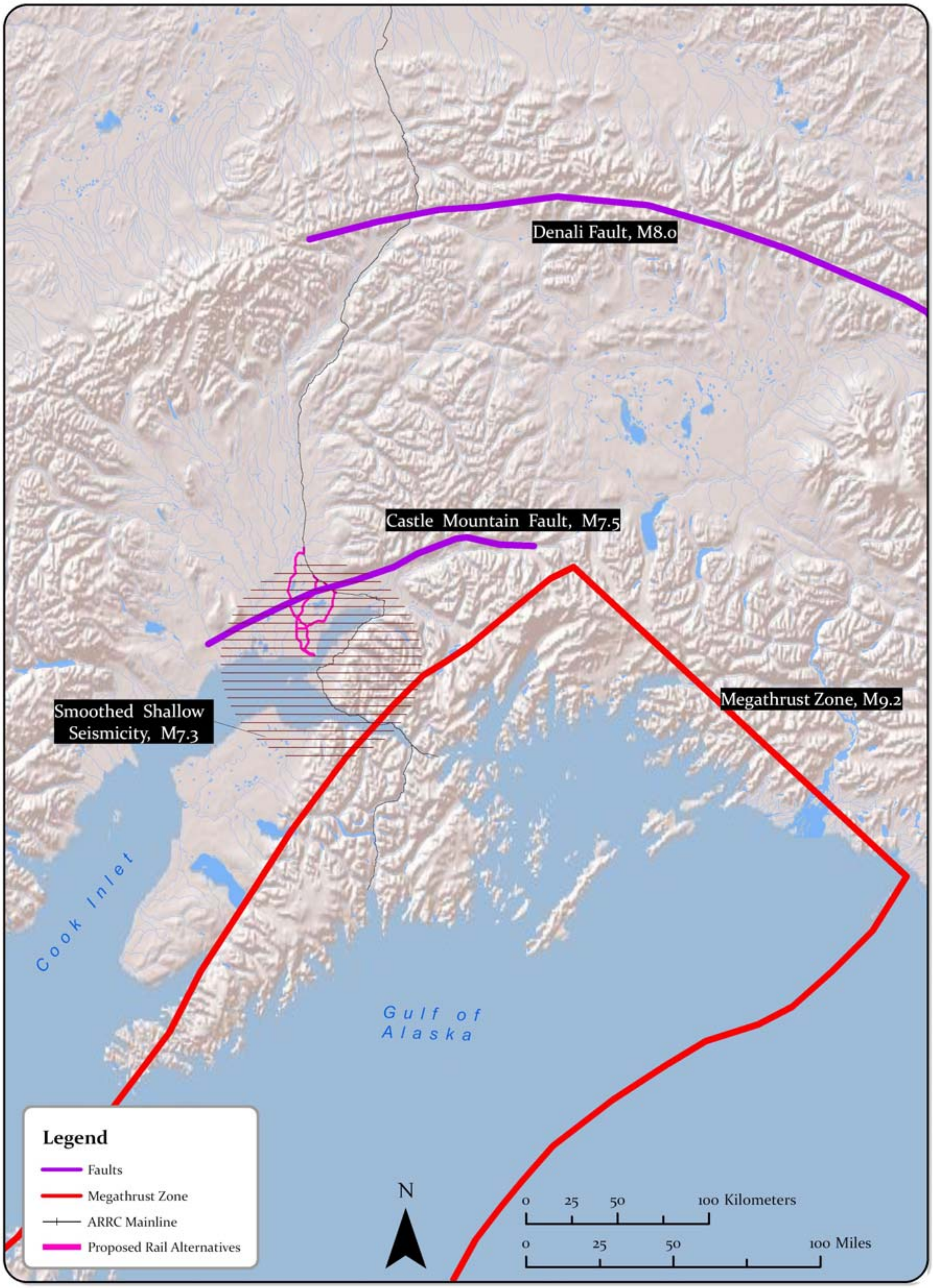

Figure 3-2. Seismicity in the Region of the Proposed Port MacKenzie Rail Extension

The greatest likelihood of potential damage is a loss of subgrade strength by water-laden unconsolidated granular sediments (liquefaction) that would cause embankments to move laterally or settle. Soil liquefaction describes the behavior of loose saturated unconsolidated soils that go from solid state to liquid as a consequence of increasing pore water pressures, decreasing in volume when subject to earthquake loading (Yould and Idriss, 2001). Liquefaction is most likely to occur in loose to moderate granular soils with poor drainage, such as silty sands or sands and gravels capped or containing seams of impermeable sediments. Subsidence and movement of subsurface deposits beneath the railbed could result. The term land-spreading is used to describe the lateral displacement of the soils as it occurs even in flat-lying areas due to liquefaction. Deposits of sands and silts along riverbeds are known to be particularly susceptible to liquefaction. The damage at stream crossings where the railbed and bridge components were constructed over saturated soils was the predominant source of damage to railroad bridges as a result of the 1964 earthquake (McCulloch and Bonilla, 1970). Because topographic relief along the proposed rail line segments and segment combinations consists of scattered gently rolling landforms, the threat of earthquake-induced mass wasting events such as landslides, rockslides, or slumping would be low.

With the segments and segment combinations being relatively close to each other, the minor differences in distance between a segment and a seismic event would not have an appreciably different effect on the segments and segment combinations. Even though the Willow Segment would cross the Castle Mountain Fault, the chances of damage occurring at that location are insignificantly different than damage occurring along other segments and segment combinations due to the regional nature of seismically induced ground motion. This would also be the case for the Houston South Segment and a portion of the Houston Segment that run parallel to and within a mile of the Castle Mountain fault.

3.6.3.2 No-Action Alternative

Under the No-Action Alternative, ARRC would not construct and operate the proposed Port MacKenzie Rail Extension and there would be no impact on the rail line from seismic activity.