

Figure 1-1. Decision making framework for evaluating risk to human health and ecological receptors

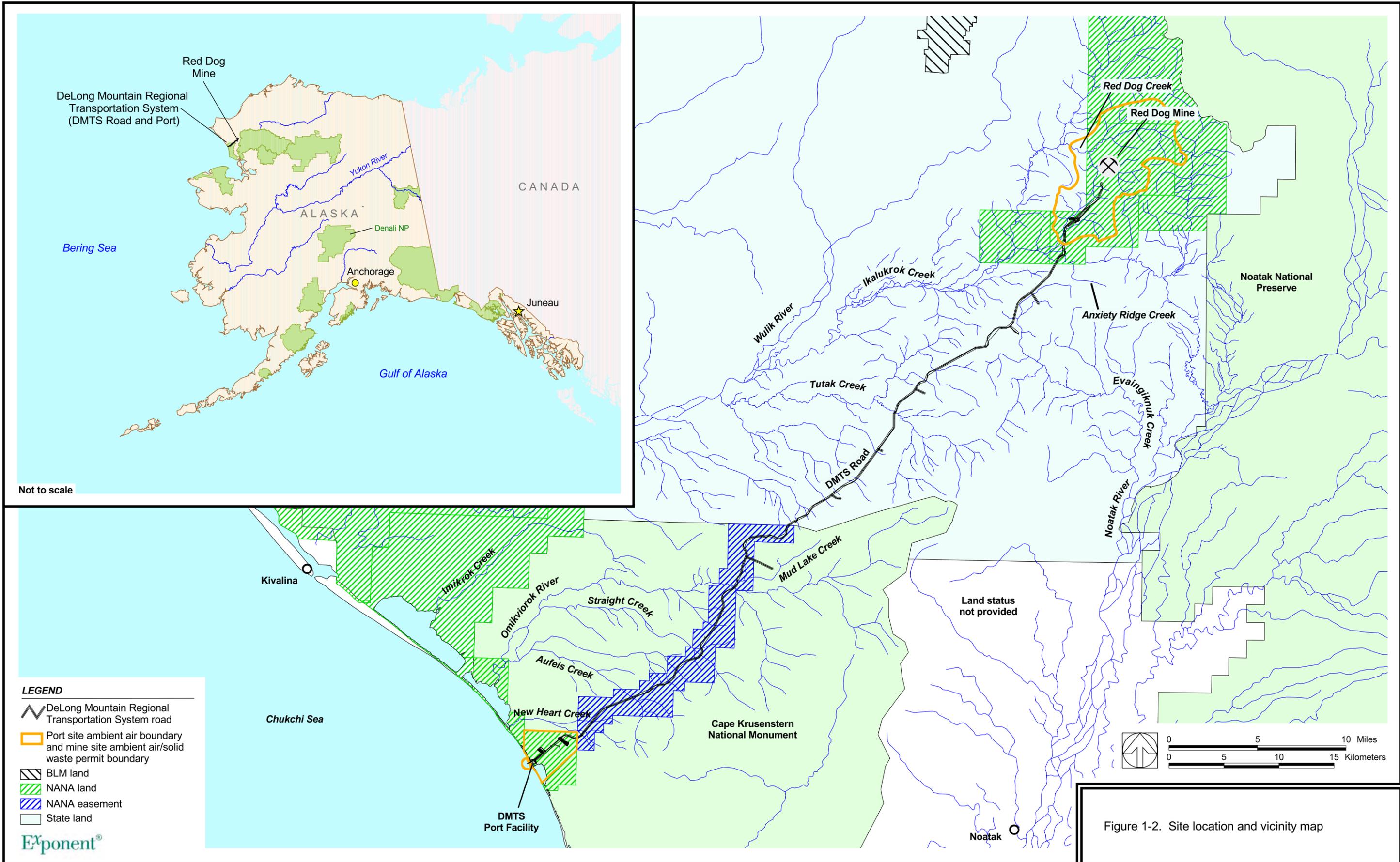


Figure 1-2. Site location and vicinity map



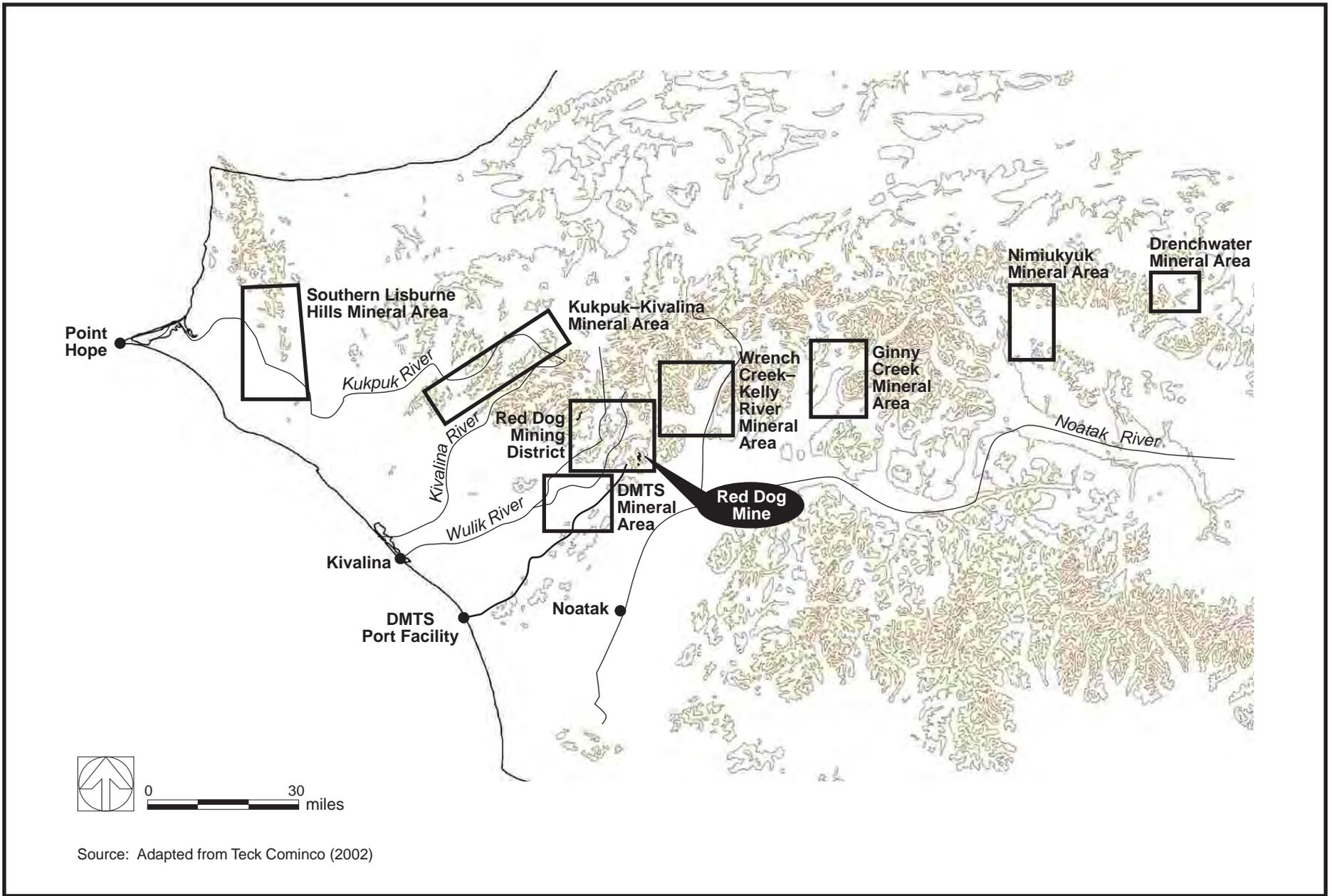
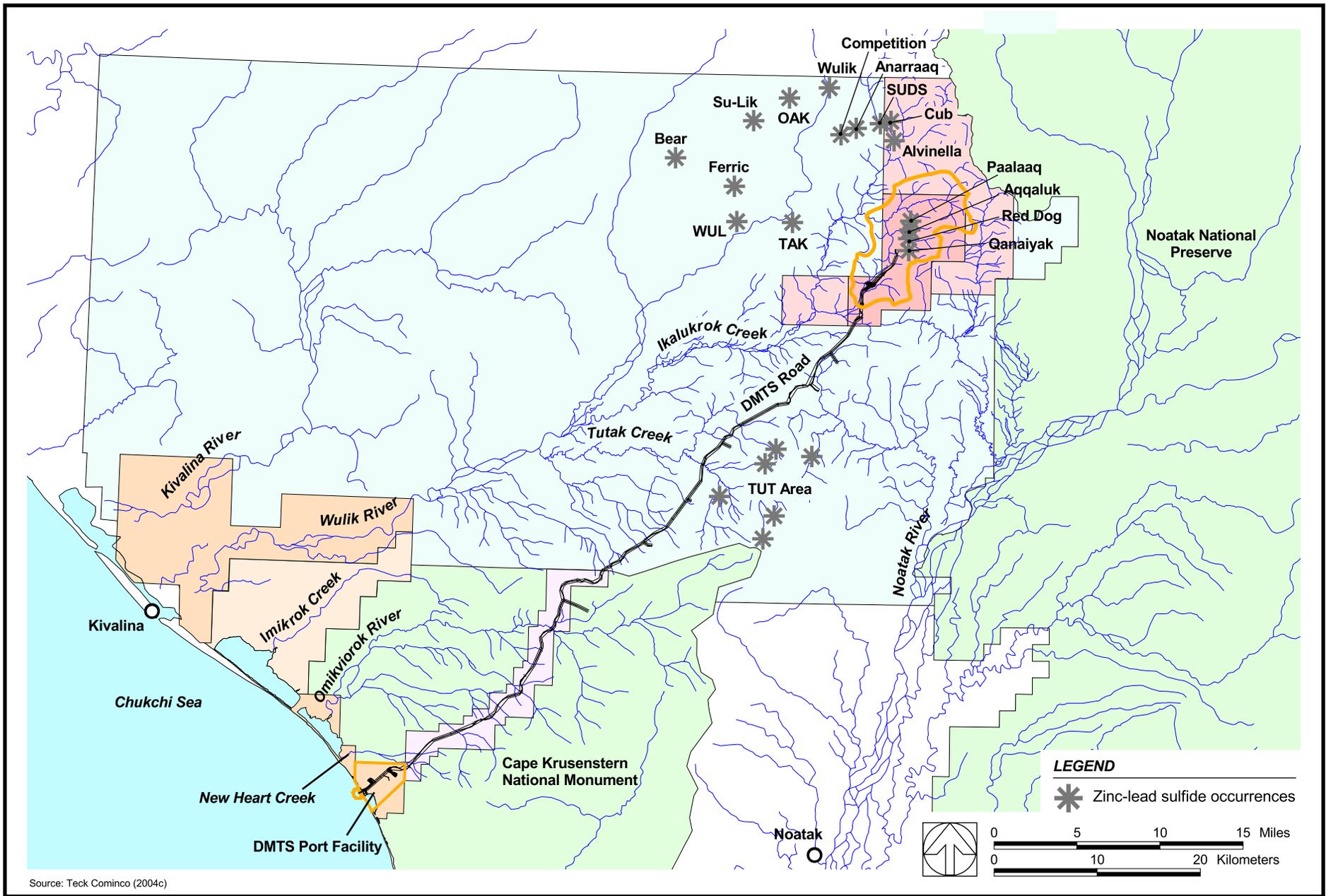


Figure 1-3. Areas of zinc, lead, and barite mineralization in the western Brooks Range, Alaska



Source: Teck Cominco (2004c)

Figure 1-4. Mineralization map for the Red Dog mining district

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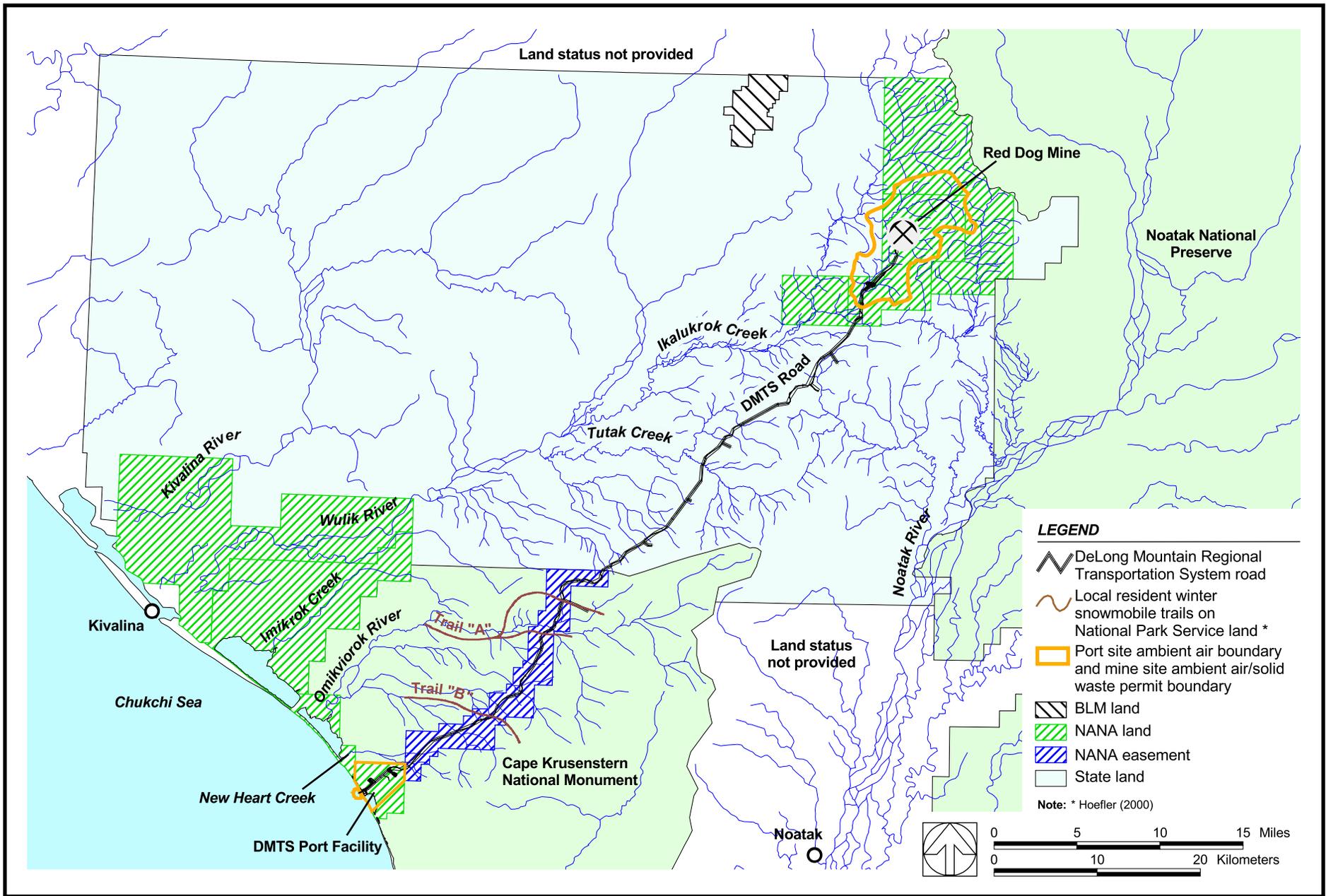


Figure 1-5. Land ownership and use map

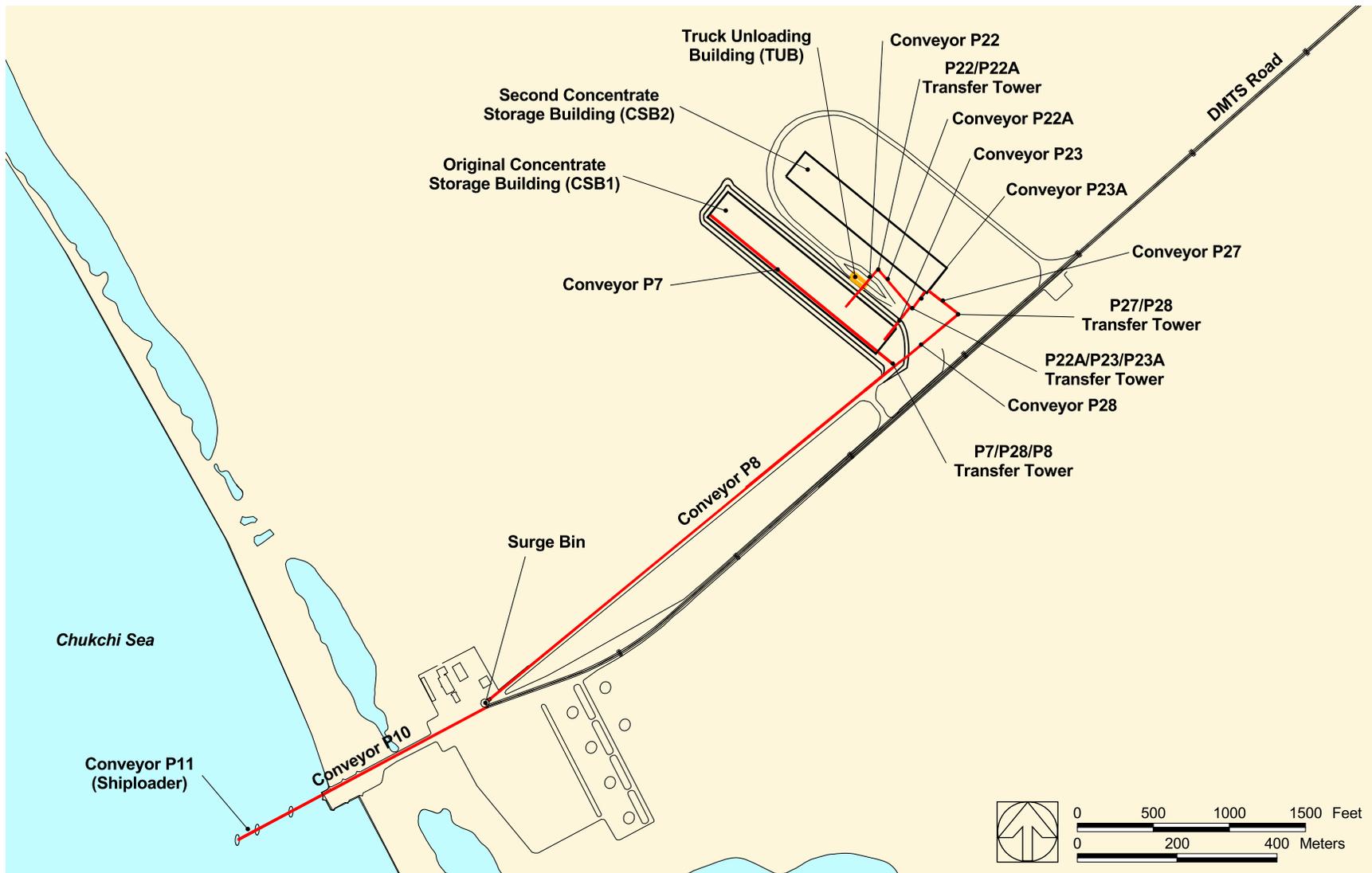


Figure 1-6. Port site storage and conveyance features map

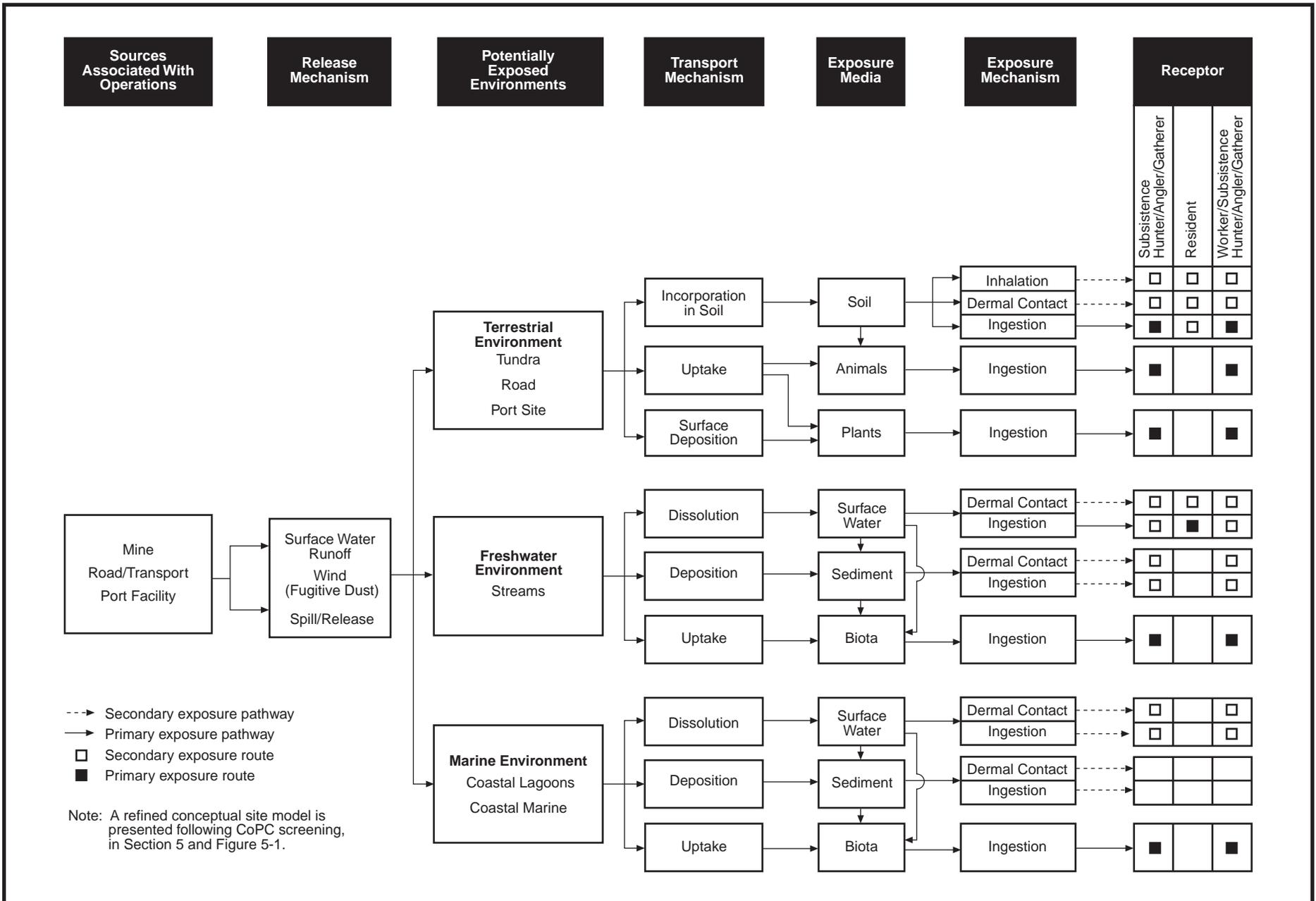


Figure 2-1. Preliminary conceptual site model for the DMTS human health risk assessment

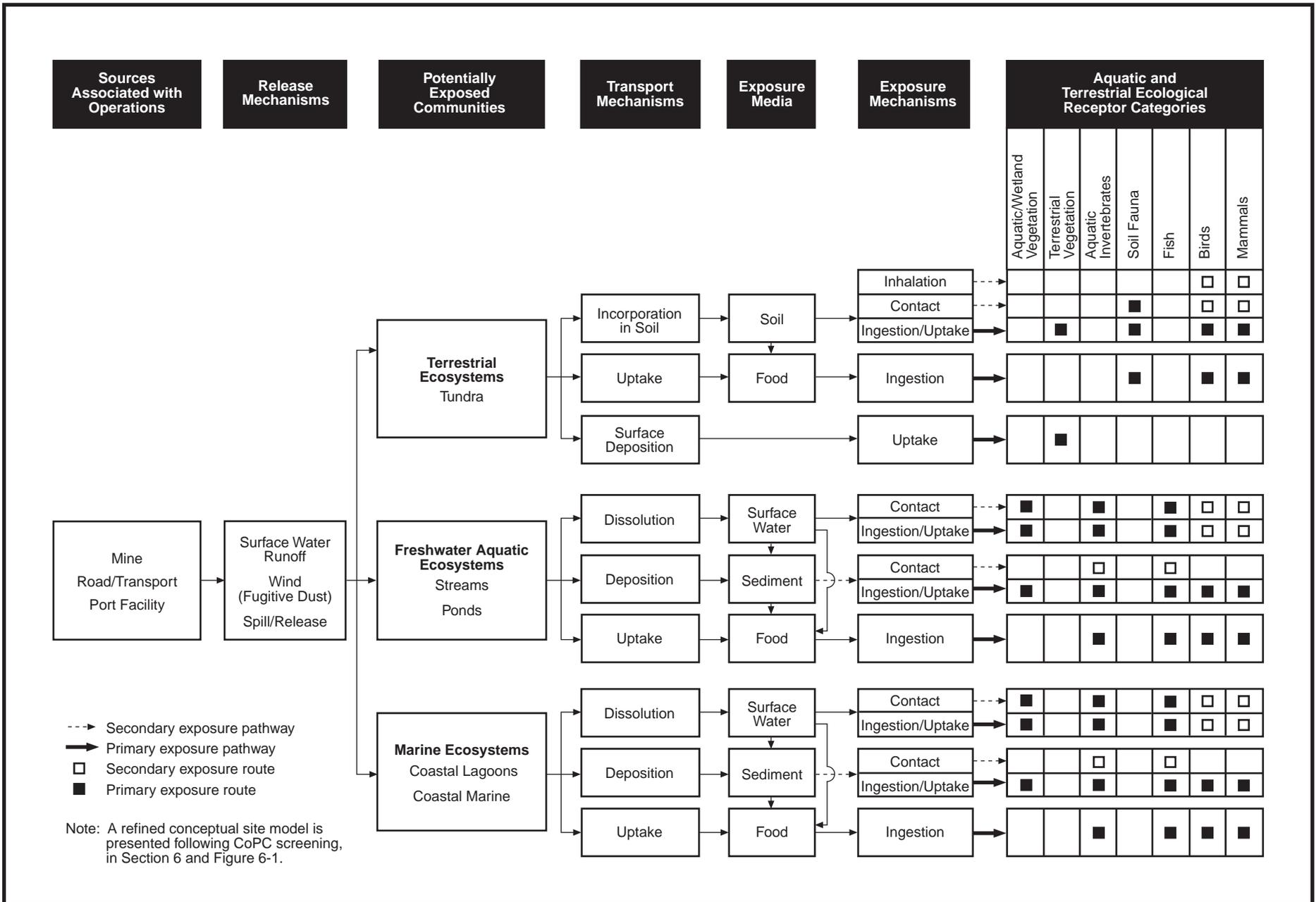


Figure 2-2. Preliminary conceptual site model for the DMTS ecological risk assessment

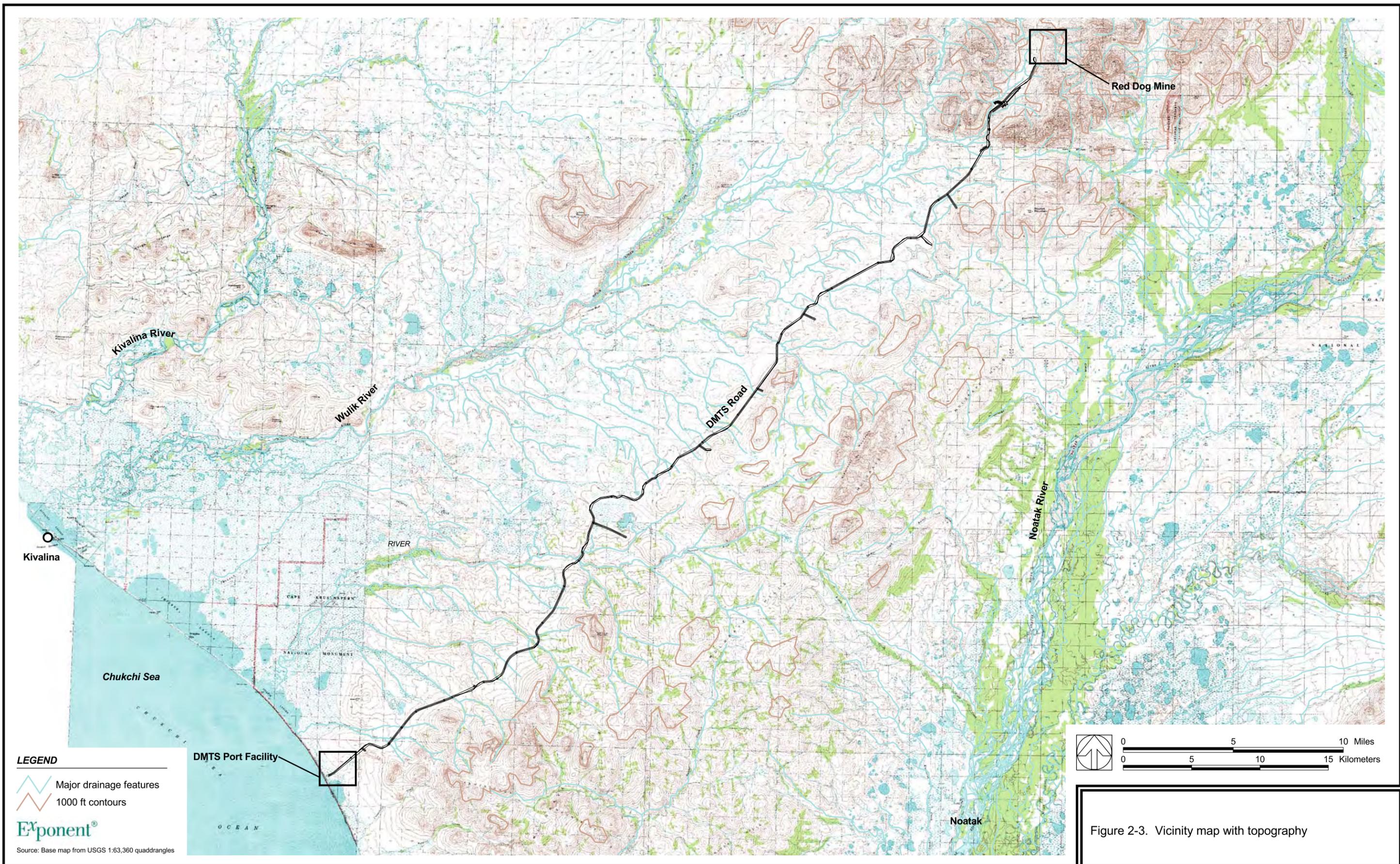


Figure 2-3. Vicinity map with topography

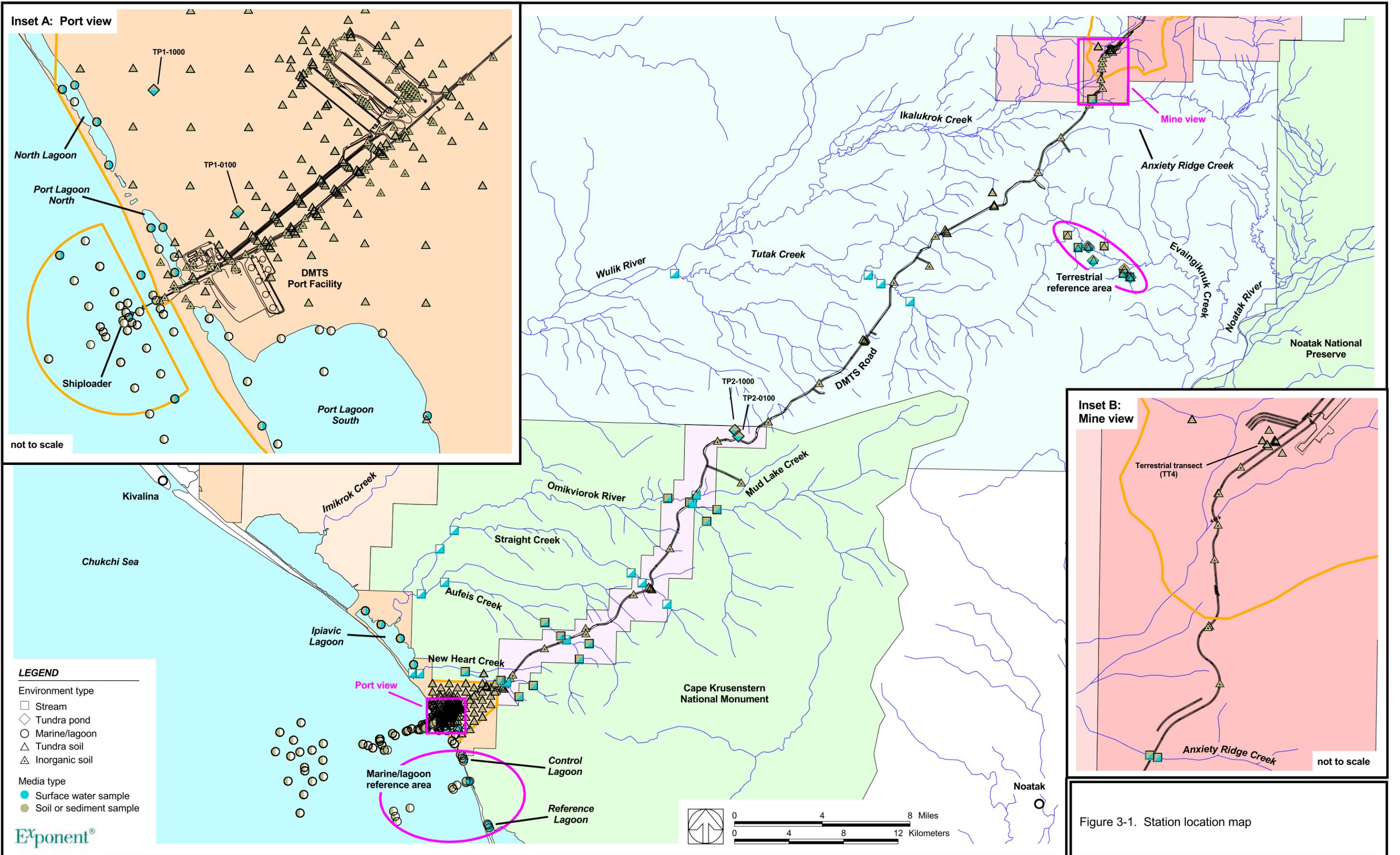


Figure 3-1. Station location map

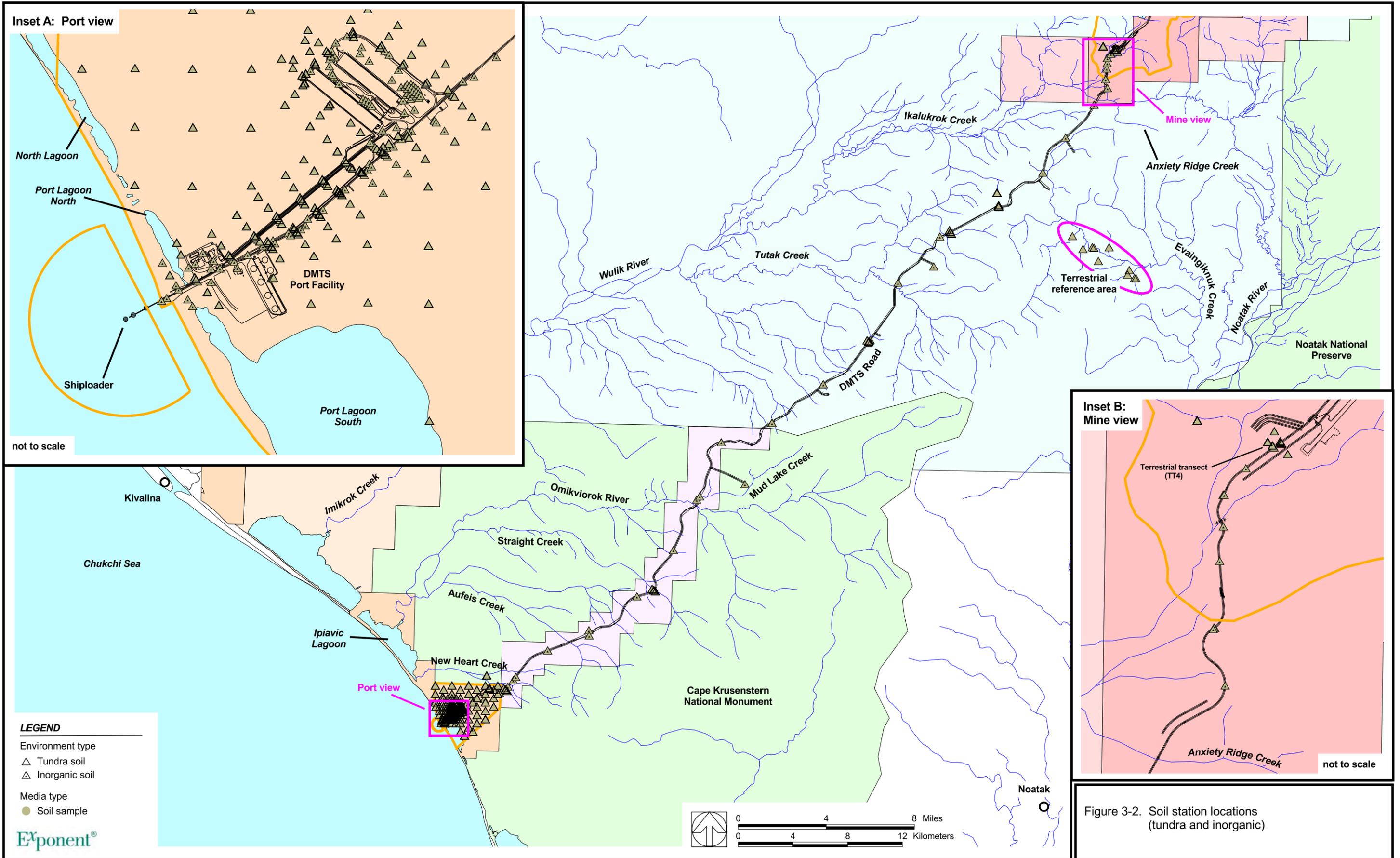


Figure 3-2. Soil station locations (tundra and inorganic)

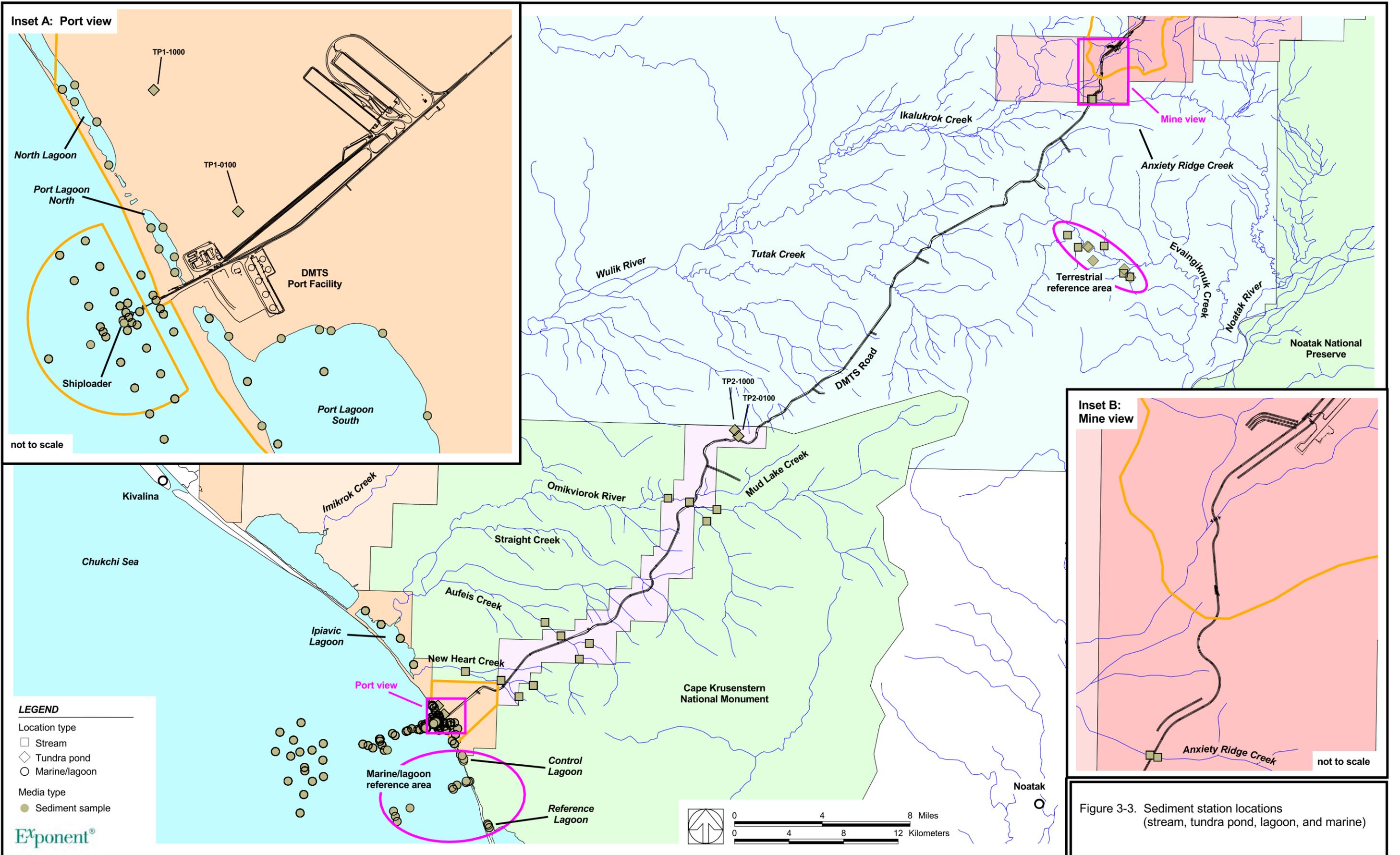


Figure 3-3. Sediment station locations (stream, tundra pond, lagoon, and marine)

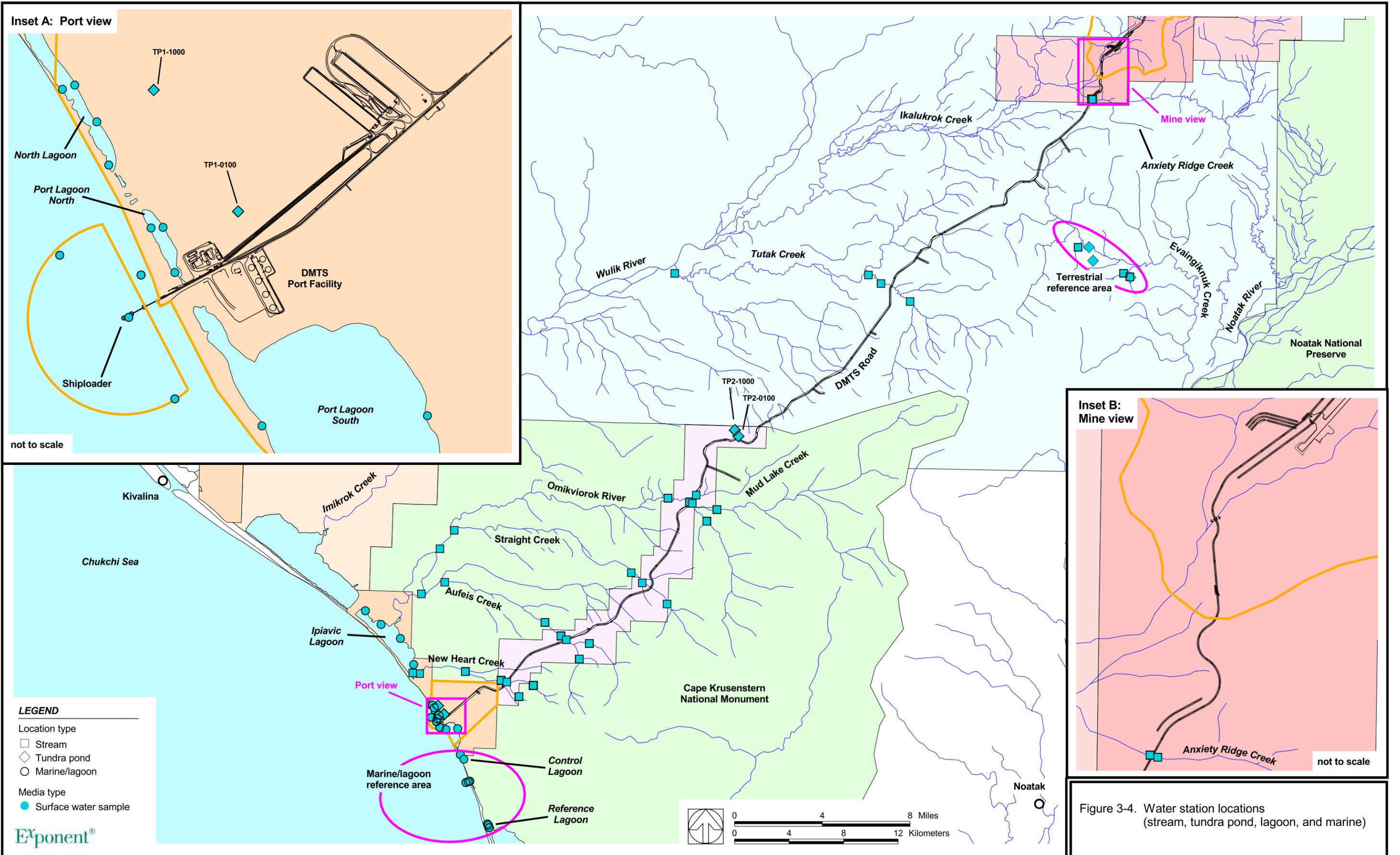


Figure 3-4. Water station locations (stream, tundra pond, lagoon, and marine)



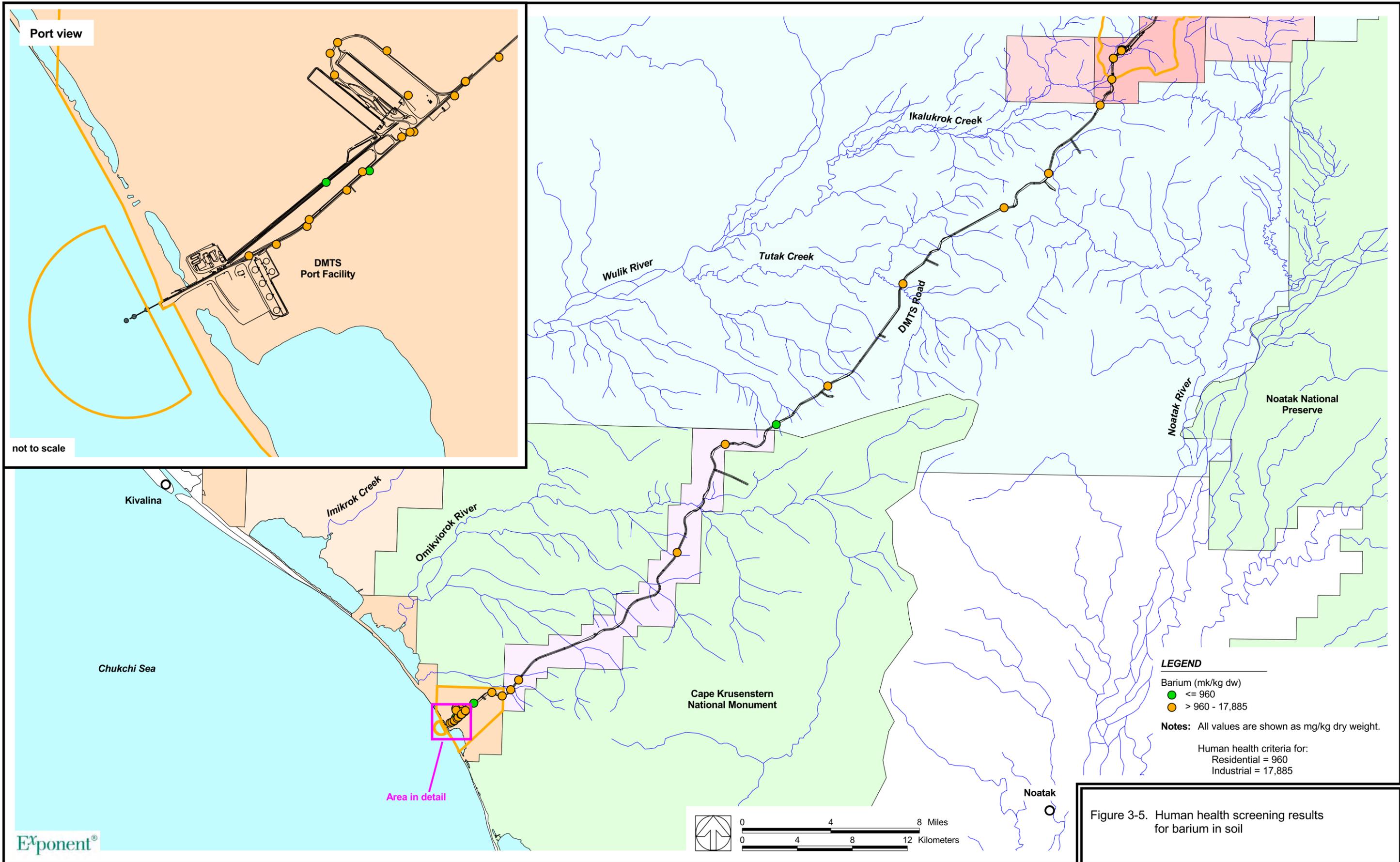


Figure 3-5. Human health screening results for barium in soil

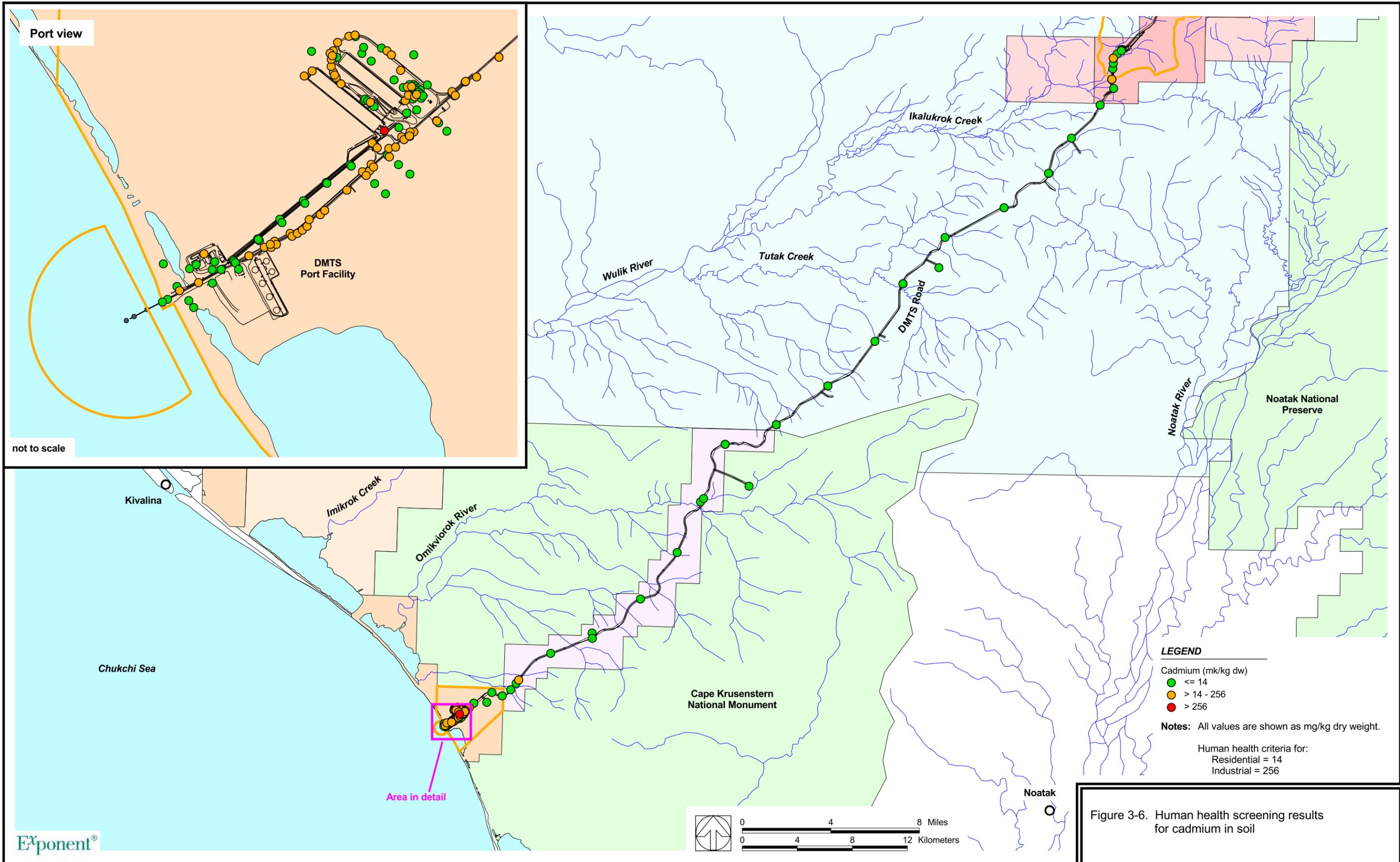
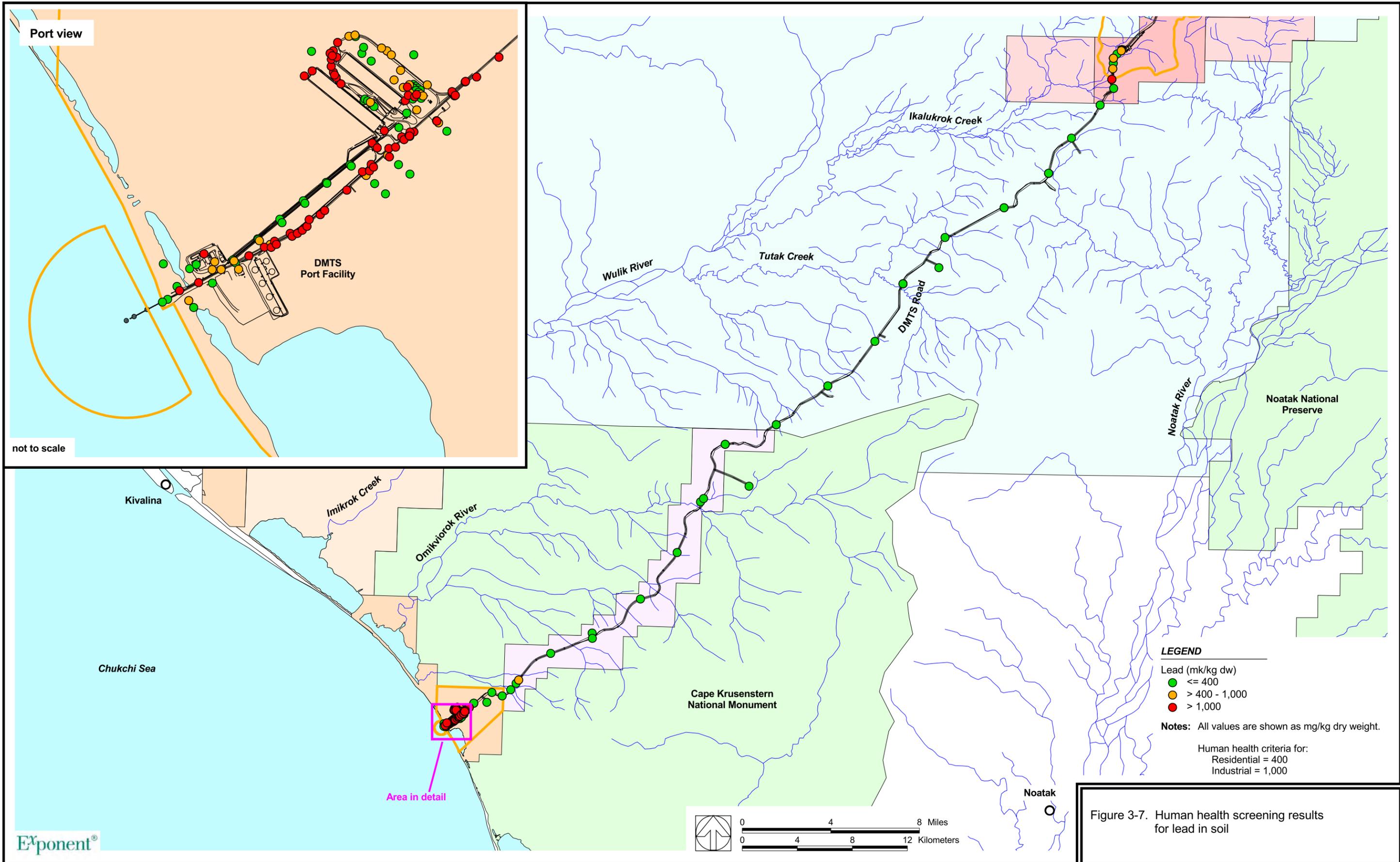


Figure 3-6. Human health screening results for cadmium in soil



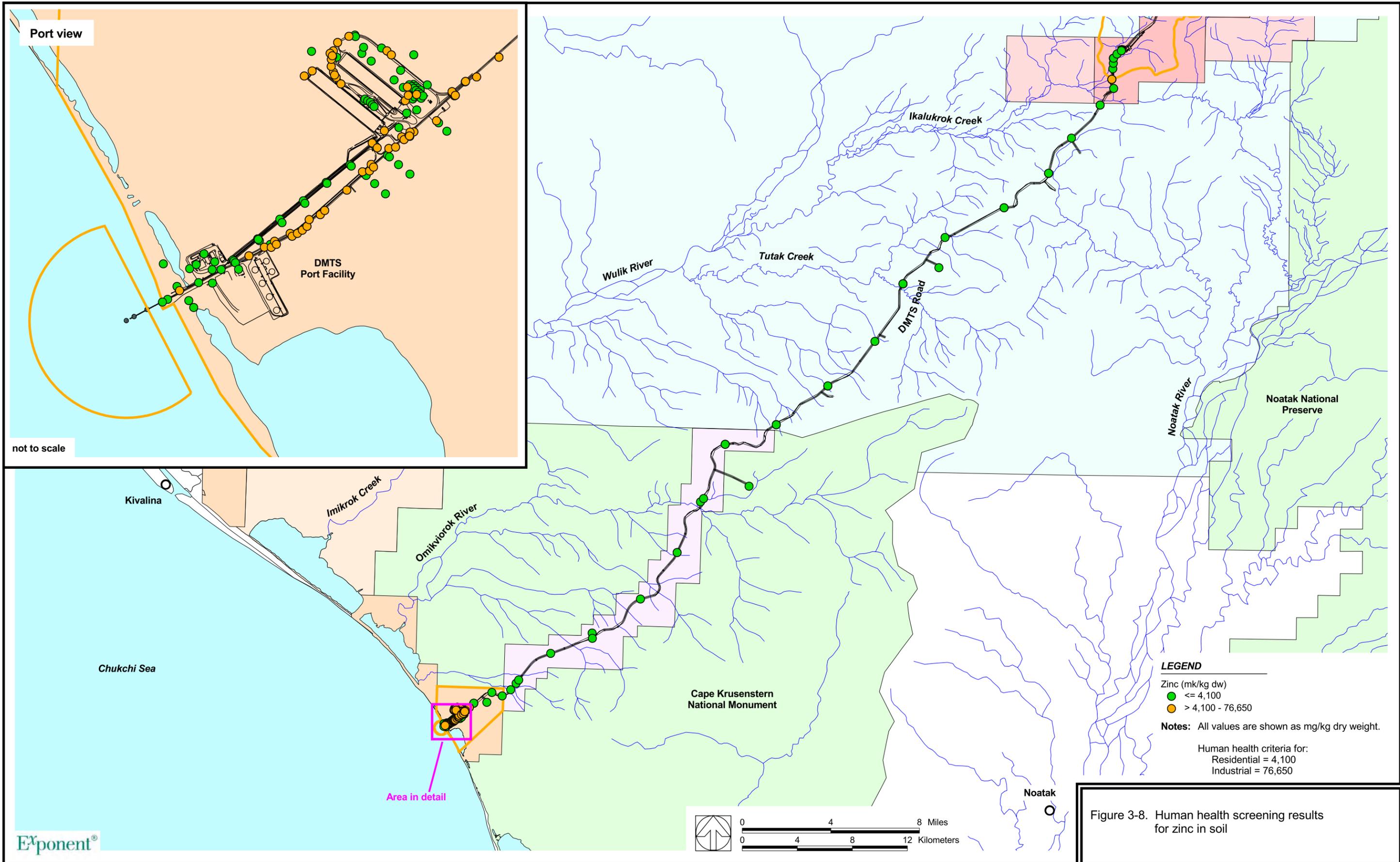


Figure 3-8. Human health screening results for zinc in soil

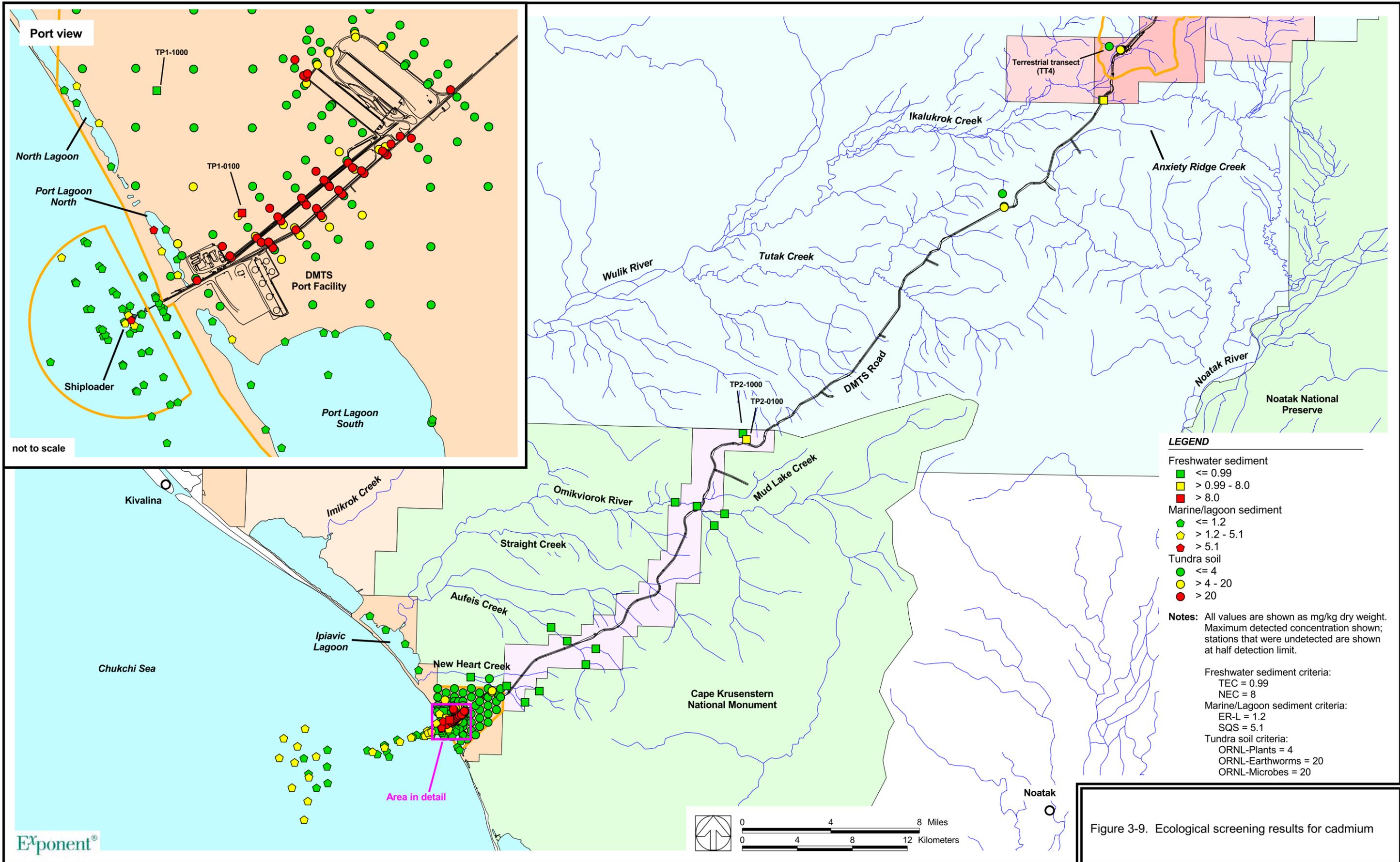


Figure 3-9. Ecological screening results for cadmium



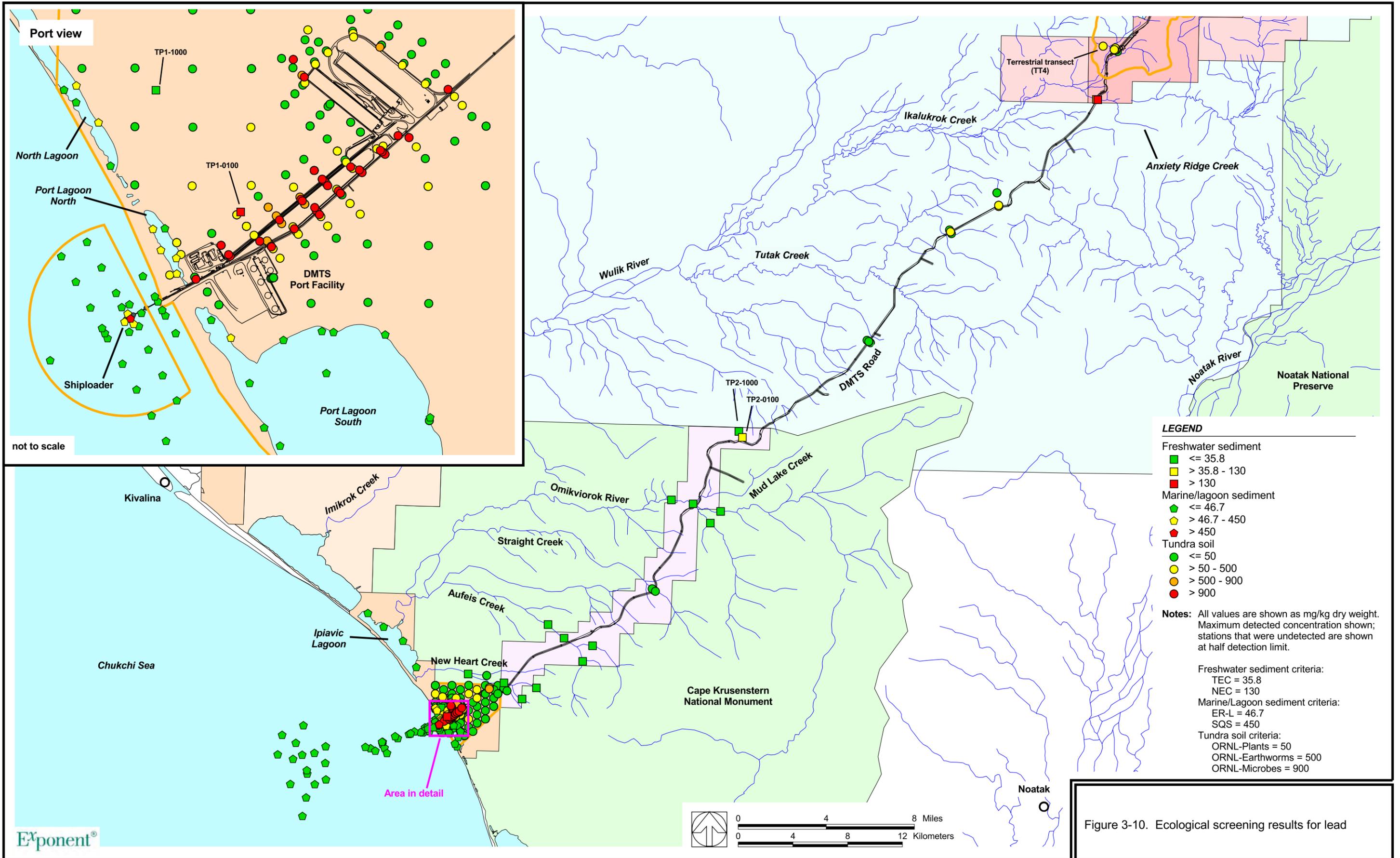


Figure 3-10. Ecological screening results for lead

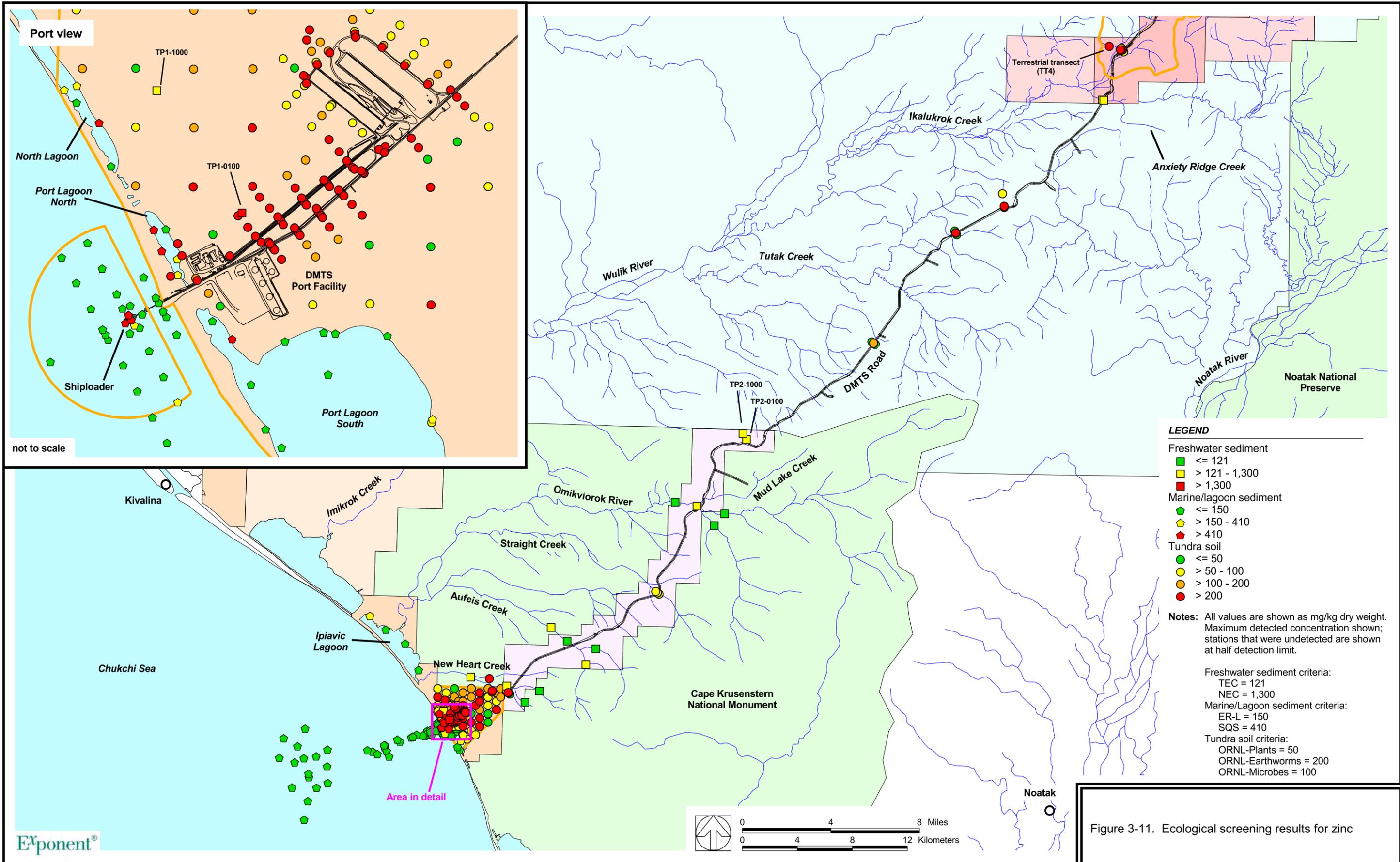


Figure 3-11. Ecological screening results for zinc

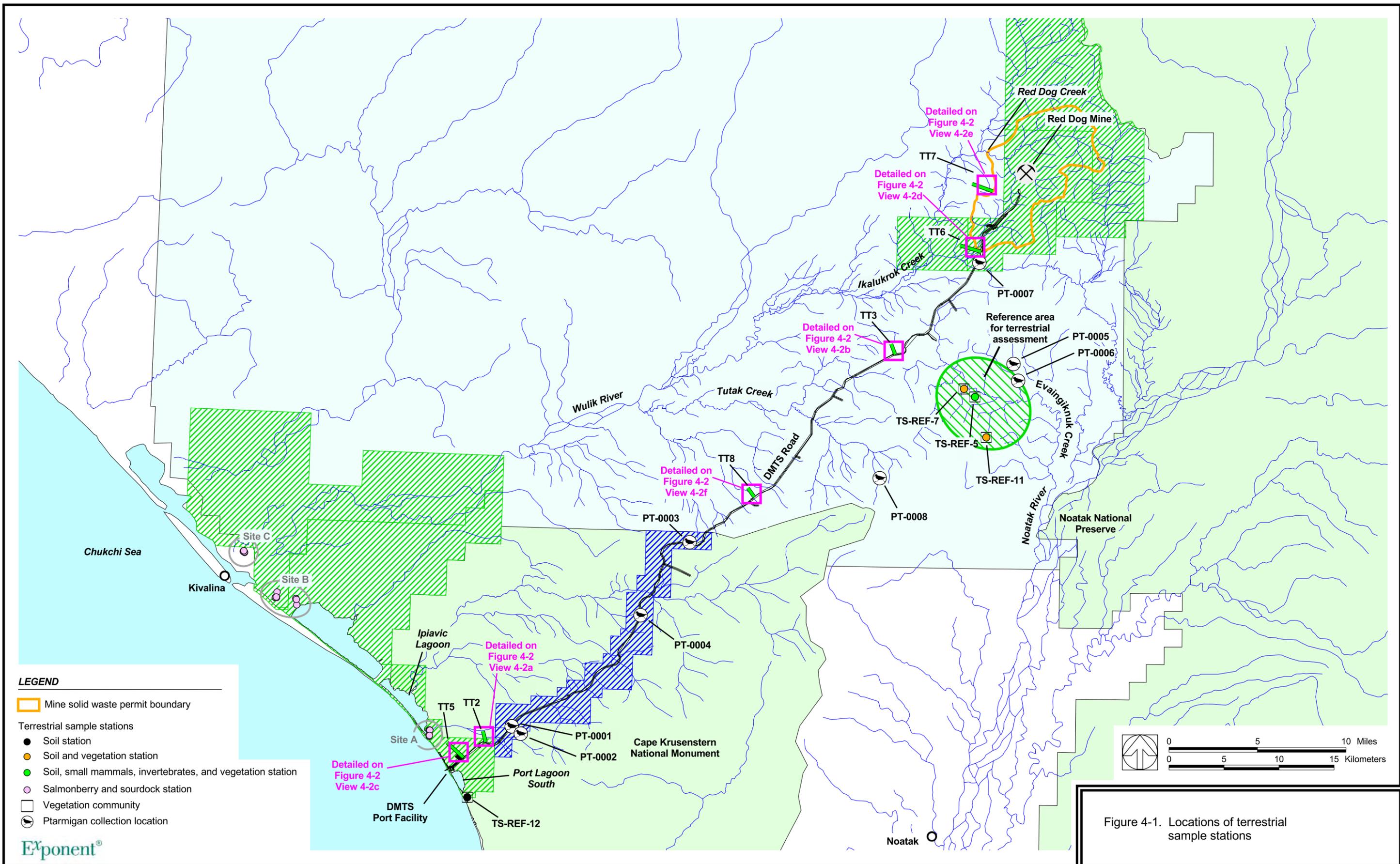
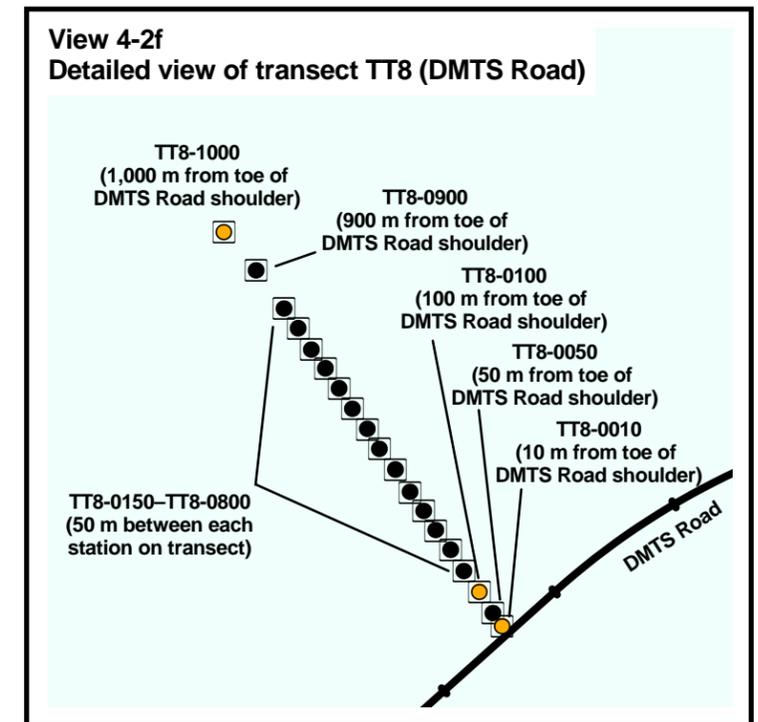
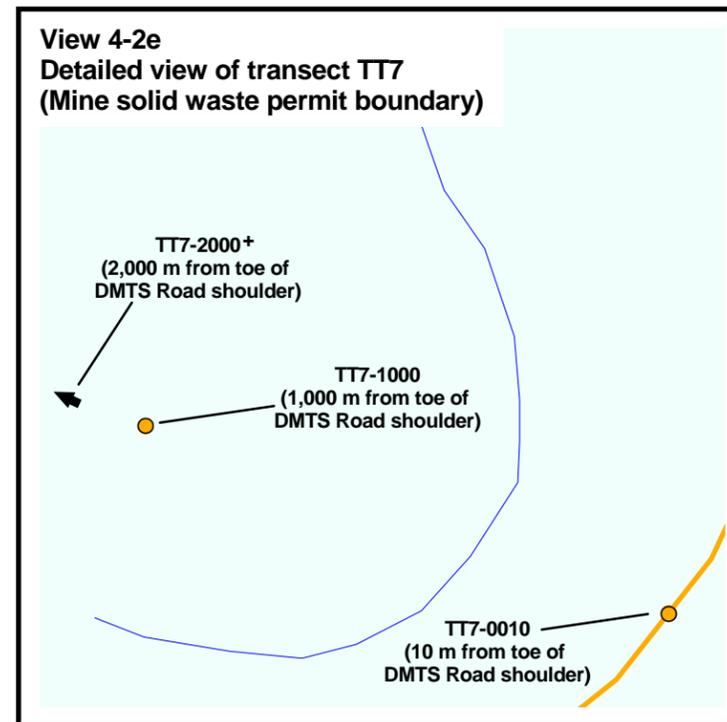
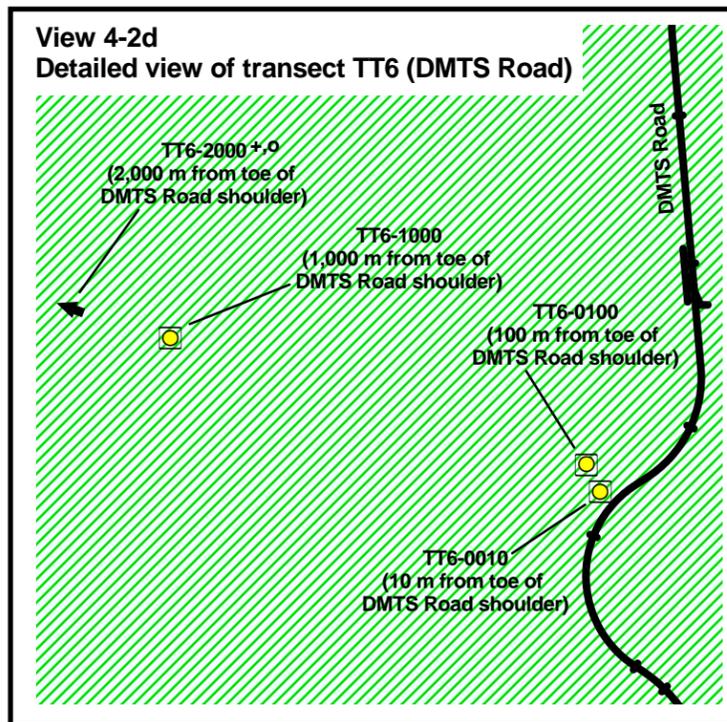
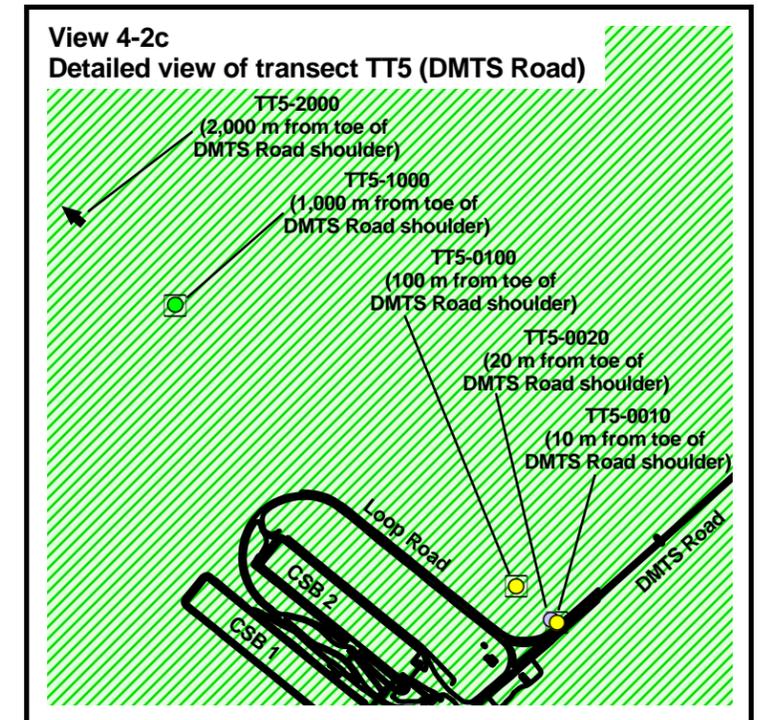
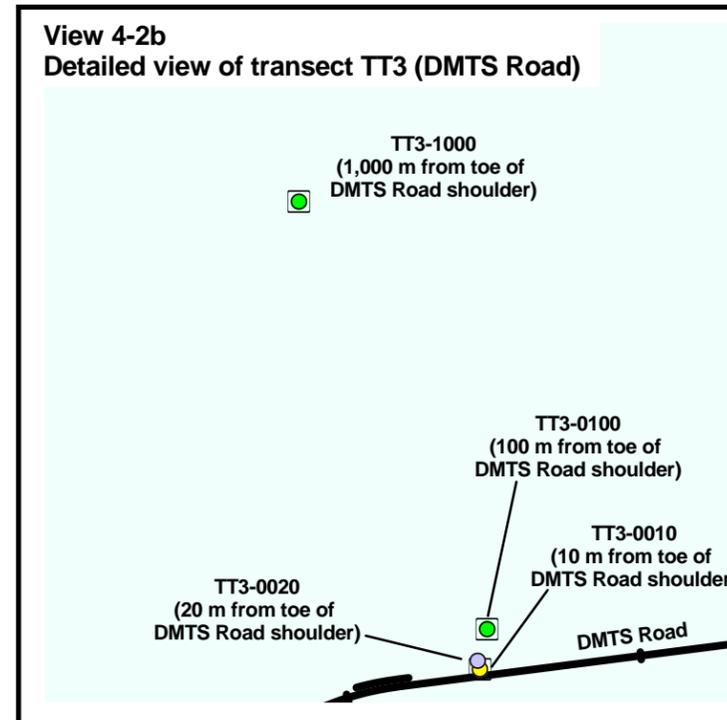
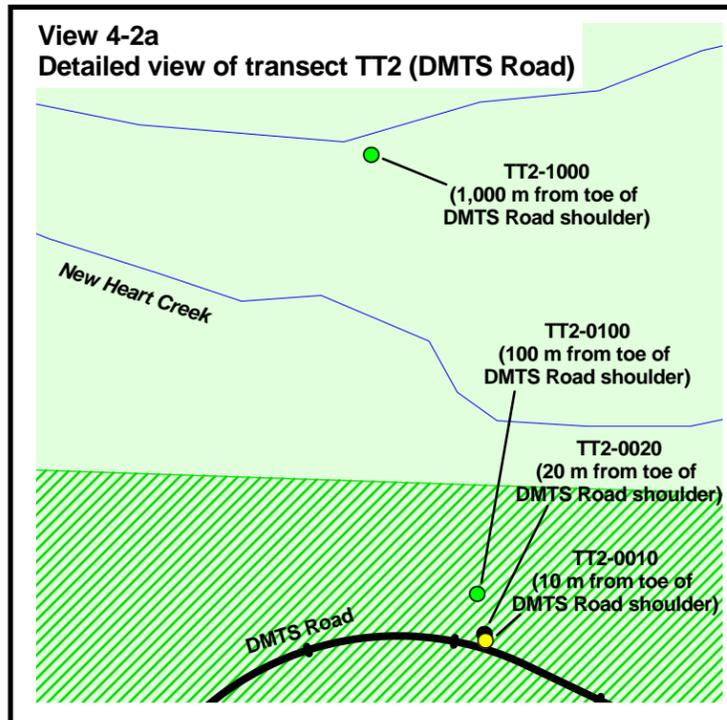


Figure 4-1. Locations of terrestrial sample stations





**LEGEND**

Mine solid waste permit boundary

Terrestrial sample stations

- Soil station
- Soil and vegetation station
- Soil, invertebrates, and vegetation station
- Soil, small mammals, invertebrates, and vegetation station
- Soil and small mammals
- Vegetation community

Notes: + No small mammals or invertebrates collected at this station  
o No vegetation community analysis at this station

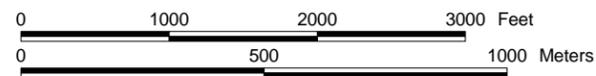
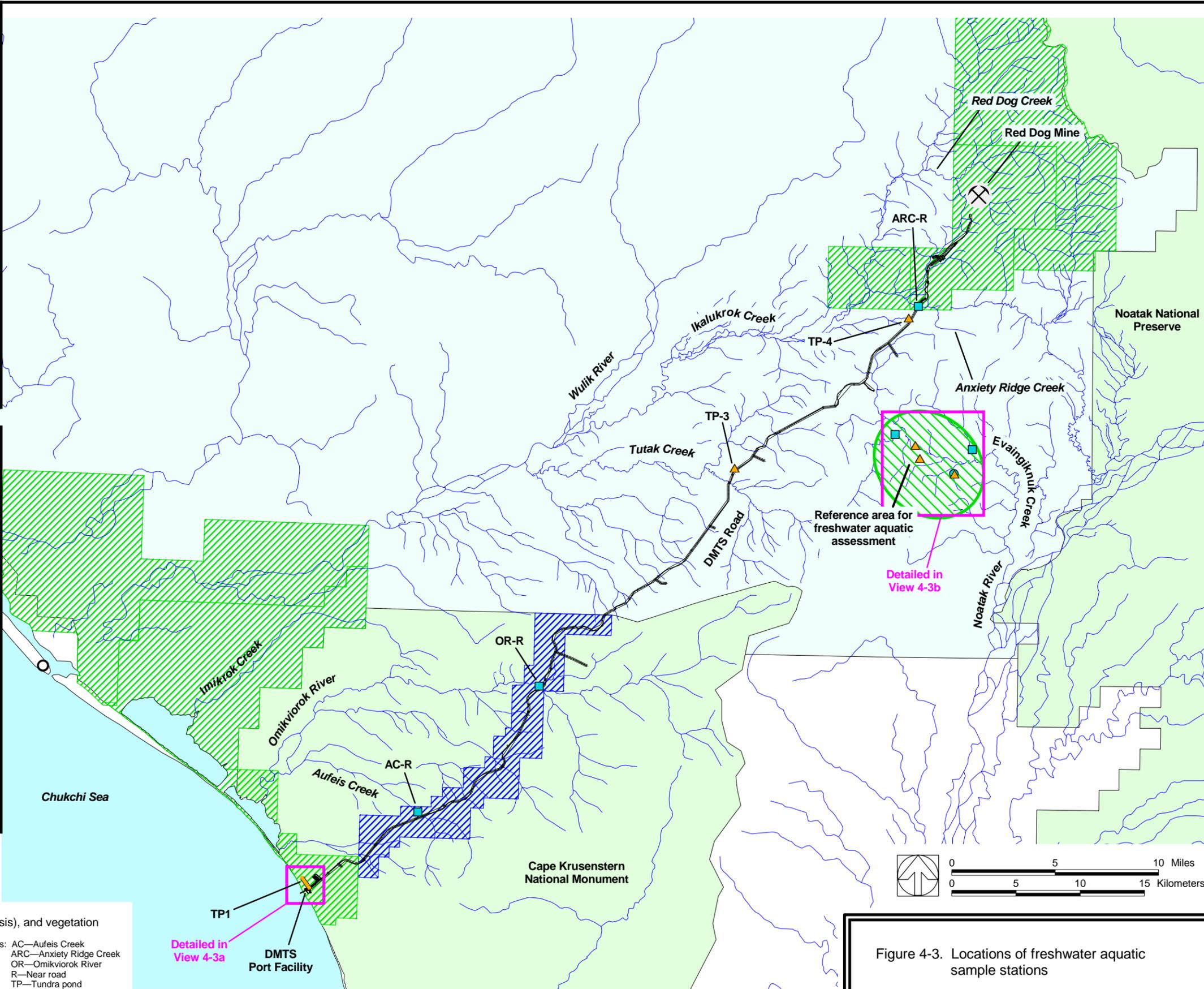
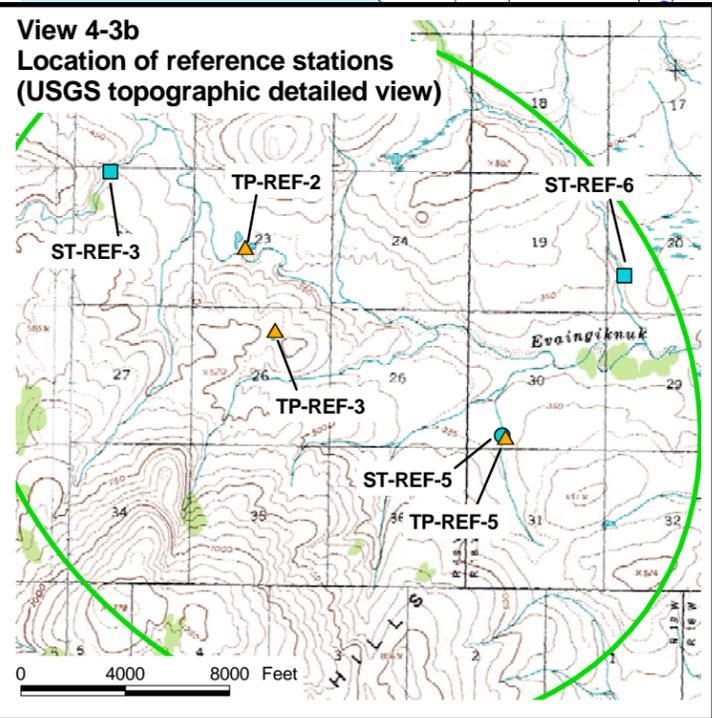
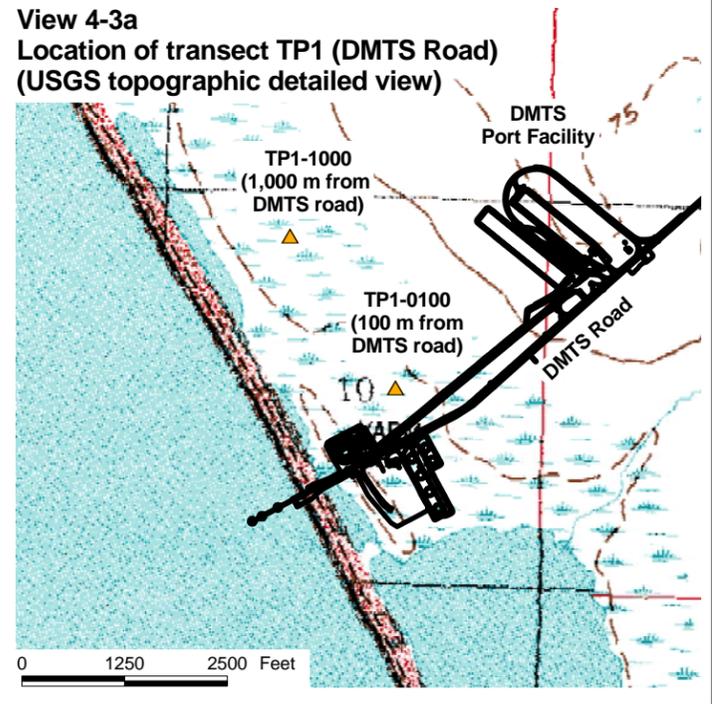


Figure 4-2. Detailed views of locations of terrestrial sample stations



**LEGEND**

Stream station

- Aquatic invertebrates (community analysis), and vegetation
- Sediment, aquatic invertebrates (tissue chemistry and community analysis), and vegetation

Tundra pond station

- ▲ Tundra soil and vegetation

Notes: AC—Aufeis Creek  
 ARC—Anxiety Ridge Creek  
 OR—Omikviorok River  
 R—Near road  
 TP—Tundra pond

Figure 4-3. Locations of freshwater aquatic sample stations

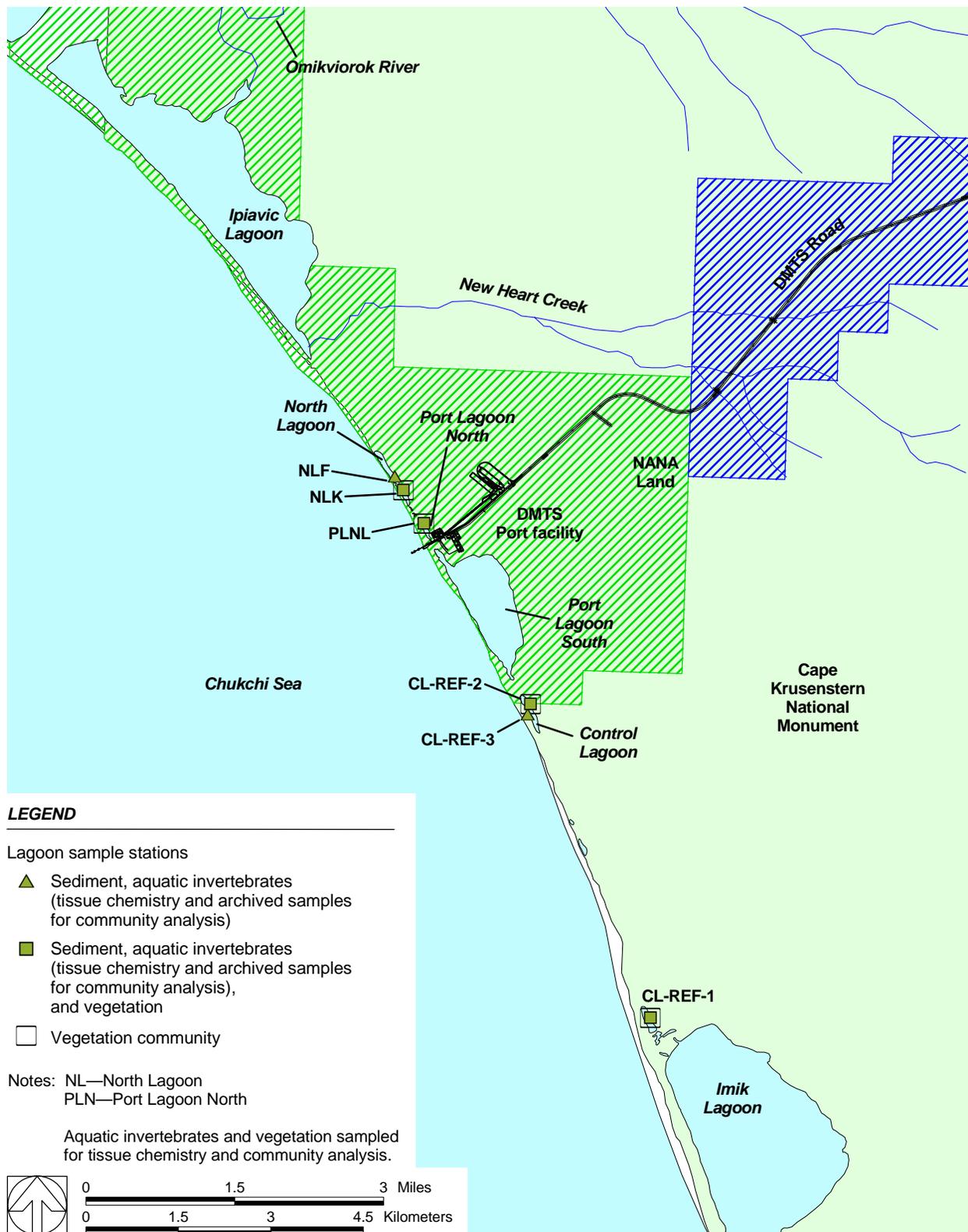


Figure 4-4. Locations of coastal lagoon sample stations

**LEGEND**

- Sediment (sampled for Ag, Cd, Cu, Hg, Pb, and Zn; extra sediment volume collected)
- Sediment (sampled for Cd, Pb, and Zn only)

Notes: All marine locations were sampled before shipping activities and during the shipping season.

NM—Near Shore Marine

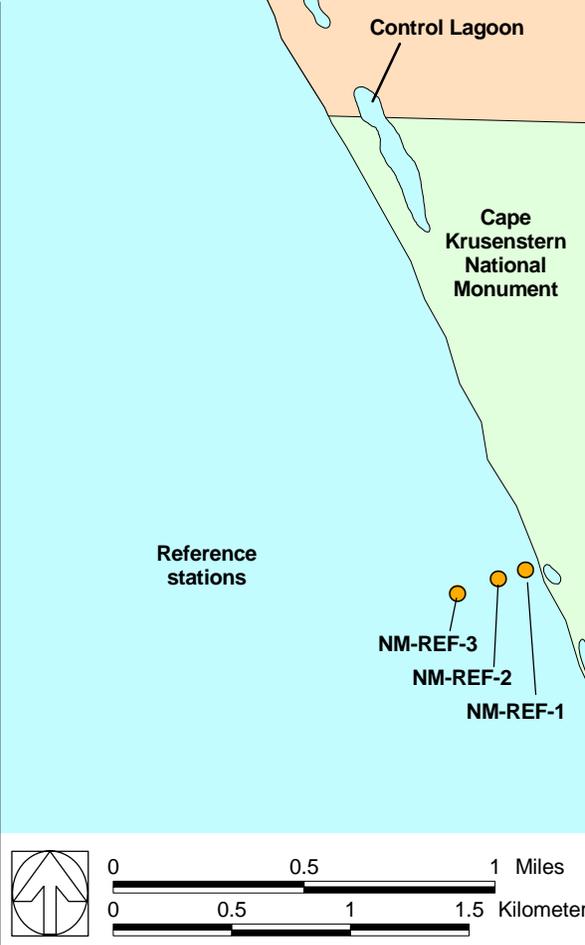
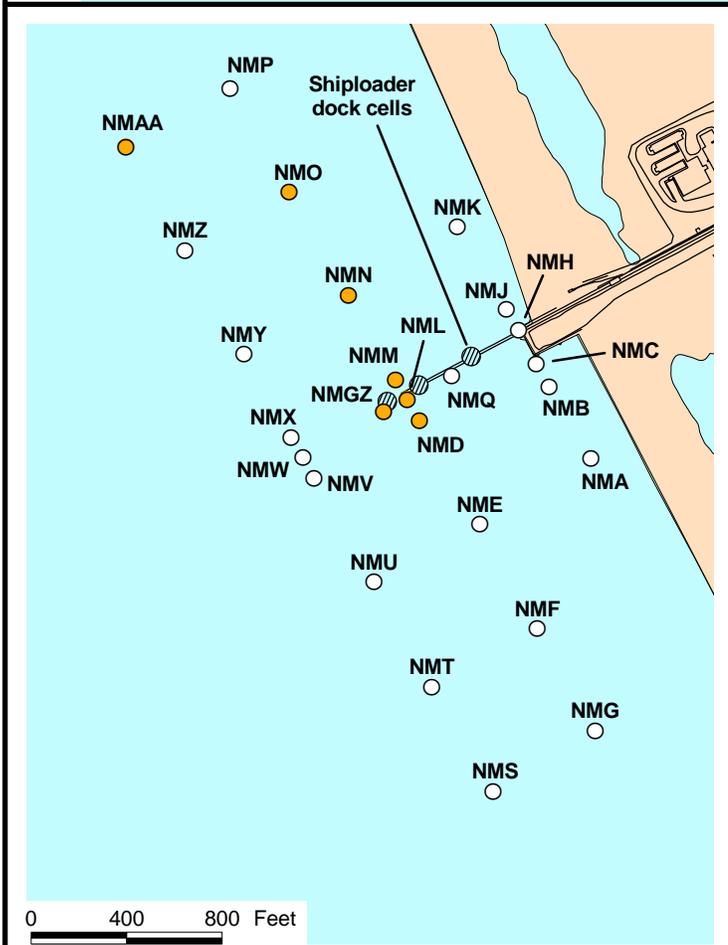
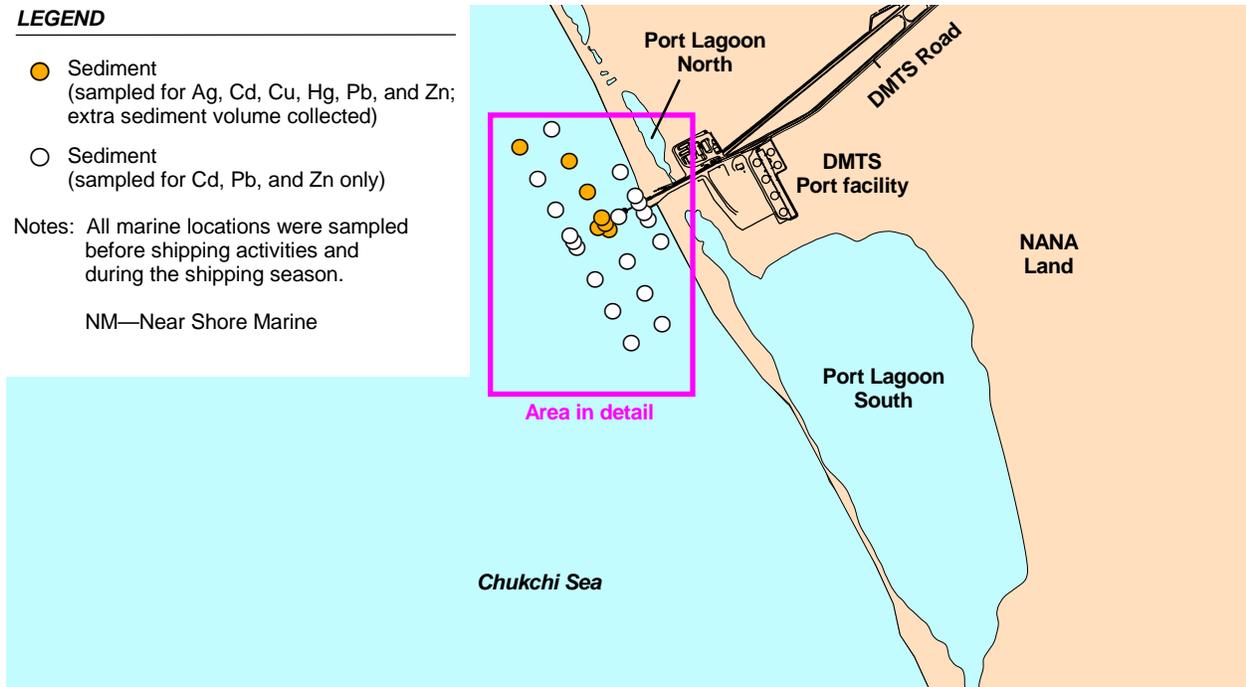


Figure 4-5. Locations of marine sediment sample stations



**LEGEND**

- Tundra soil sampling location
- 🌿 Sedges
- 🍄 Lichen
- 🌳 Willow
- Traps for small mammals
- × Pit traps for soil invertebrates
- 1m<sup>2</sup> microplot for plant community analysis

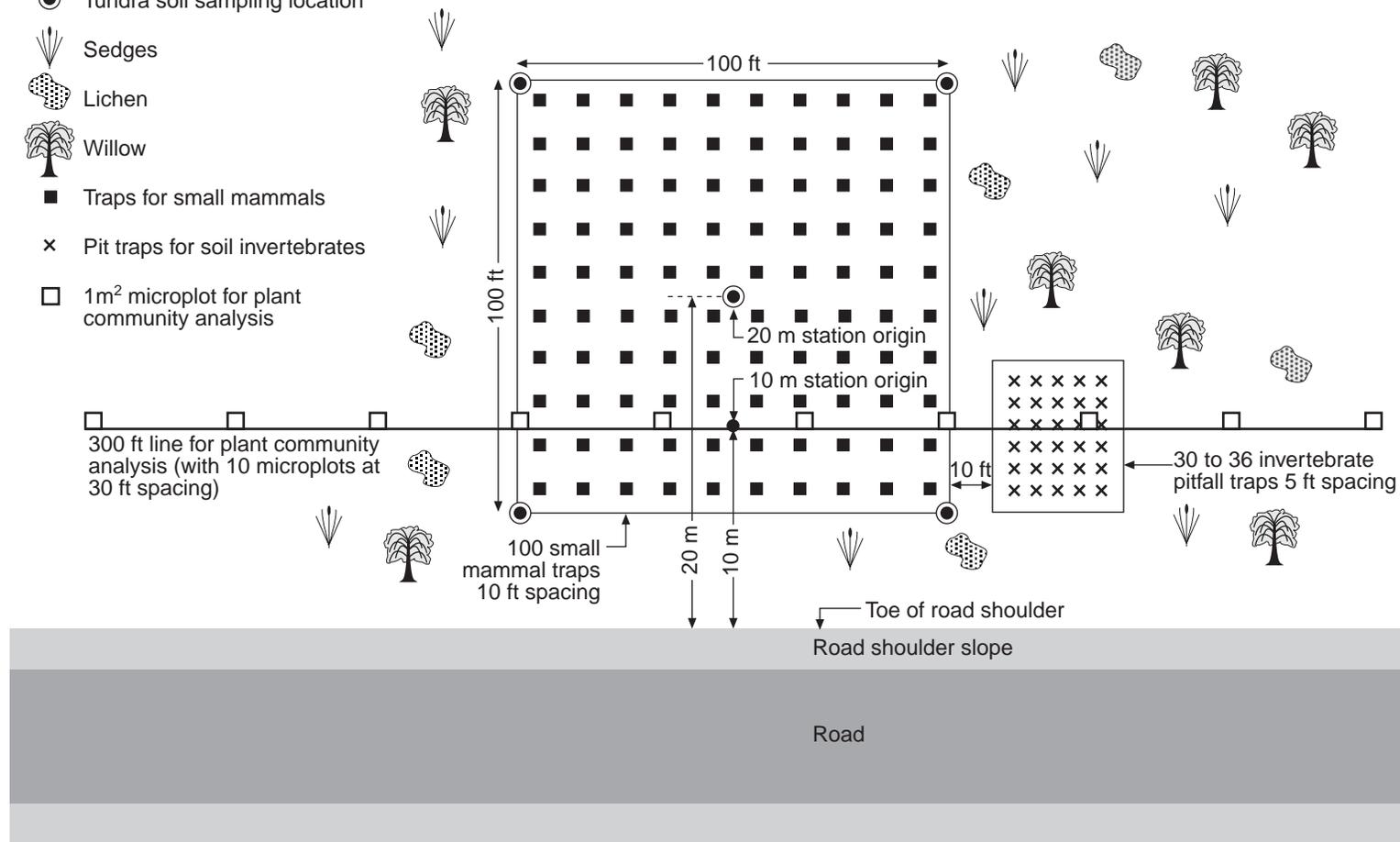


Figure 4-6. Schematic layout of typical 10 m and 20 m terrestrial transect station

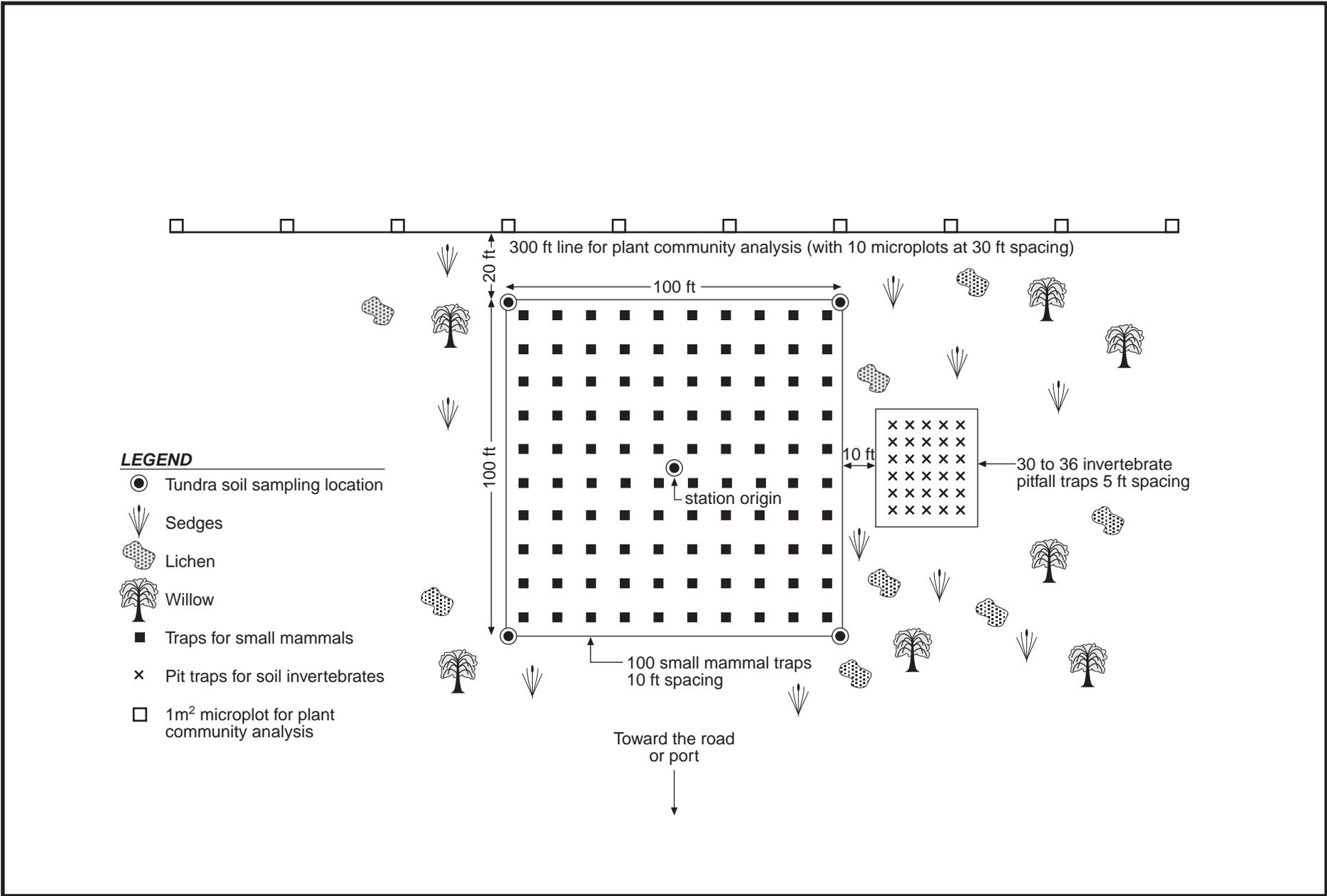
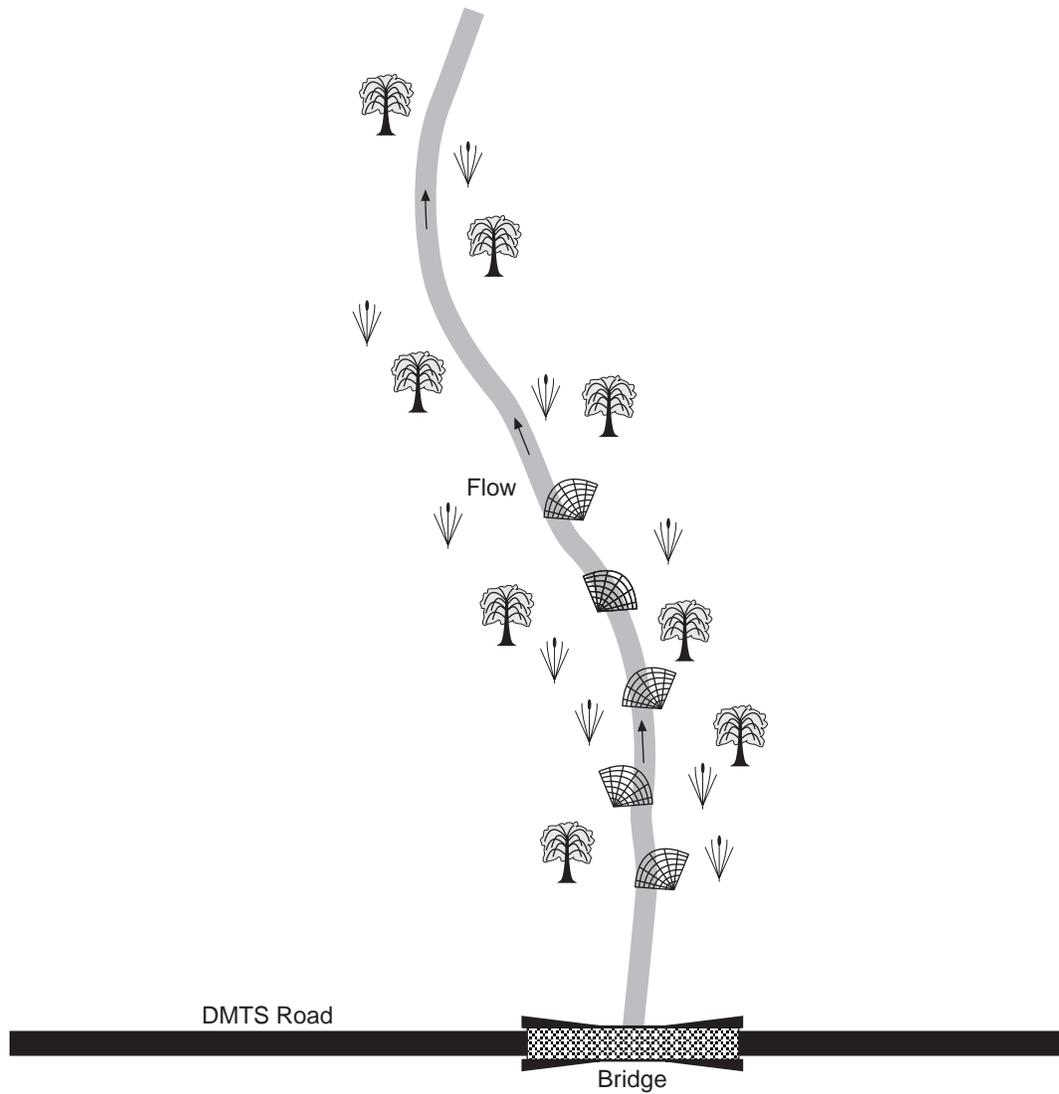


Figure 4-7. Schematic layout of typical 100 m, 1,000 m, and 2,000 m terrestrial transect station



**LEGEND**

-  Drift nets
-  Sedges
-  Willow

Note: The typical range of stream reach length between the road edge and the last net is 150–300 ft.

Figure 4-8. Schematic layout of typical stream station

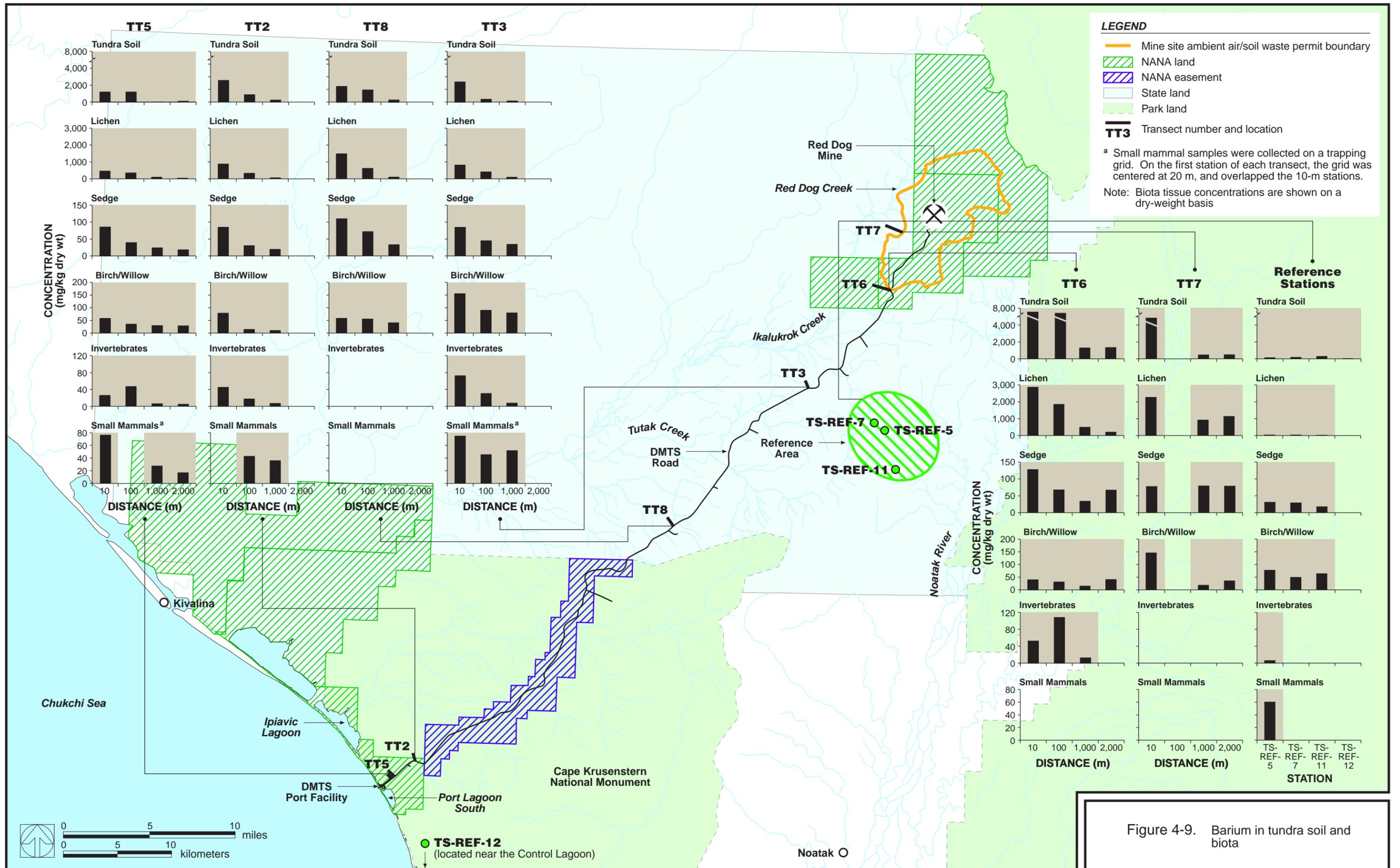
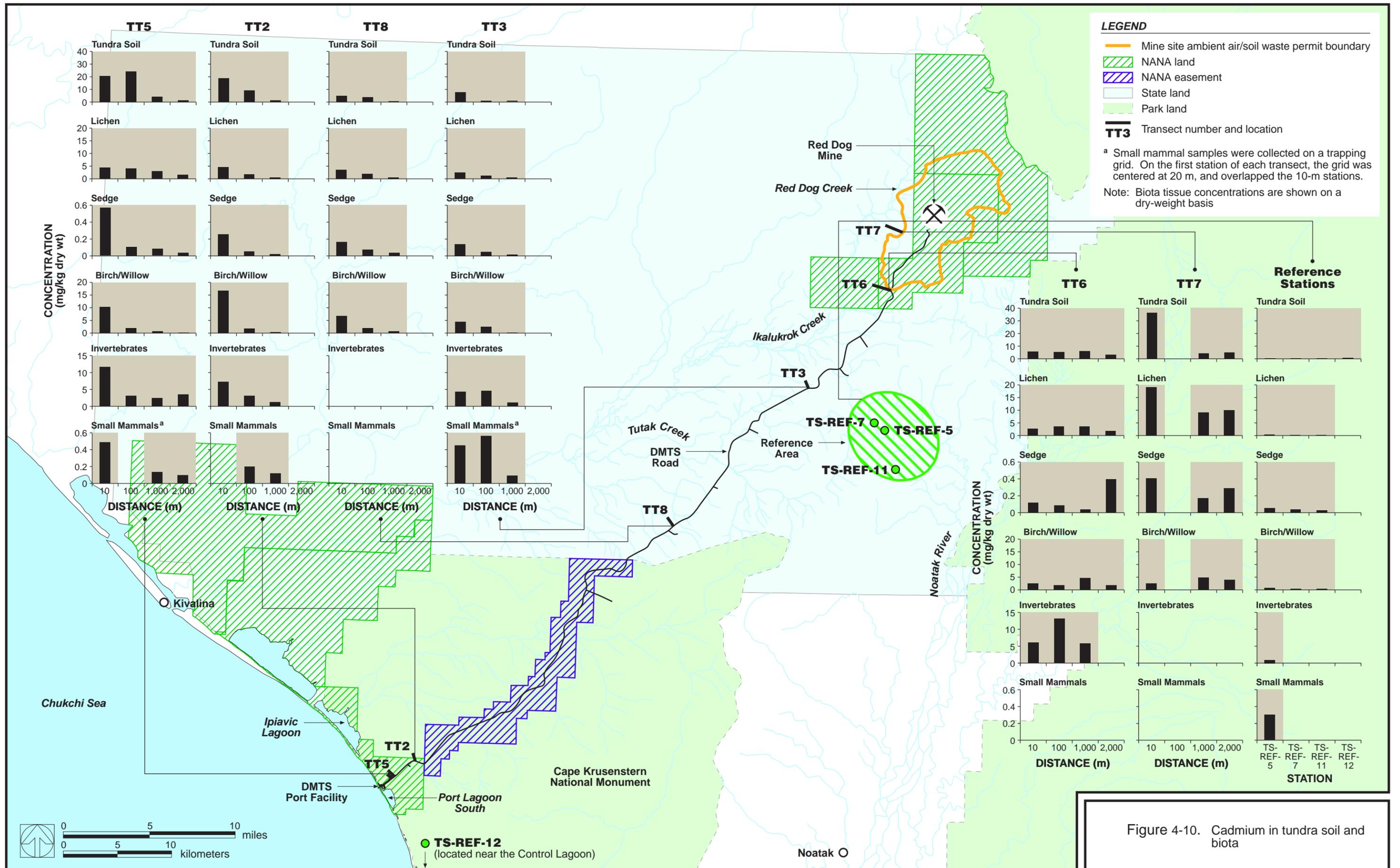


Figure 4-9. Barium in tundra soil and biota



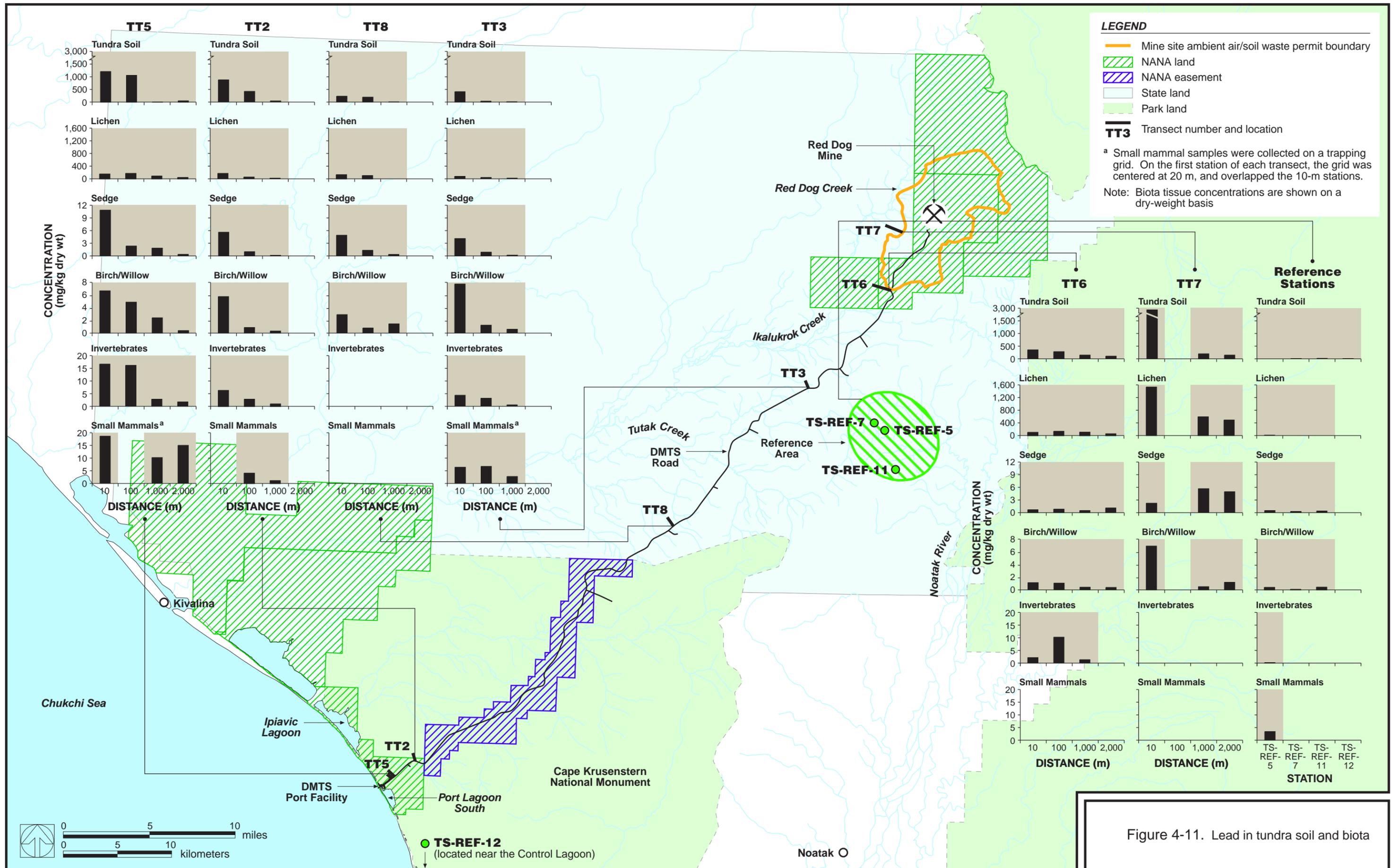


Figure 4-11. Lead in tundra soil and biota

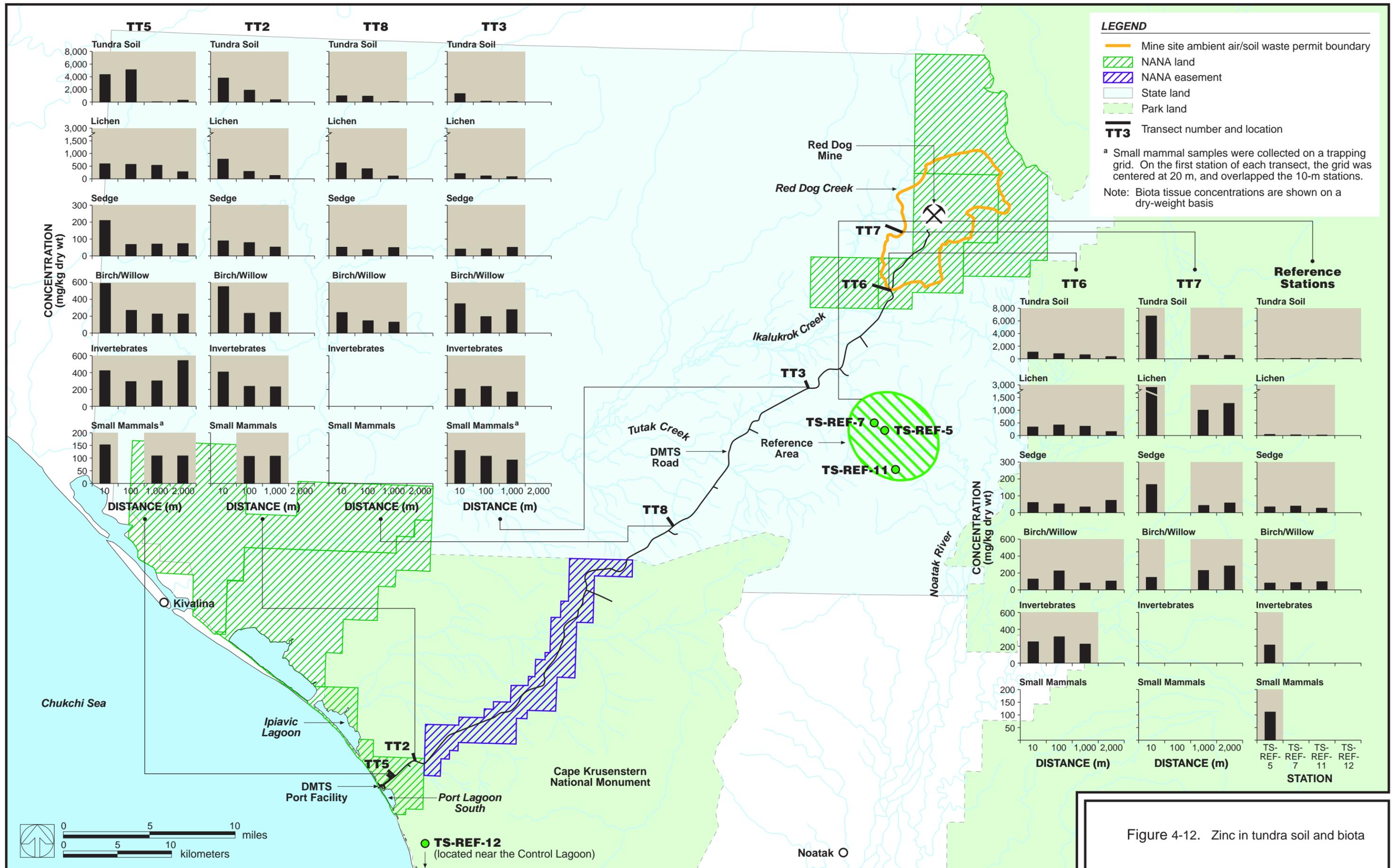


Figure 4-12. Zinc in tundra soil and biota

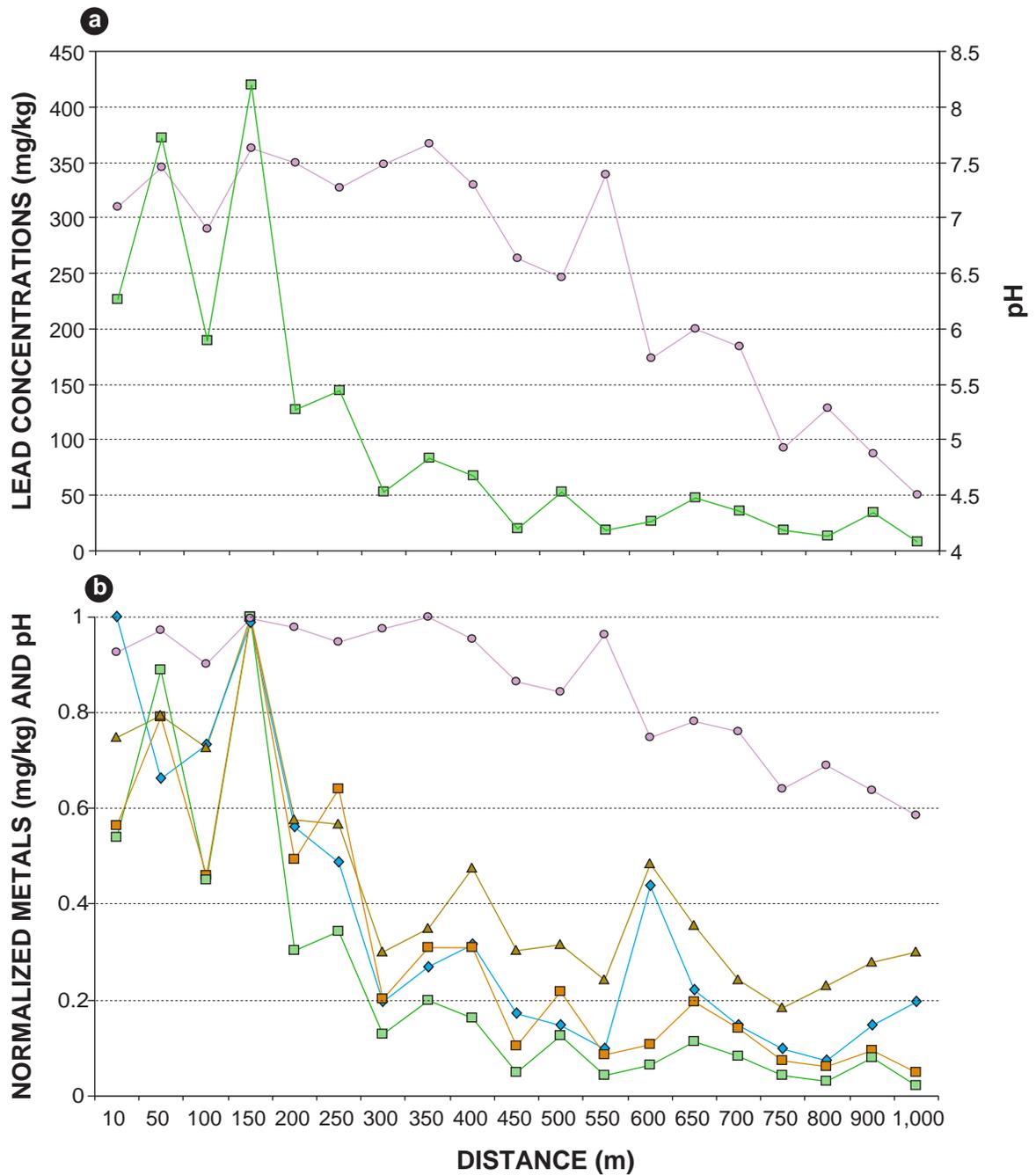
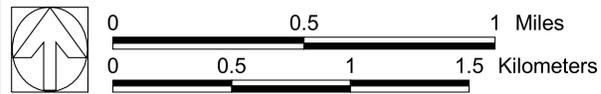
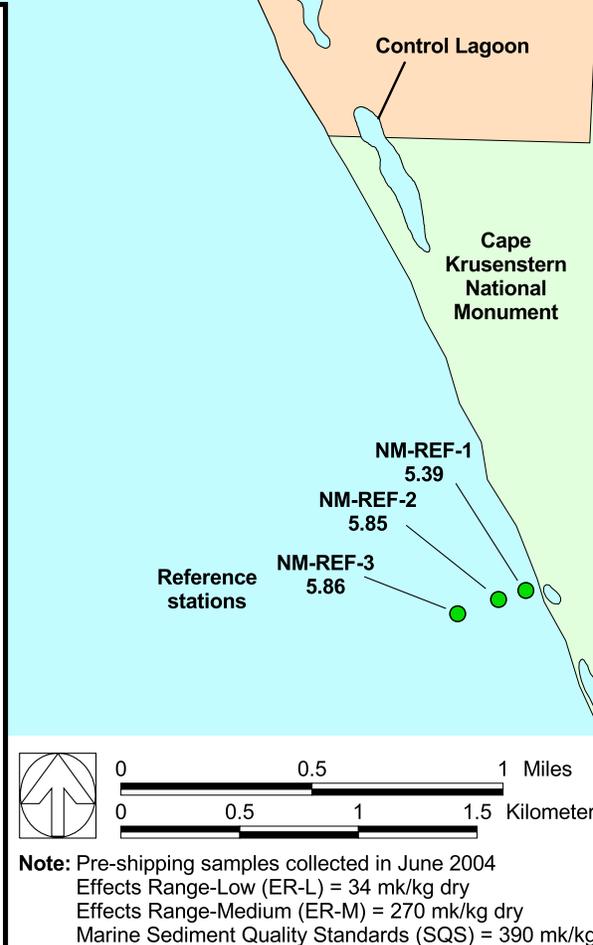
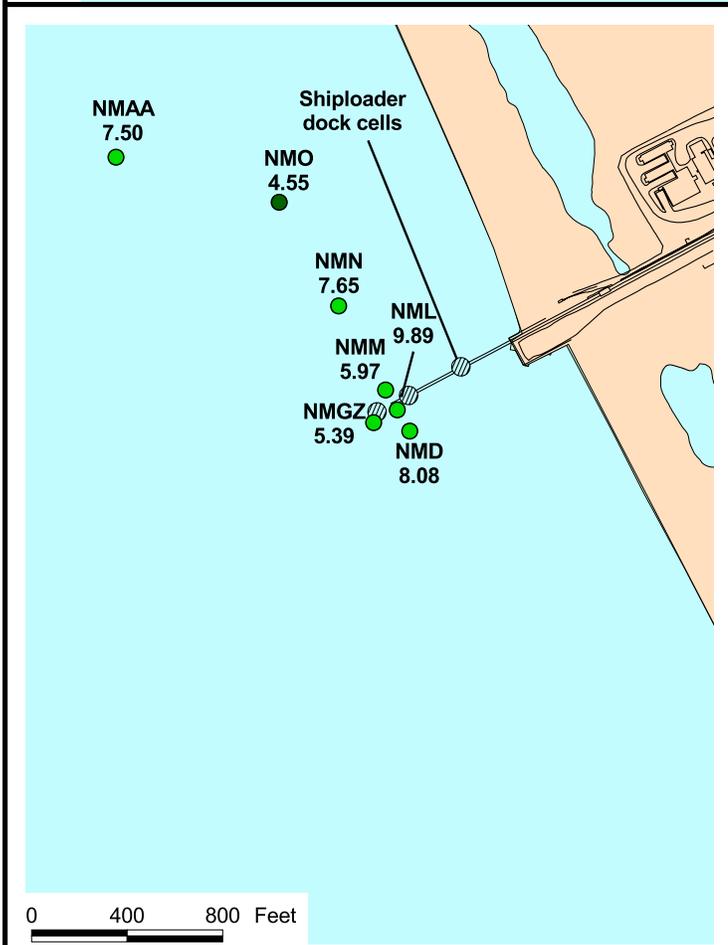
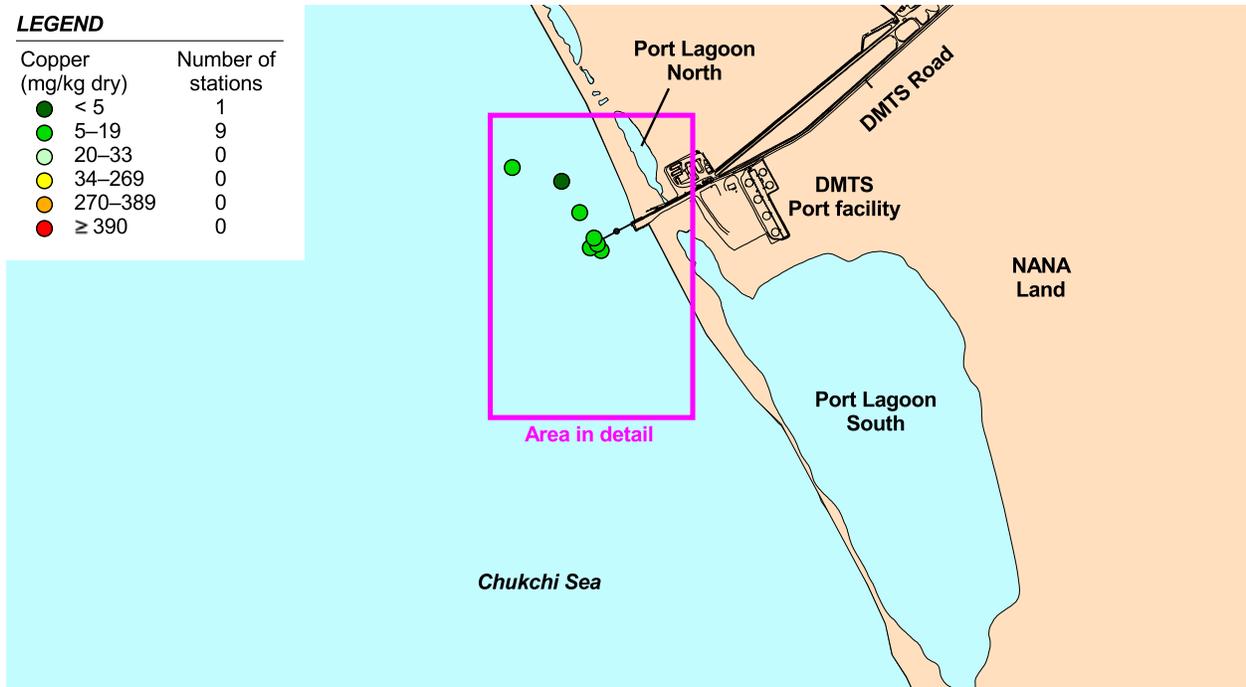


Figure 4-13. Concentrations as a function of distance from the road (Transect TT8) a) pH and lead; b) normalized metals and pH



**LEGEND**

Copper (mg/kg dry)	Number of stations
< 5	1
5-19	9
20-33	0
34-269	0
270-389	0
≥ 390	0



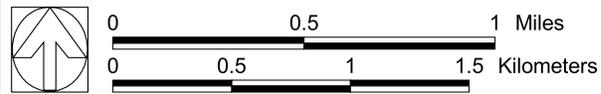
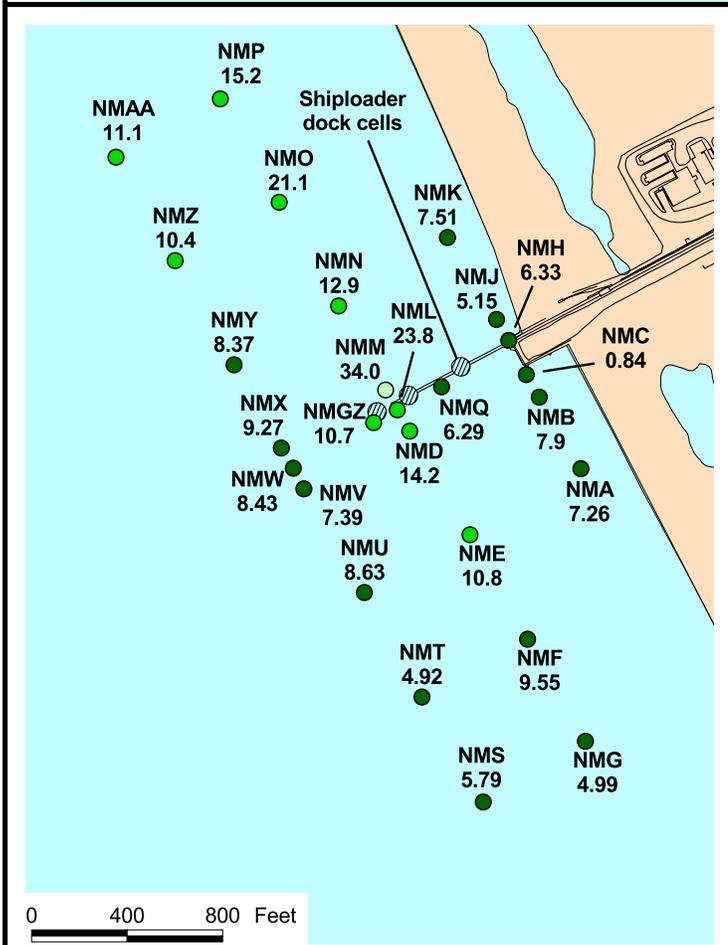
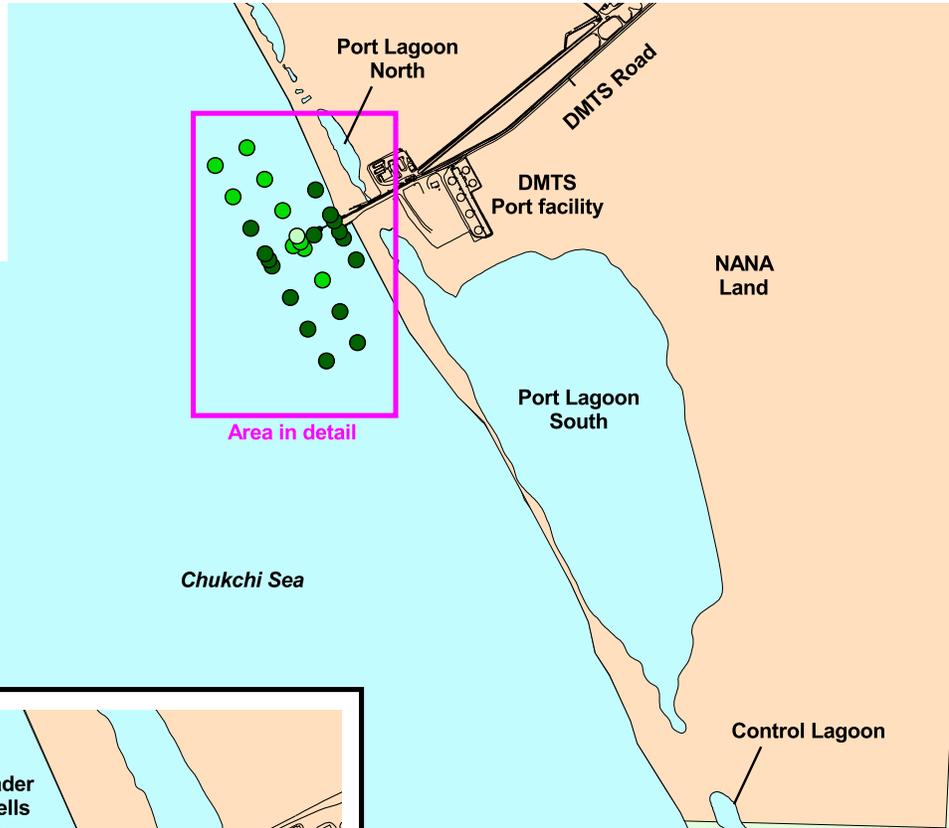
**Note:** Pre-shipping samples collected in June 2004  
 Effects Range-Low (ER-L) = 34 mk/kg dry  
 Effects Range-Medium (ER-M) = 270 mk/kg dry  
 Marine Sediment Quality Standards (SQS) = 390 mk/kg dry

Figure 4-15. 2004 pre-shipping copper concentration (mg/kg dry)



**LEGEND**

Lead (mg/kg dry)	Number of stations
< 10	20
10-24.9	9
25-46.9	1
47-219.9	0
220-449.9	0
≥ 450	0



**Note:** Pre-shipping samples collected in June 2004  
 Effects Range-Low (ER-L) = 47 mk/kg dry  
 Effects Range-Medium (ER-M) = 220 mk/kg dry  
 Marine Sediment Quality Standards (SQS) = 450 mk/kg dry

Figure 4-16. 2004 pre-shipping lead concentration (mg/kg dry)



**LEGEND**

Mercury (mg/kg dry)	Number of stations
● < 0.05	10
● 0.05–0.10	0
● 0.11–0.14	0
● 0.15–0.40	0
● 0.41–0.70	0
● ≥ 0.71	0

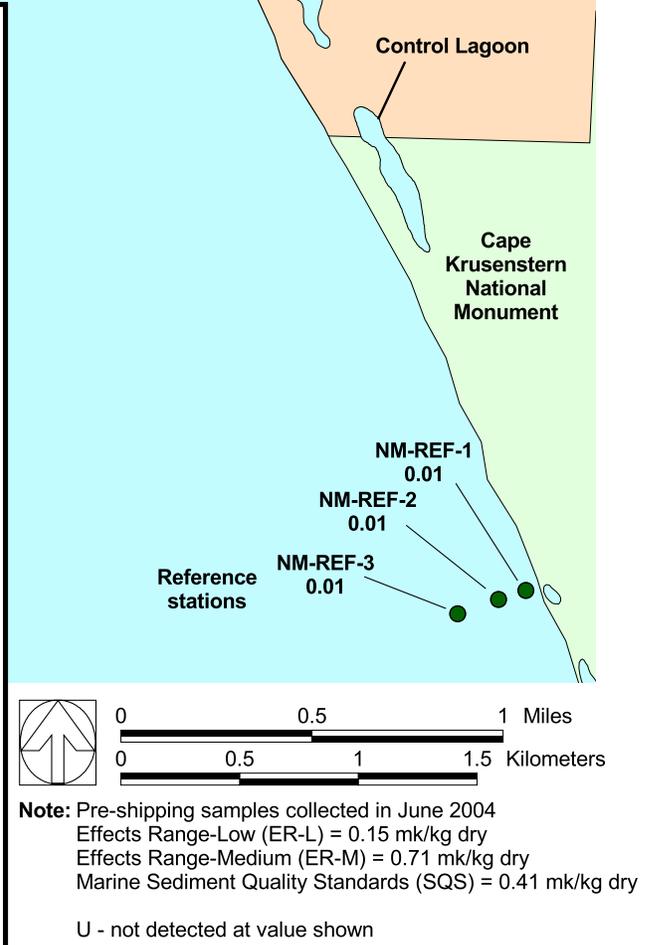
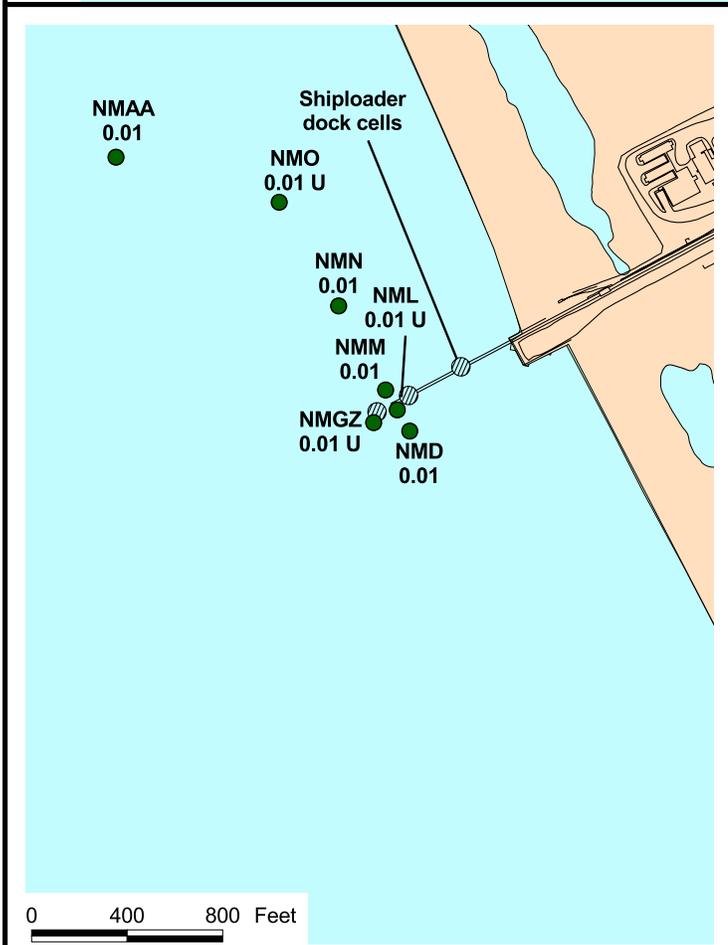
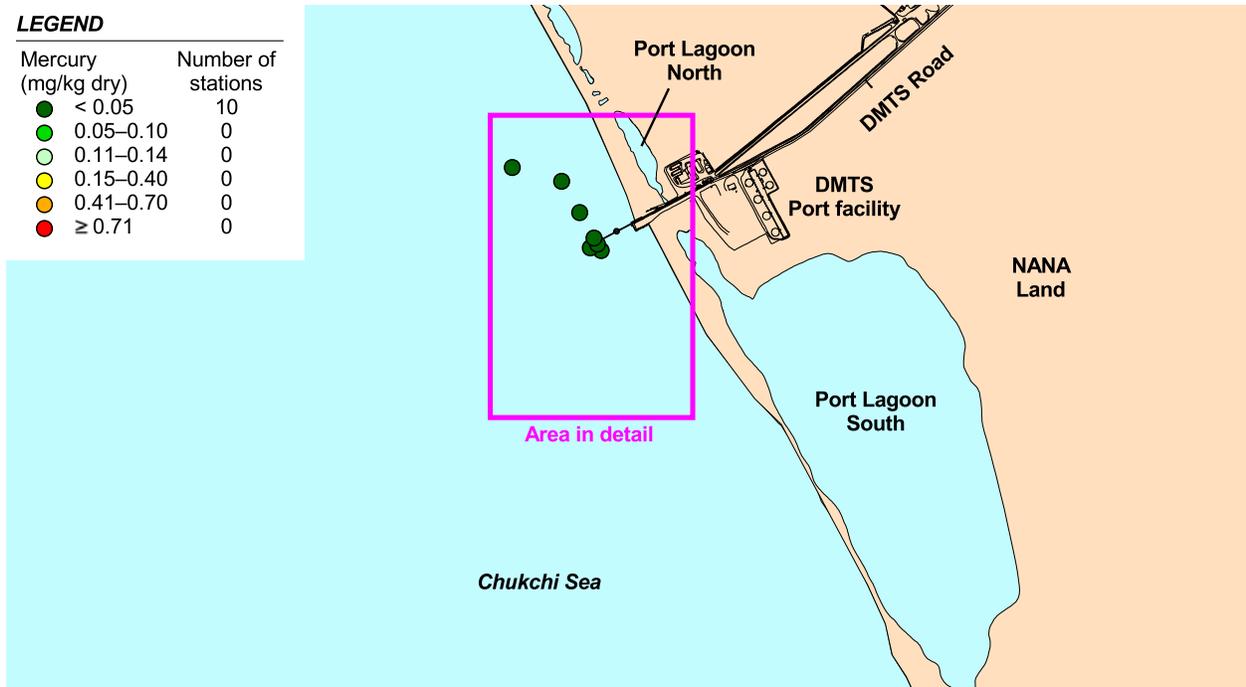
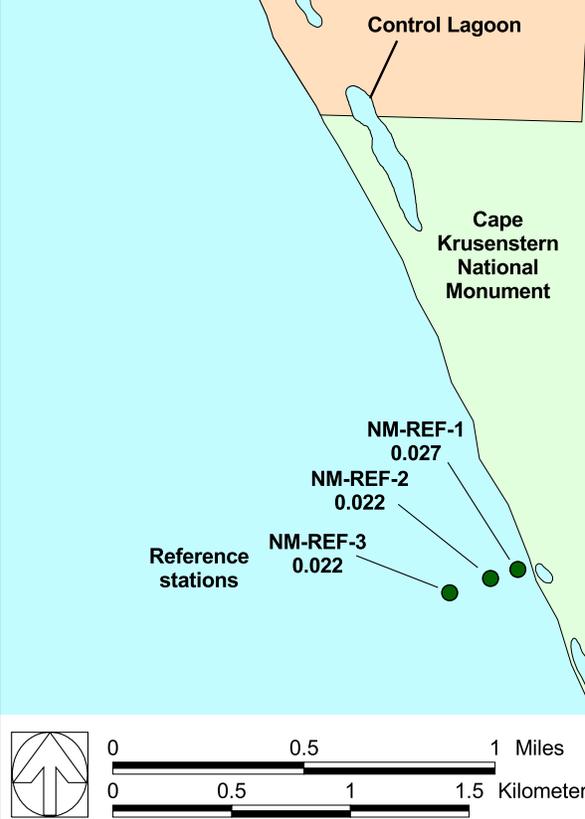
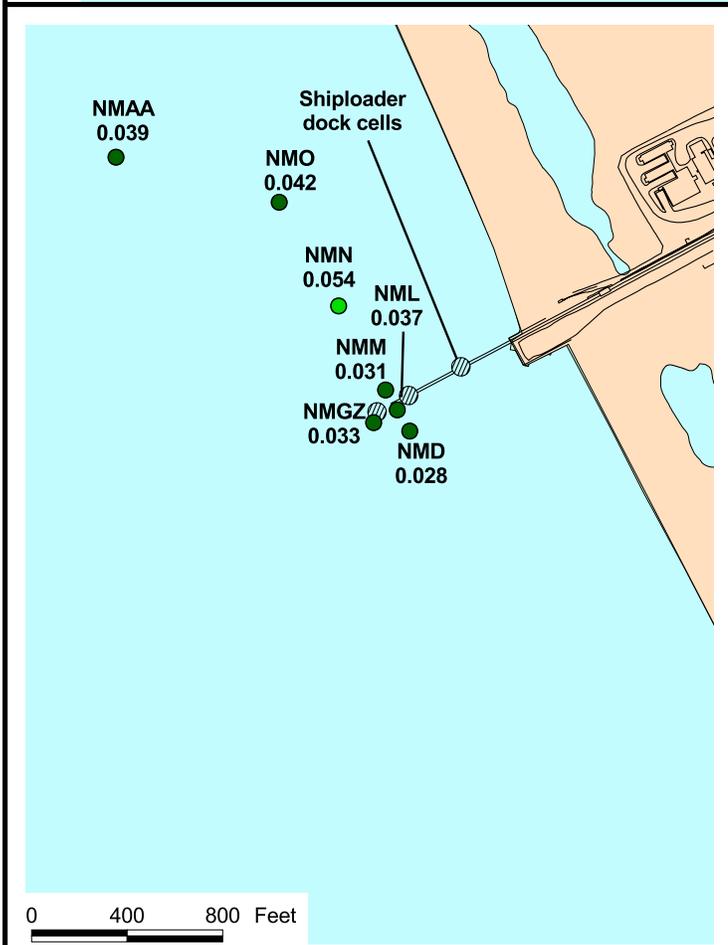
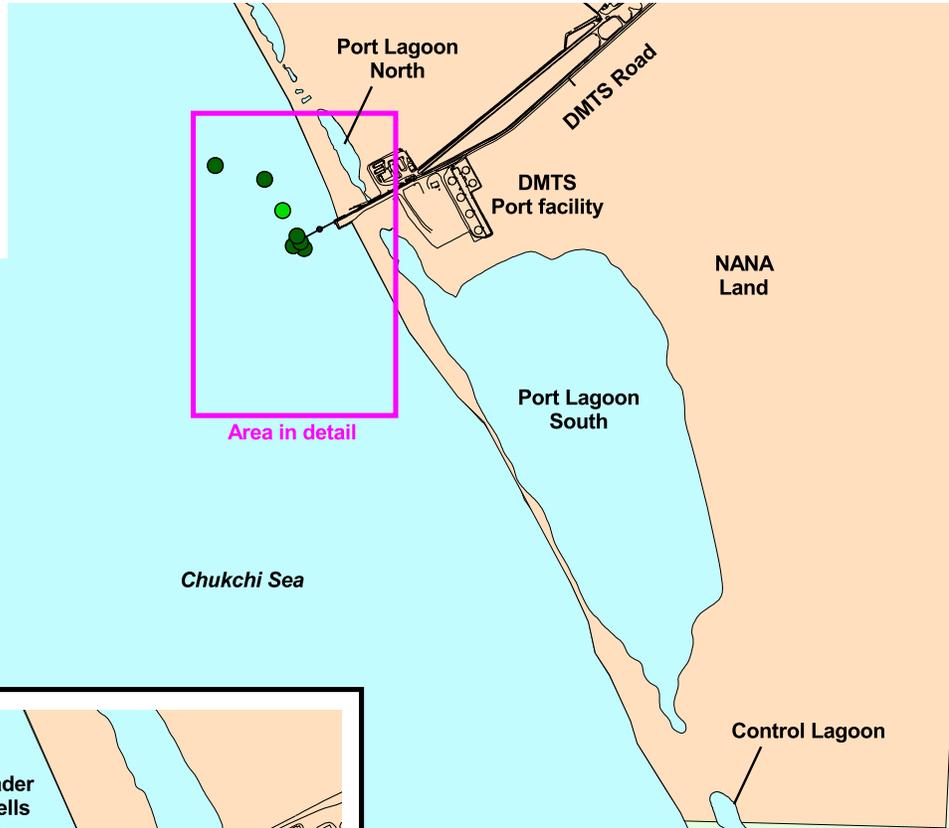


Figure 4-17. 2004 pre-shipping mercury concentration (mg/kg dry)



**LEGEND**

Silver (mg/kg dry)	Number of stations
● < 0.05	9
● 0.05–0.09	1
● 0.1–0.9	0
● 1.0–3.6	0
● 3.7–6.0	0
● ≥ 6.1	0



**Note:** Pre-shipping samples collected in June 2004  
 Effects Range-Low (ER-L) = 1.0 mk/kg dry  
 Effects Range-Medium (ER-M) = 3.7 mk/kg dry  
 Marine Sediment Quality Standards (SQS) = 6.1 mk/kg dry

Figure 4-18. 2004 pre-shipping silver concentration (mg/kg dry)



**LEGEND**

Zinc (mg/kg dry)	Number of stations
< 20	2
25-49	26
50-99	2
100-149	0
150-409	0
≥ 410	0

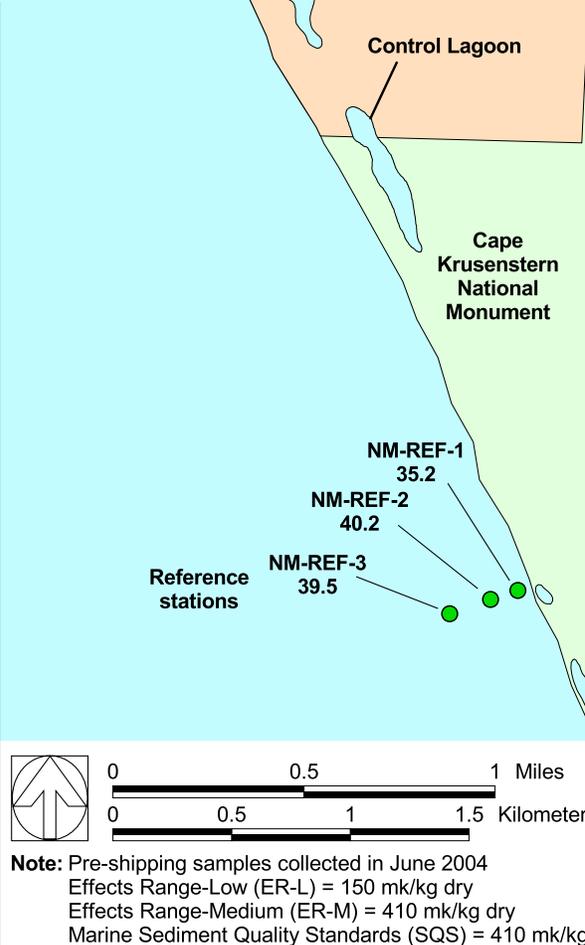
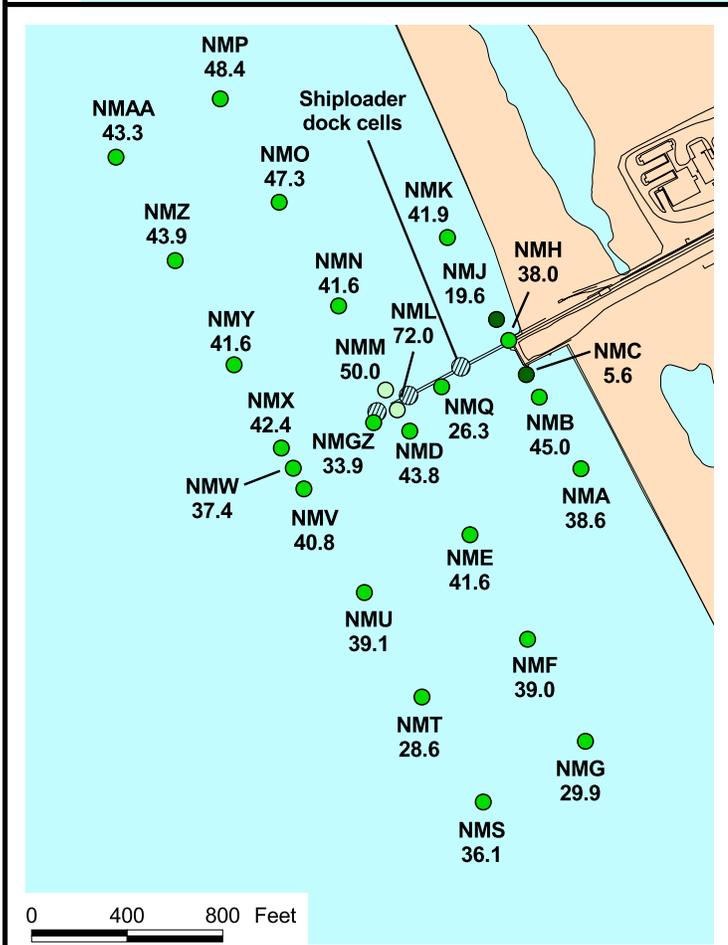
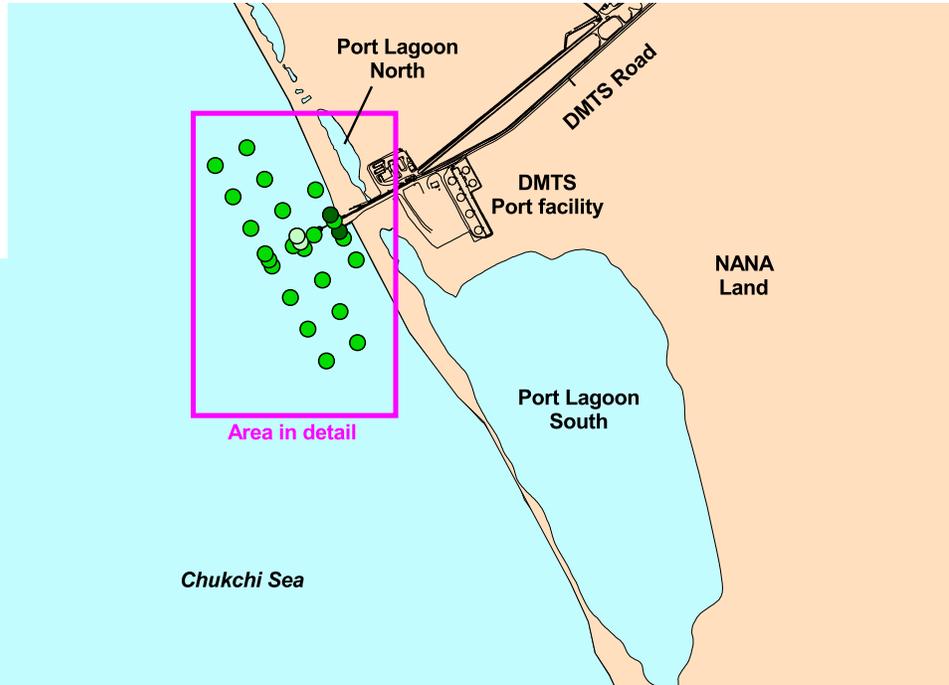
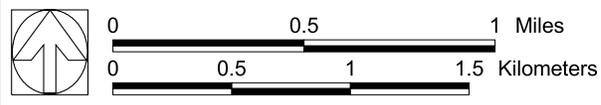
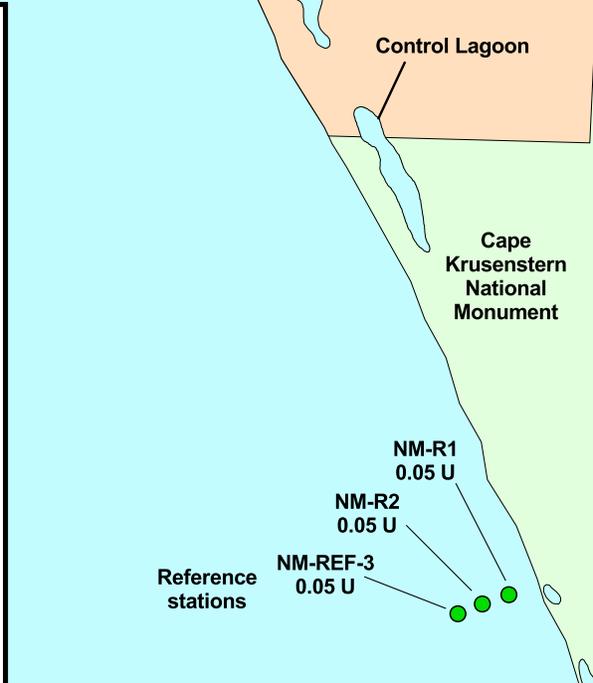
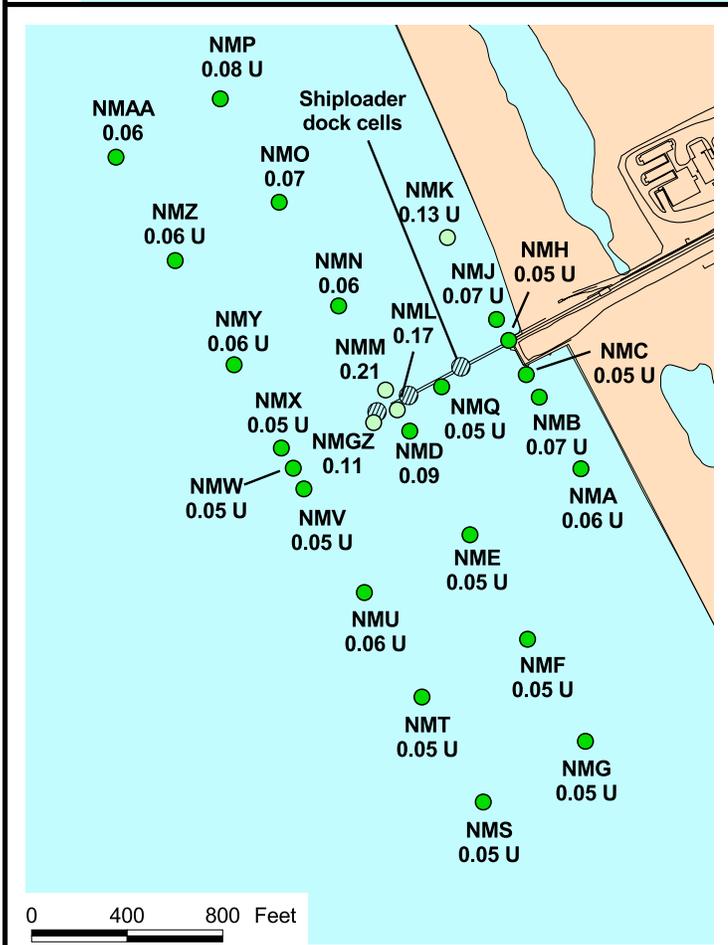
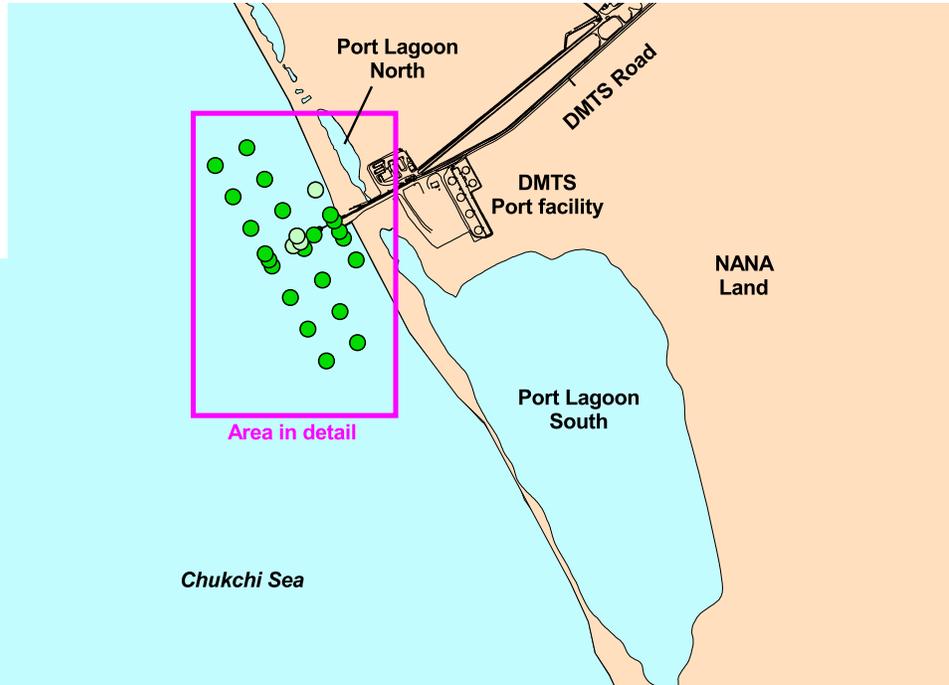


Figure 4-19. 2004 pre-shipping zinc concentration (mg/kg dry)



**LEGEND**

Cadmium (mg/kg dry)	Number of stations
< 0.05	0
0.05-0.1	25
0.11-1.1	4
1.2-5.0	0
5.1-9.5	0
≥ 9.6	0



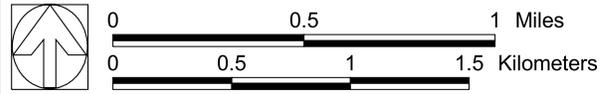
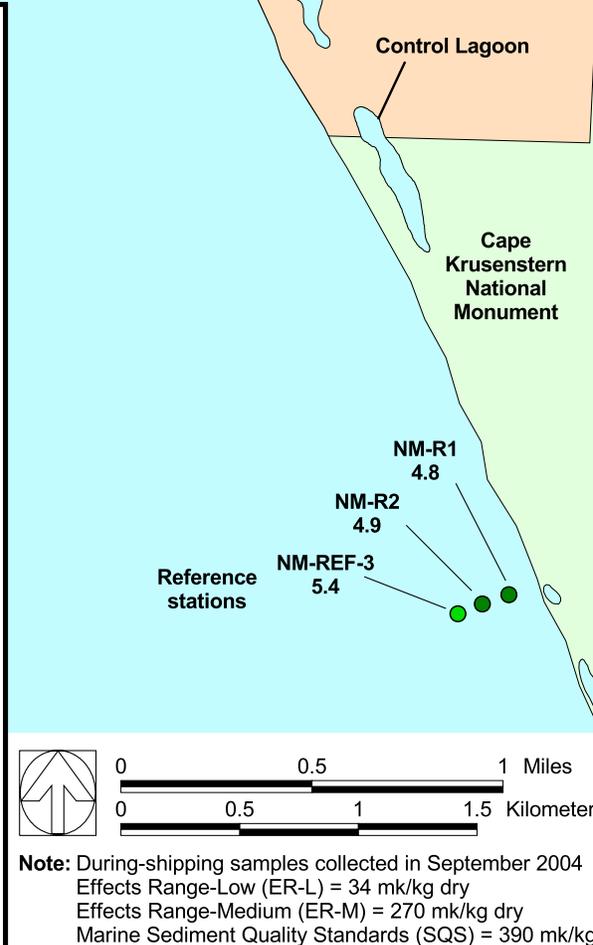
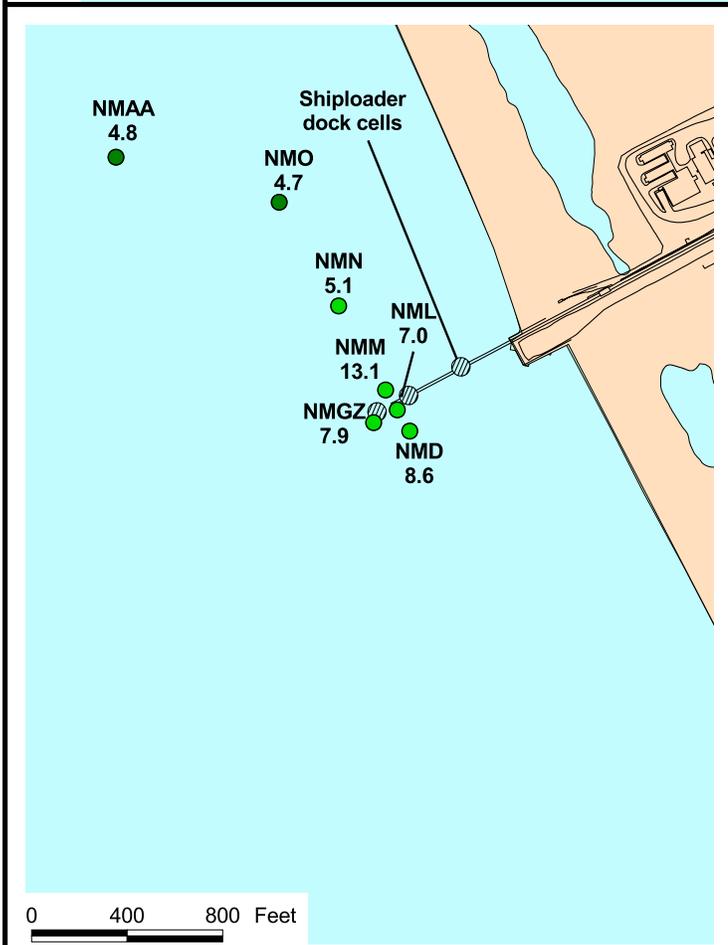
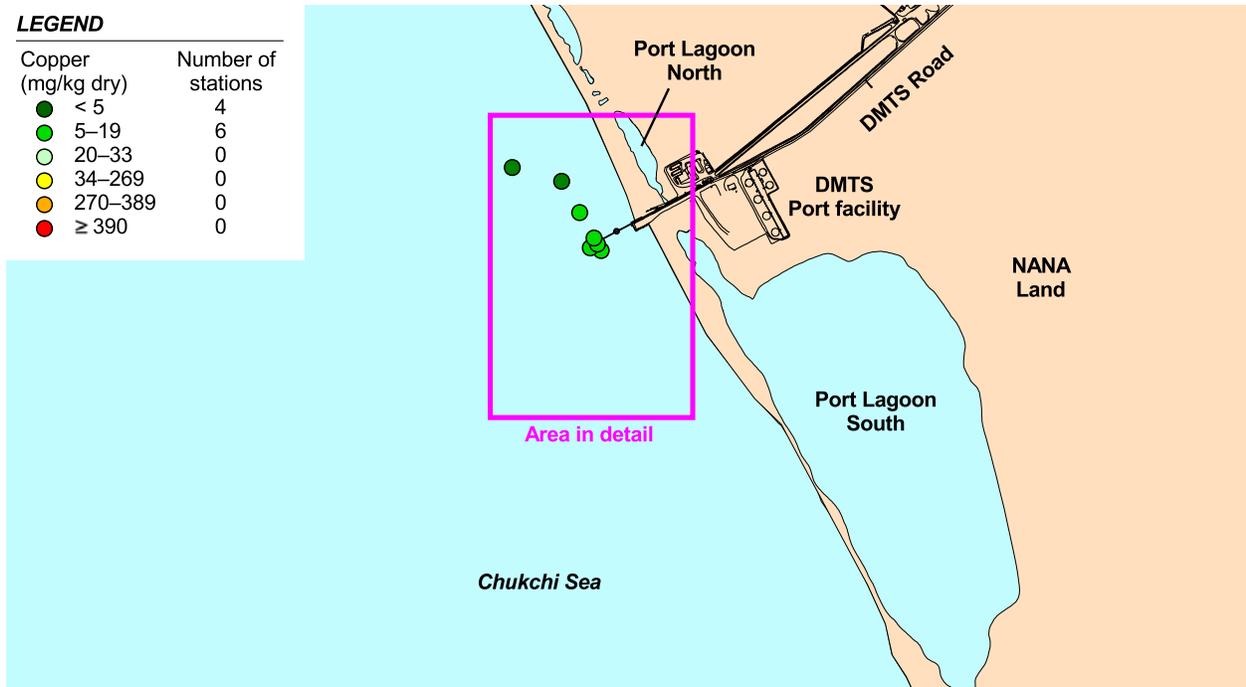
**Note:** During-shipping samples collected in September 2004  
 Effects Range-Low (ER-L) = 1.2 mk/kg dry  
 Effects Range-Medium (ER-M) = 9.6 mk/kg dry  
 Marine Sediment Quality Standards (SQS) = 5.1 mk/kg dry  
 U - not detected at value shown

Figure 4-20. 2004 during-shipping cadmium concentration (mg/kg dry)



**LEGEND**

Copper (mg/kg dry)	Number of stations
< 5	4
5-19	6
20-33	0
34-269	0
270-389	0
≥ 390	0



**Note:** During-shipping samples collected in September 2004  
 Effects Range-Low (ER-L) = 34 mk/kg dry  
 Effects Range-Medium (ER-M) = 270 mk/kg dry  
 Marine Sediment Quality Standards (SQS) = 390 mk/kg dry

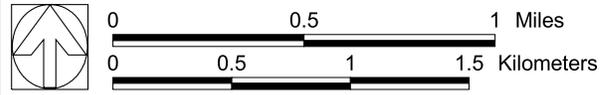
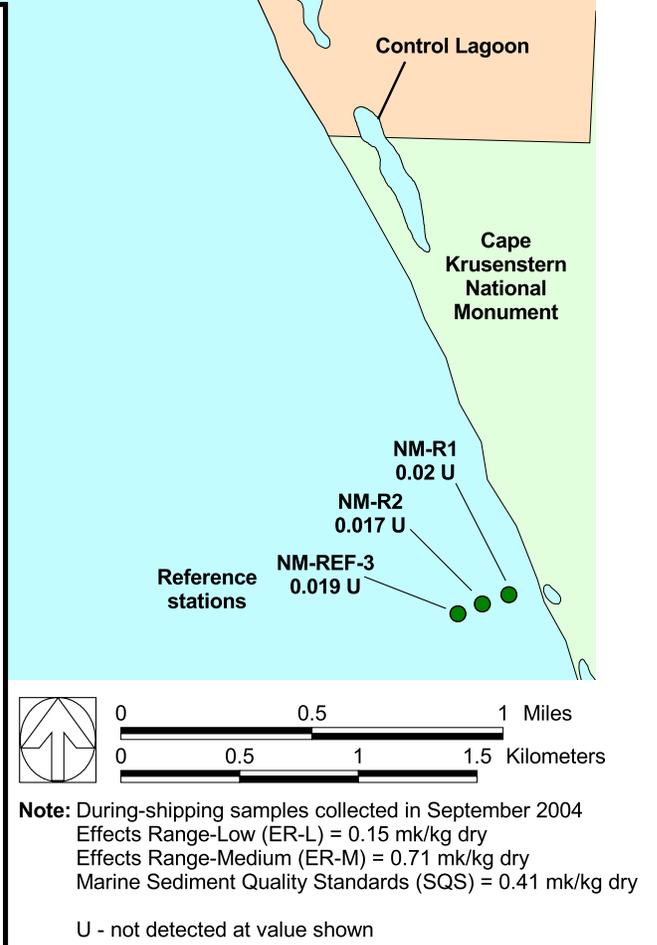
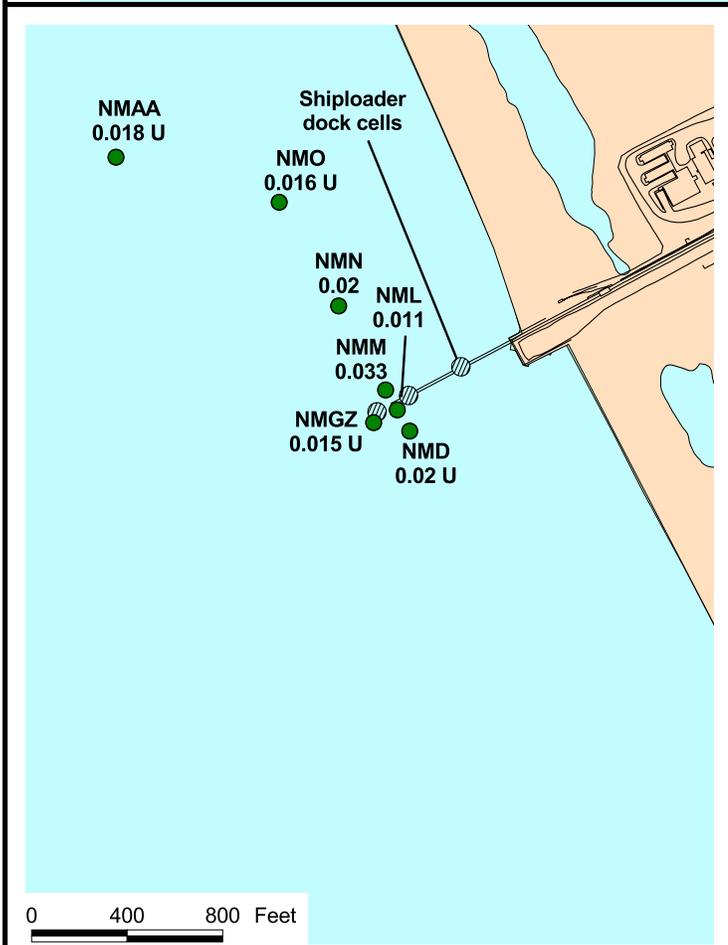
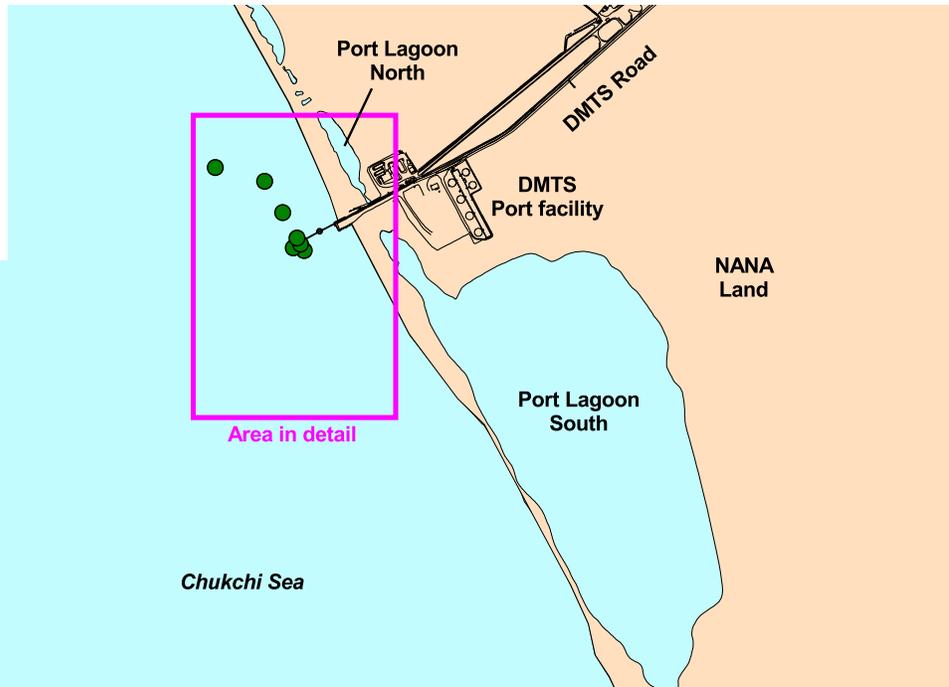
Figure 4-21. 2004 during-shipping copper concentration (mg/kg dry)





**LEGEND**

Mercury (mg/kg dry)	Number of stations
● < 0.05	10
● 0.05–0.10	0
● 0.11–0.14	0
● 0.15–0.40	0
● 0.41–0.70	0
● ≥ 0.71	0



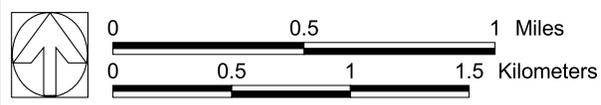
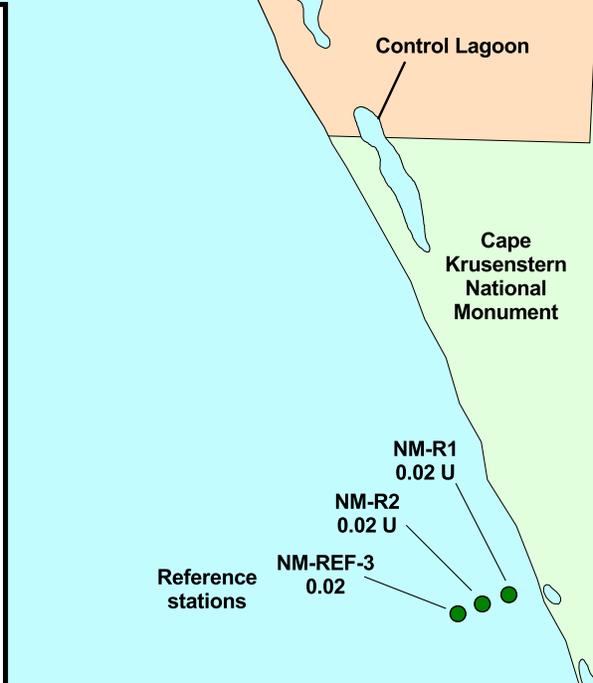
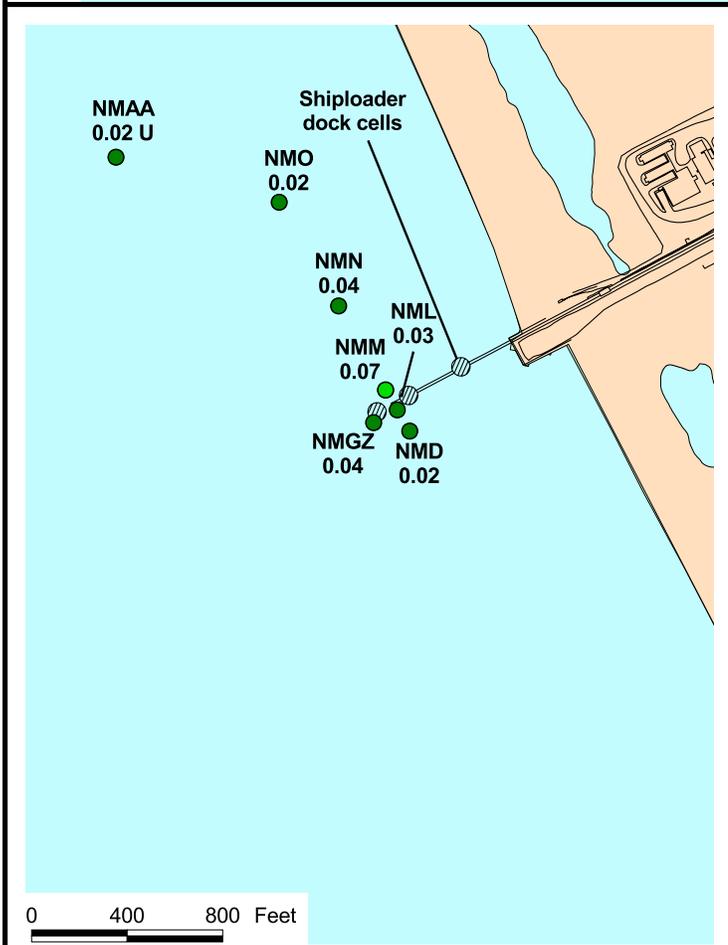
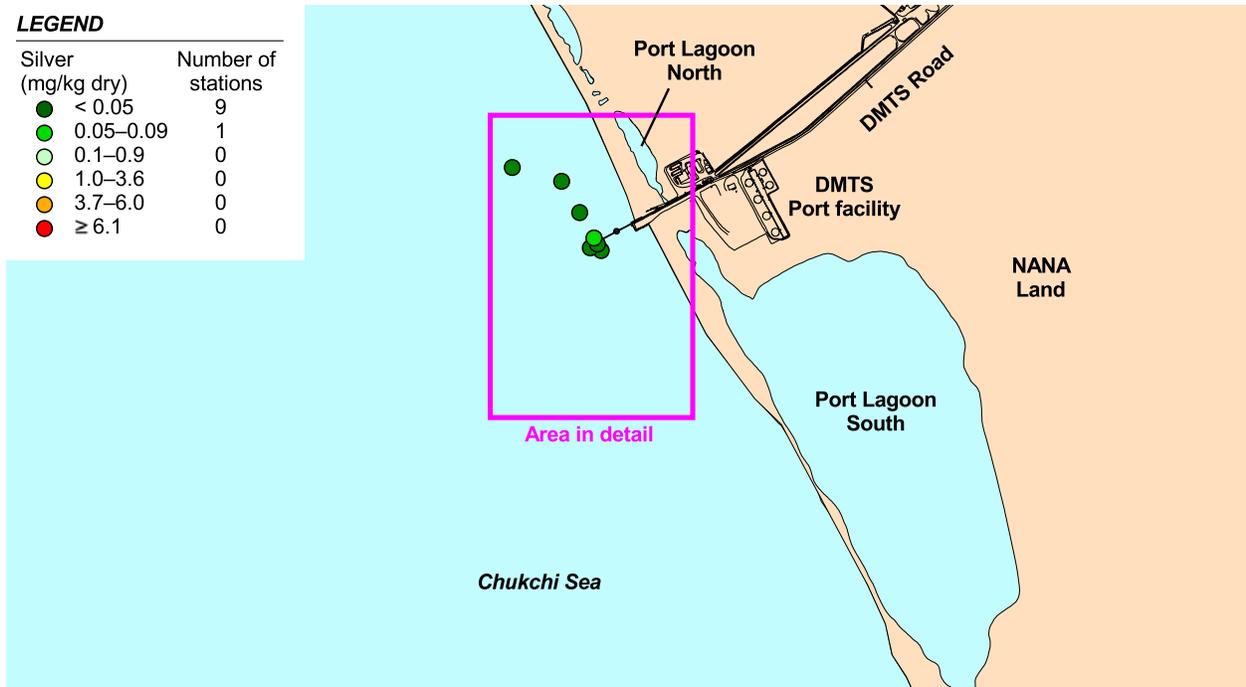
**Note:** During-shipping samples collected in September 2004  
 Effects Range-Low (ER-L) = 0.15 mk/kg dry  
 Effects Range-Medium (ER-M) = 0.71 mk/kg dry  
 Marine Sediment Quality Standards (SQS) = 0.41 mk/kg dry  
 U - not detected at value shown

Figure 4-23. 2004 during-shipping mercury concentration (mg/kg dry)



**LEGEND**

Silver (mg/kg dry)	Number of stations
< 0.05	9
0.05–0.09	1
0.1–0.9	0
1.0–3.6	0
3.7–6.0	0
≥ 6.1	0



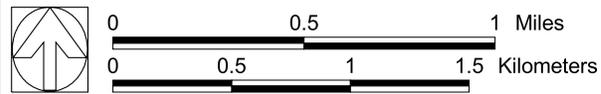
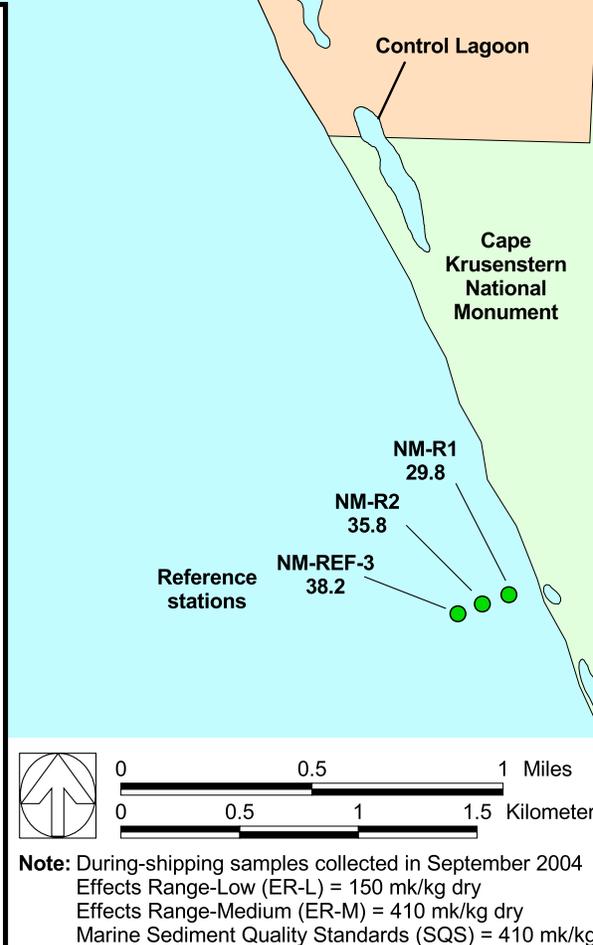
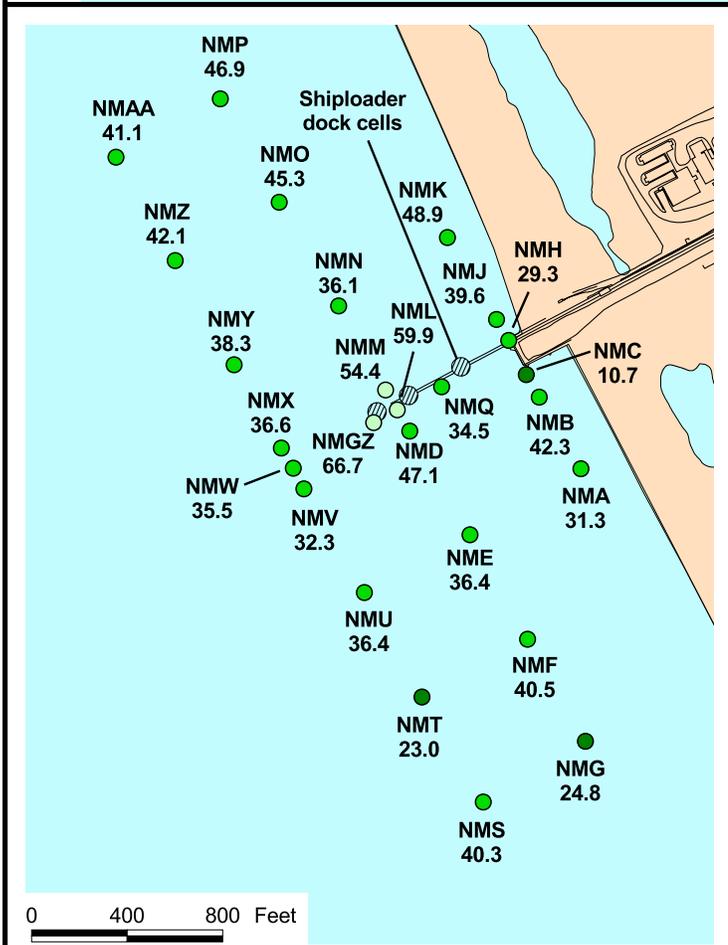
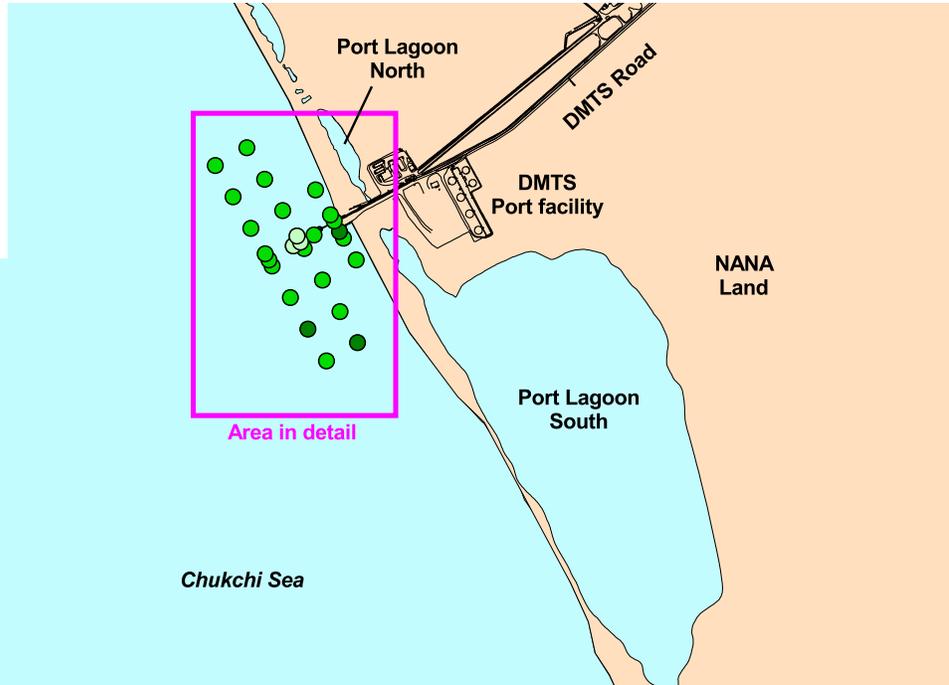
**Note:** During-shipping samples collected in September 2004  
 Effects Range-Low (ER-L) = 1.0 mk/kg dry  
 Effects Range-Medium (ER-M) = 3.7 mk/kg dry  
 Marine Sediment Quality Standards (SQS) = 6.1 mk/kg dry  
 U - not detected at value shown

Figure 4-24. 2004 during-shipping silver concentration (mg/kg dry)



**LEGEND**

Zinc (mg/kg dry)	Number of stations
< 20	3
25-49	23
50-99	3
100-149	0
150-409	0
≥ 410	0



**Note:** During-shipping samples collected in September 2004  
 Effects Range-Low (ER-L) = 150 mk/kg dry  
 Effects Range-Medium (ER-M) = 410 mk/kg dry  
 Marine Sediment Quality Standards (SQS) = 410 mk/kg dry

Figure 4-25. 2004 during-shipping zinc concentration (mg/kg dry)



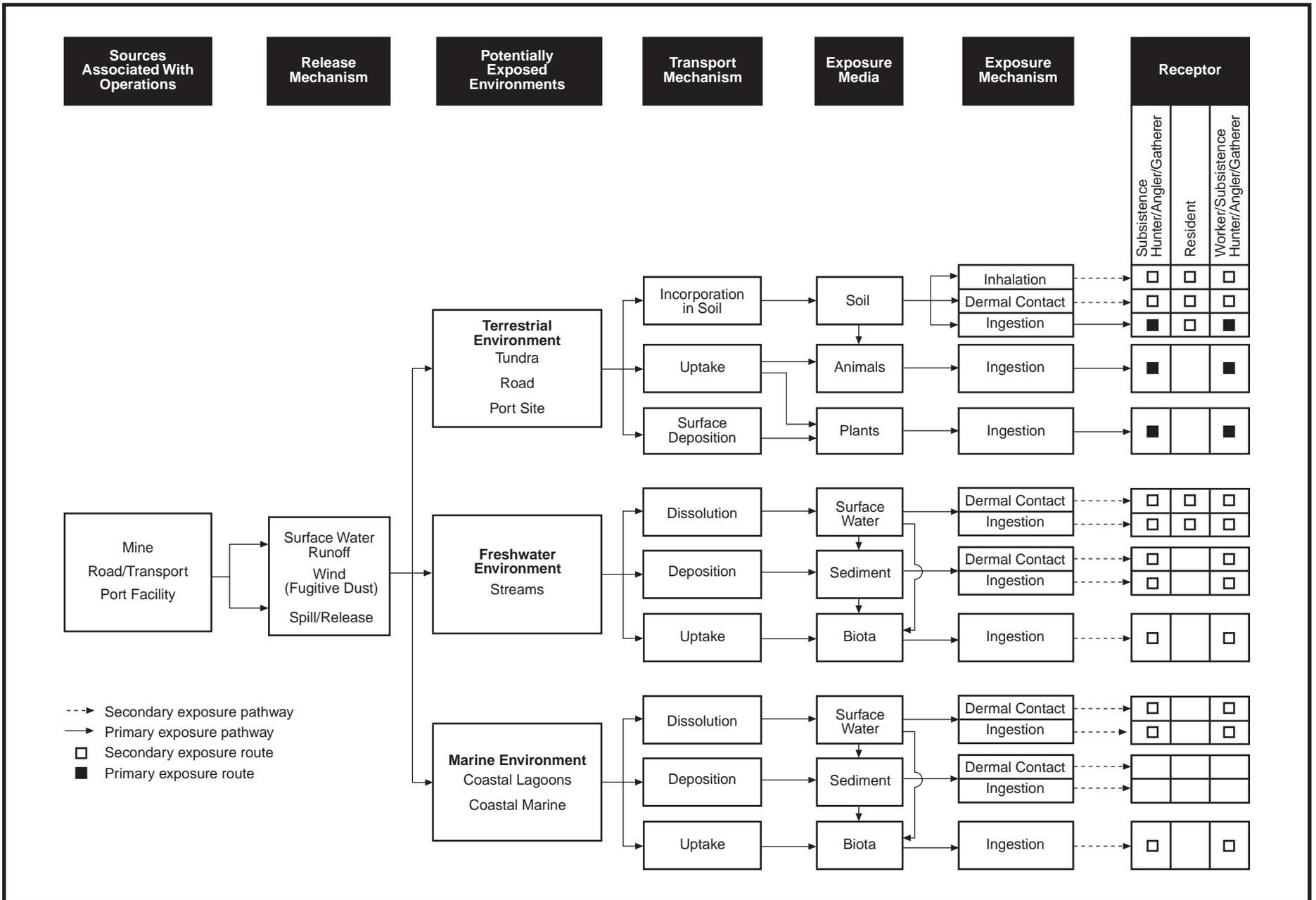


Figure 5-1. Refined conceptual site model for the DMTS human health risk assessment

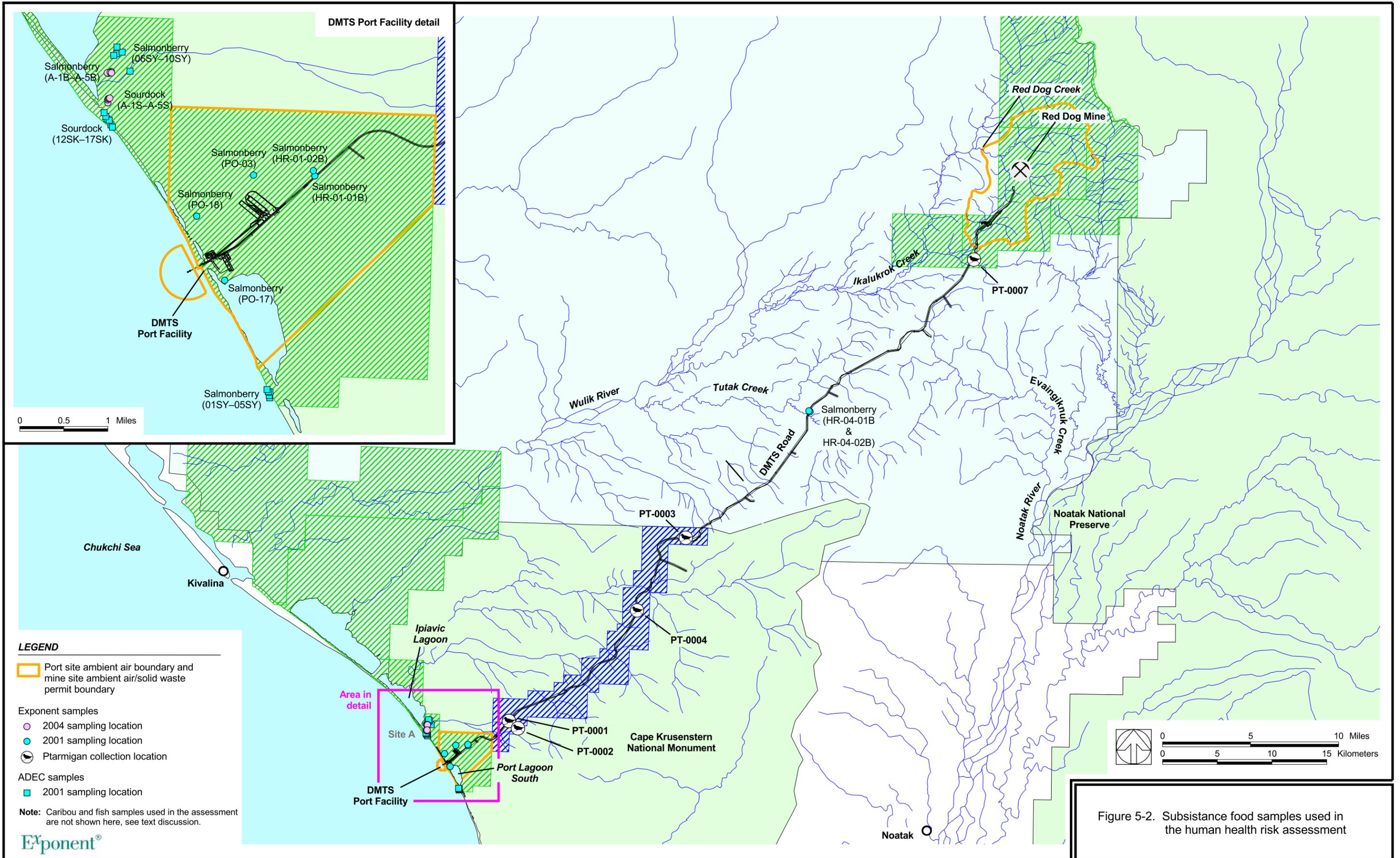


Figure 5-2. Subsistence food samples used in the human health risk assessment



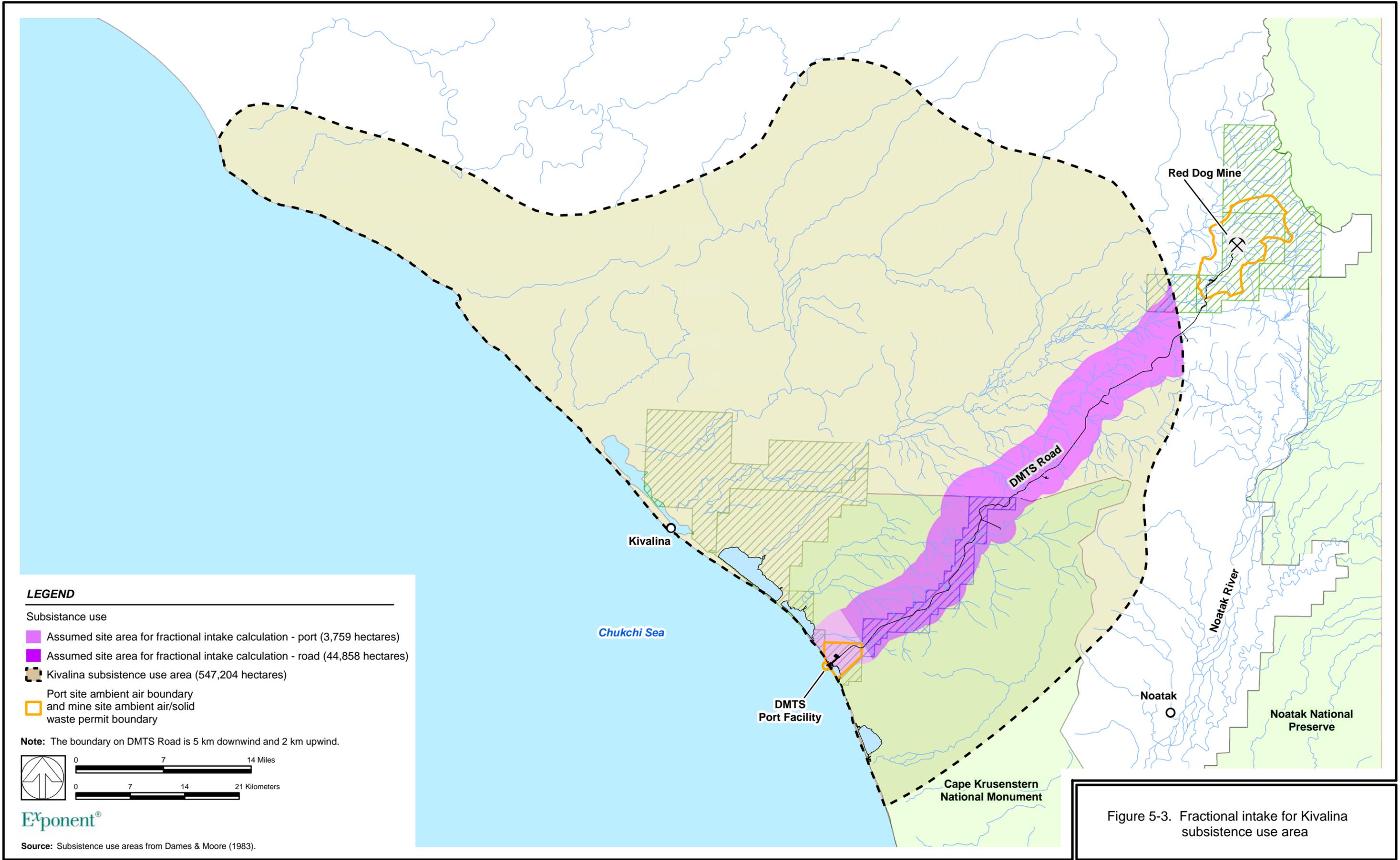


Figure 5-3. Fractional intake for Kivalina subsistence use area

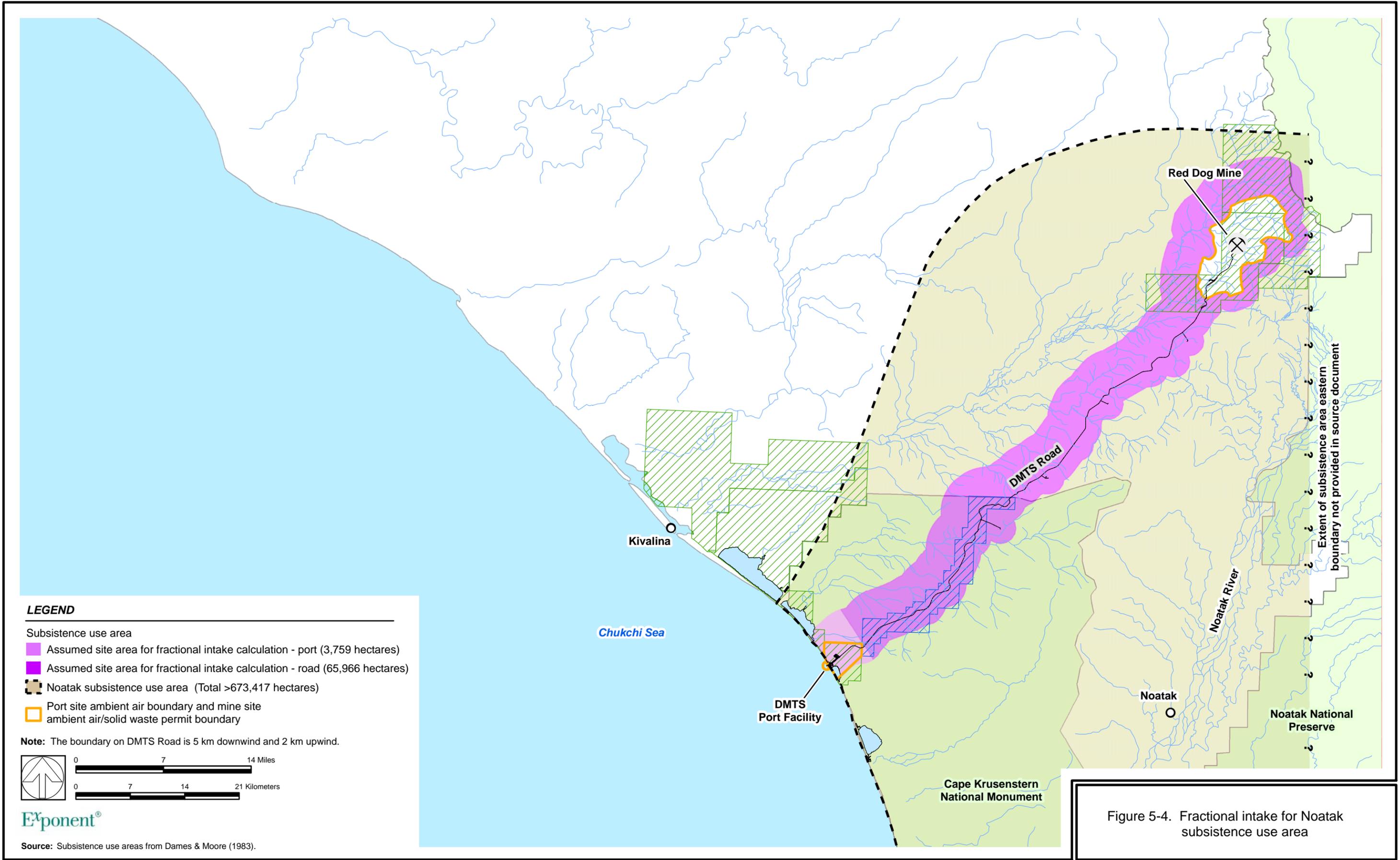
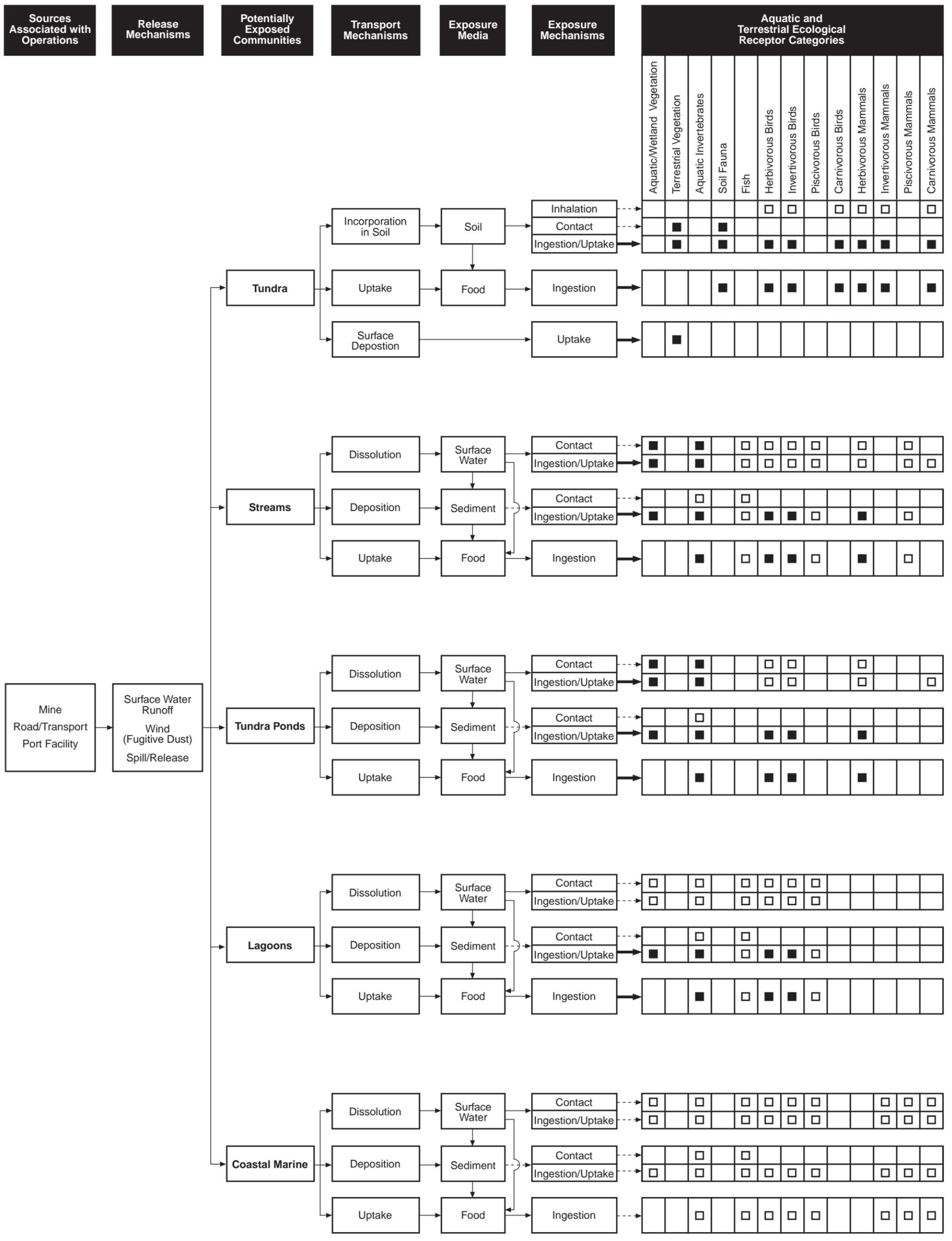


Figure 5-4. Fractional intake for Noatak subsistence use area



- - -> Secondary exposure pathway  
 → Primary exposure pathway  
 □ Secondary exposure route  
 ■ Primary exposure route

Figure 6-1. Refined conceptual site model for the DMTS ecological risk assessment

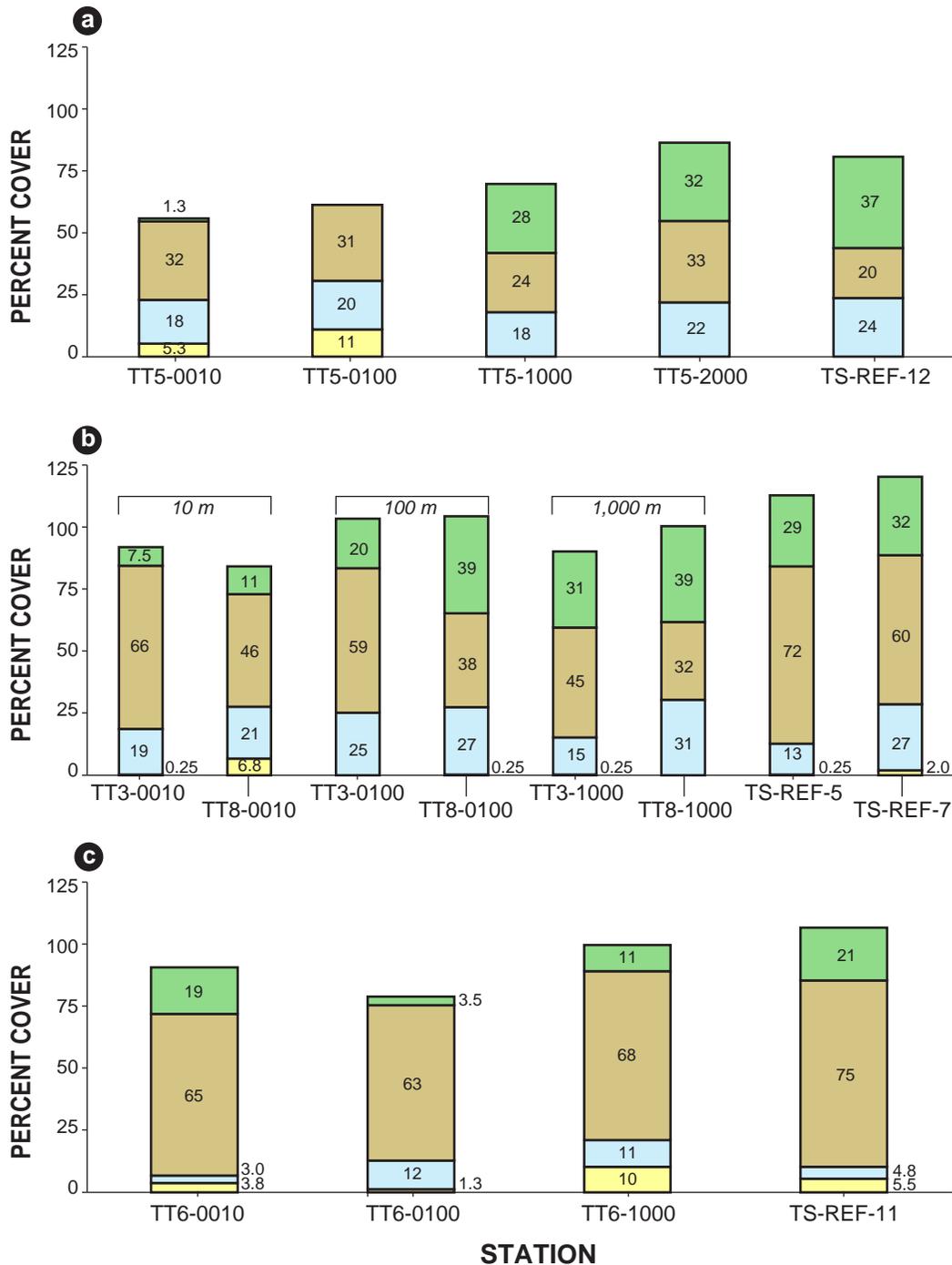


Figure 6-2. Vascular plant canopy composition of terrestrial vegetation communities along the DMTS road a) coastal plain mesic tussock tundra; b) foothills mesic tussock tundra; c) hillslope mesic open shrubland

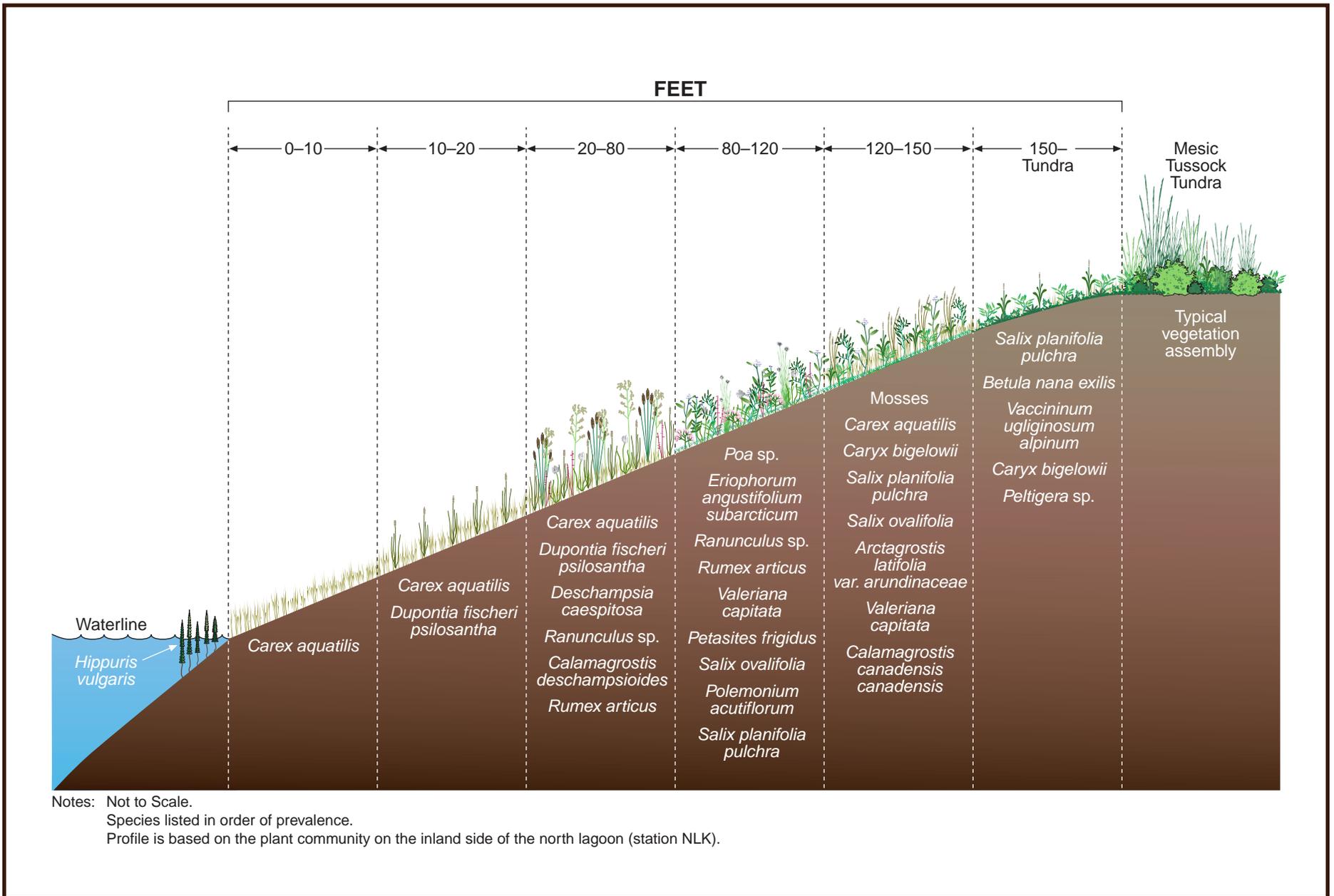
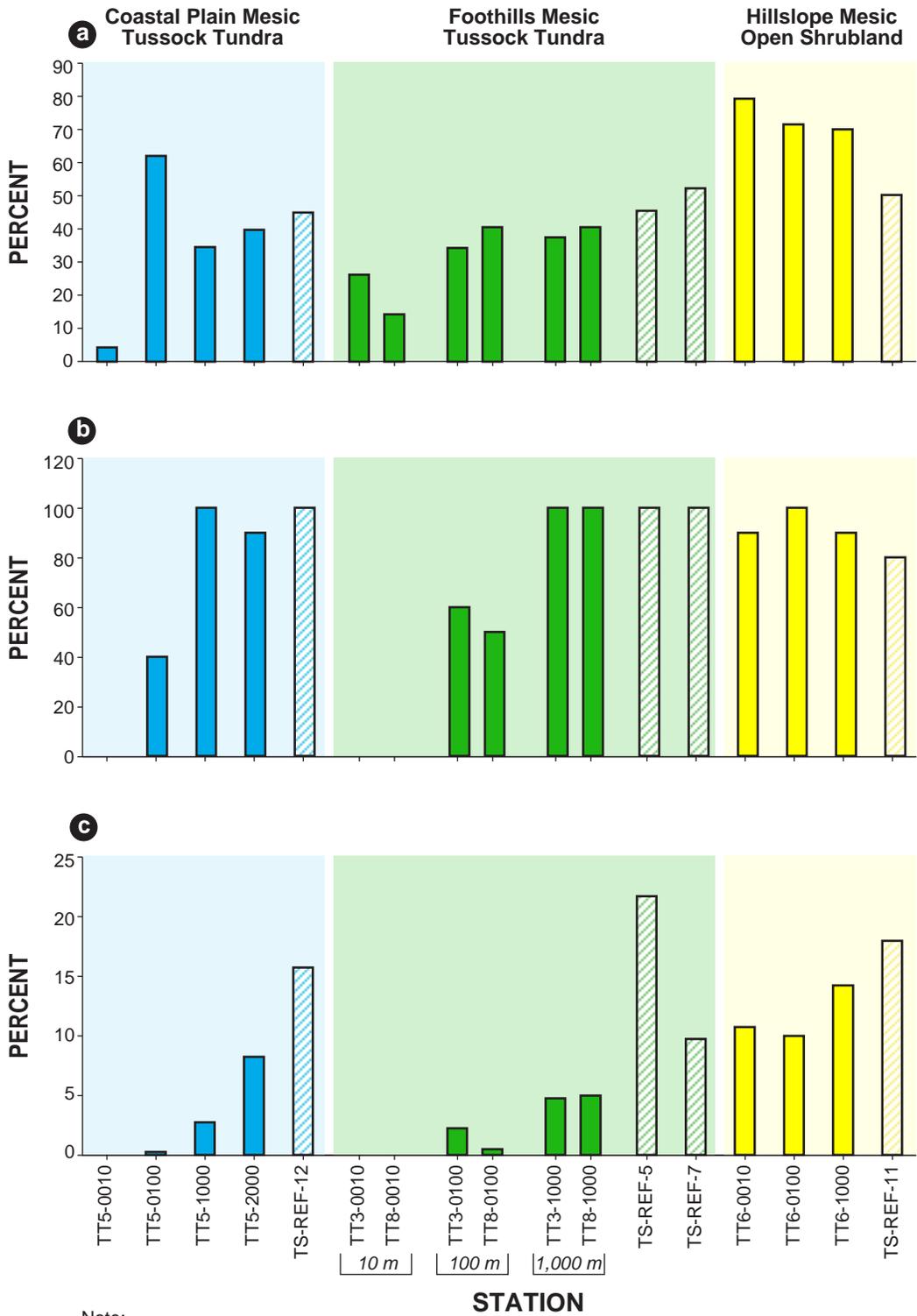


Figure 6-3. Representative example of coastal lagoon vegetation profile



Note:

Covers represent average microplot (1-m<sup>2</sup>) cover percentages, including areas shaded by a taller canopy.

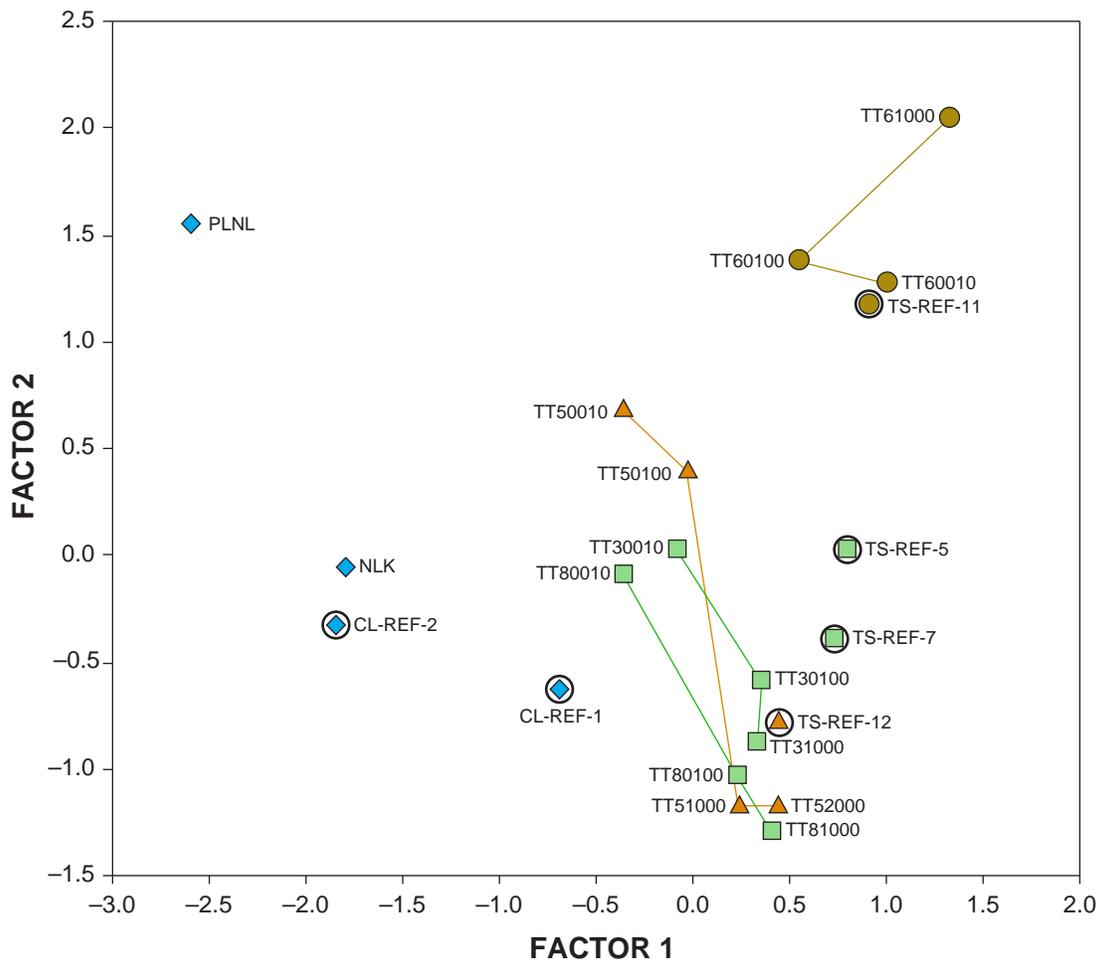
Lichen frequency is the percentage of 1-m<sup>2</sup> microplots that contained lichens.

Moss frequency was 90–100 percent at all stations (not shown)

Hatched bars = Reference stations

Solid bars = Site stations

Figure 6-4. Average percent cover and frequency of mosses and lichens in microplots at terrestrial survey stations a) moss cover; b) lichen frequency; c) lichen cover



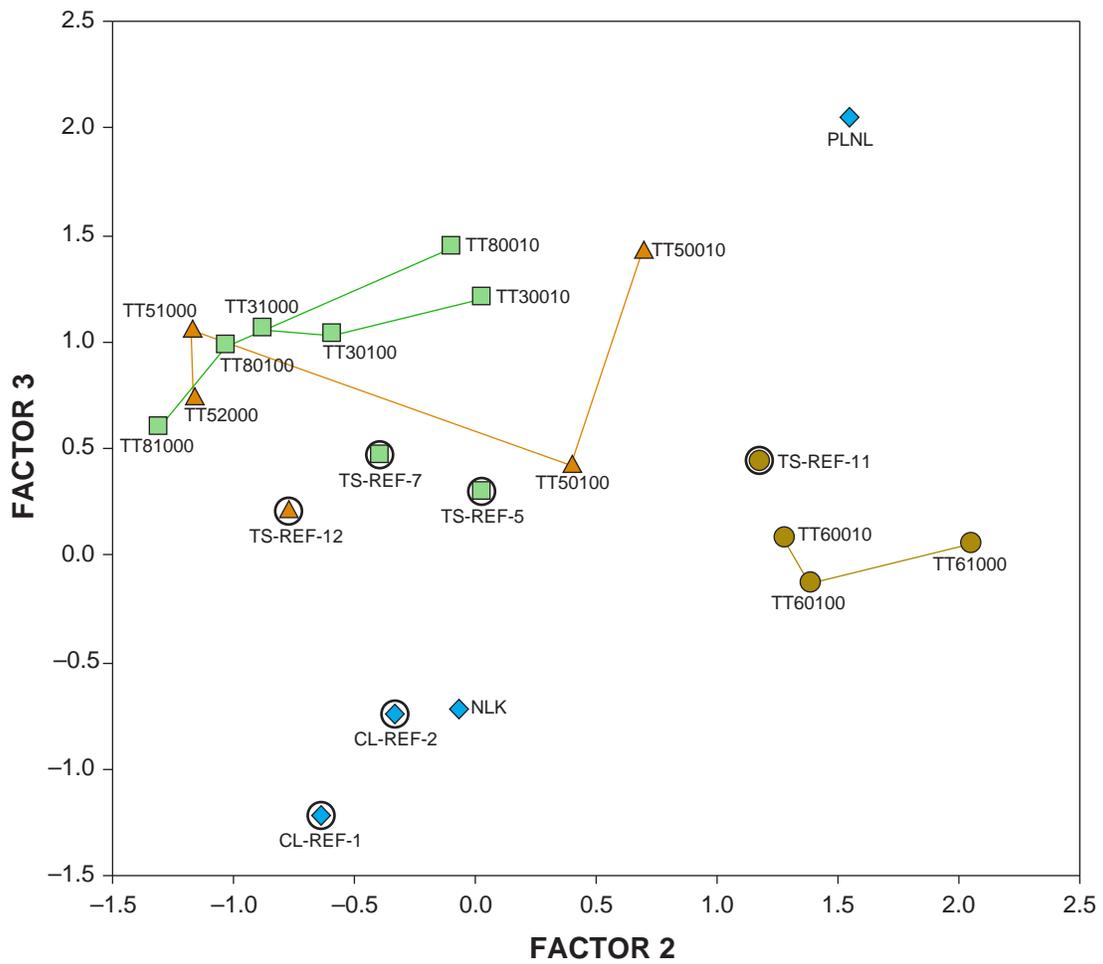
**LEGEND**

- ◆ Lagoon
- ▲ Coastal
- Tundra
- Hillslope
- Reference

**Coefficients for standardized factor scores of first 3 factors**

	Factor 1	Factor 2	Factor 3
Diversity	2.300	-0.032	0.092
Deciduous shrubs	0.199	0.179	0.166
Evenness	0.164	-0.363	0.093
Moss	0.152	0.116	-0.502
Evergreen shrubs	0.146	-0.316	0.185
Richness	0.135	0.399	-0.057
Lichen	0.135	0.095	-0.370
Forbs	-0.143	0.267	0.309
Graminoids	-0.161	-0.195	-0.506
Eigenvalue	4.054	1.802	1.217
Variance	45.0%	20.0%	13.5%
Total variance	45.0%	65.1%	78.6%

Figure 6-5. Factors 1 and 2 from principal component analysis of vegetation community variables



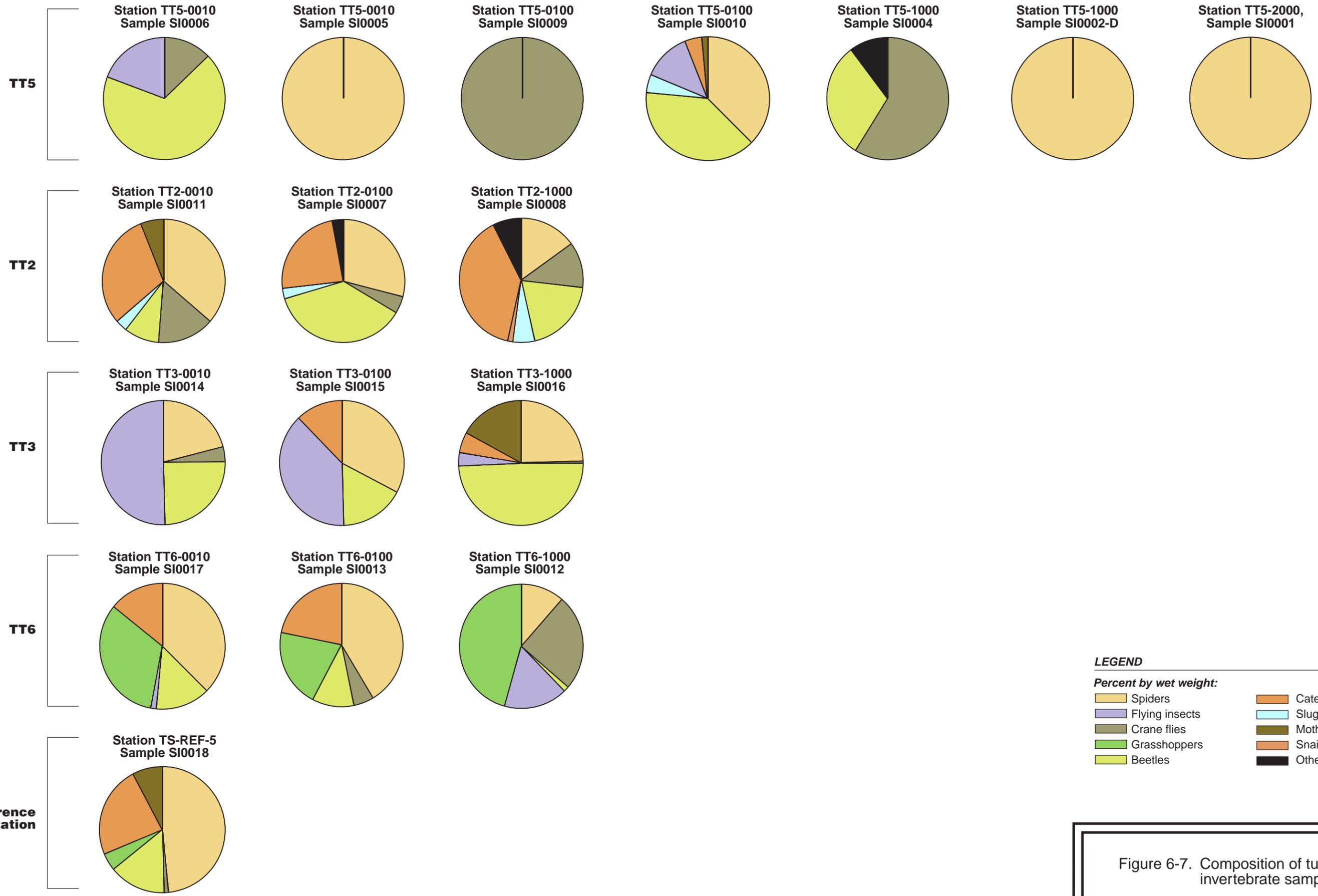
**LEGEND**

- ◆ Lagoon
- ▲ Coastal
- Tundra
- Hillslope
- Reference

**Coefficients for standardized factor scores of first 3 factors**

	Factor 1	Factor 2	Factor 3
Richness	0.135	0.399	-0.057
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Evenness	0.164	-0.363	0.093
Eigenvalue	4.054	1.802	1.217
Variance	45.0%	20.0%	13.5%
Total variance	45.0%	65.1%	78.6%

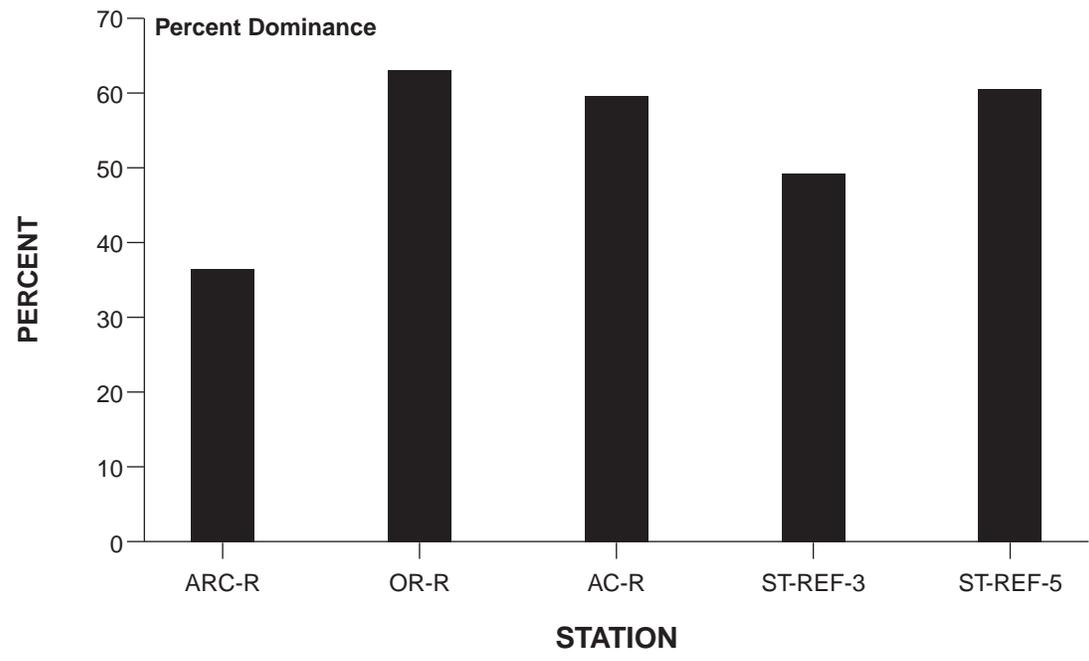
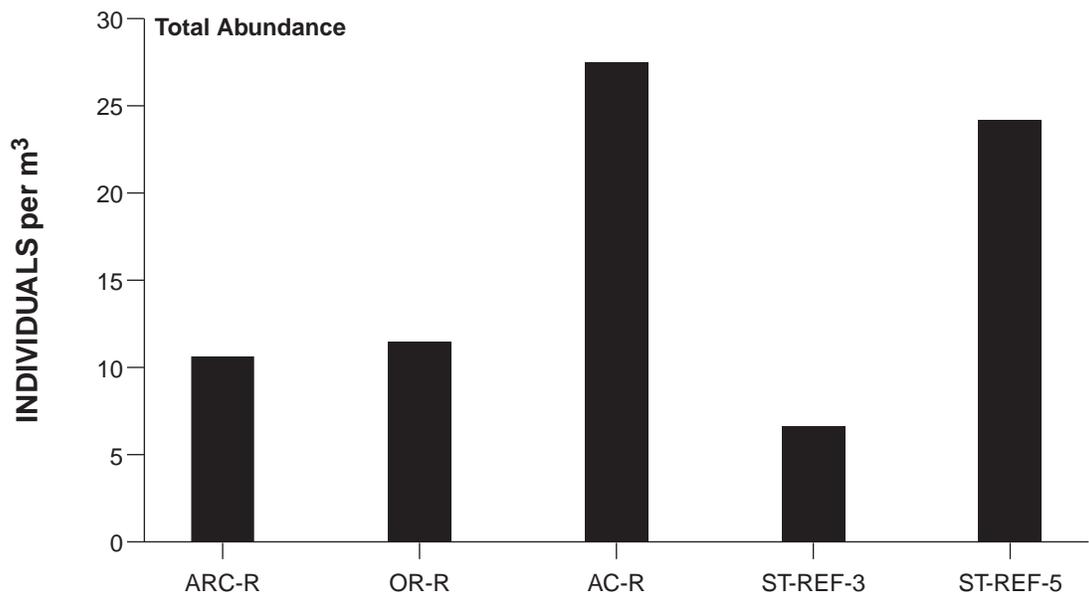
Figure 6-6. Factors 2 and 3 from principal component analysis of vegetation community variables



**LEGEND**  
 Percent by wet weight:

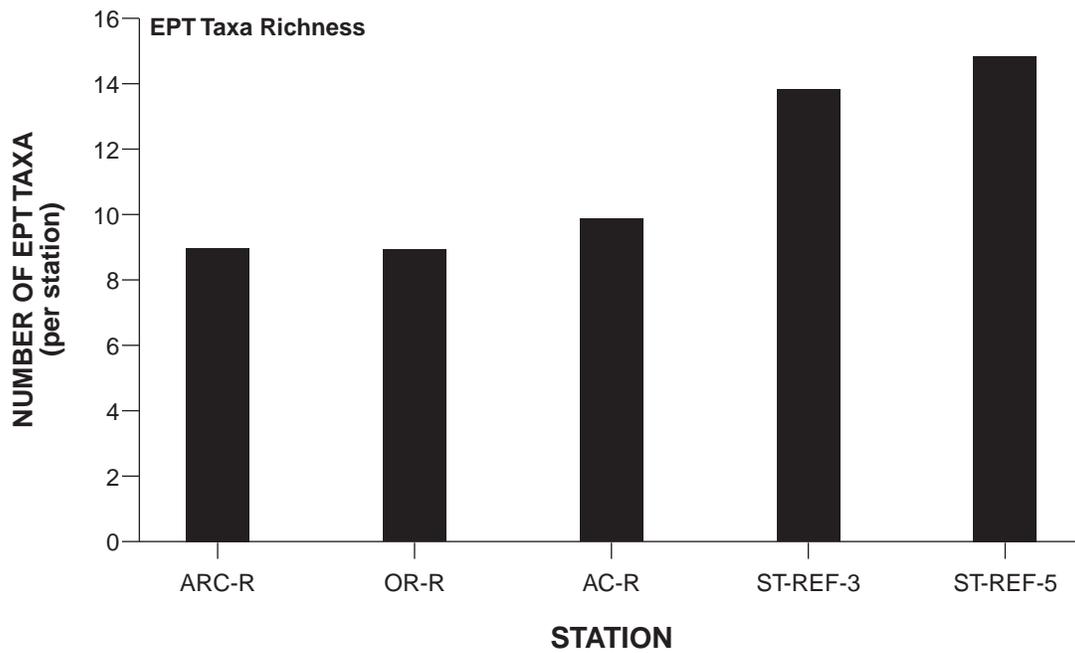
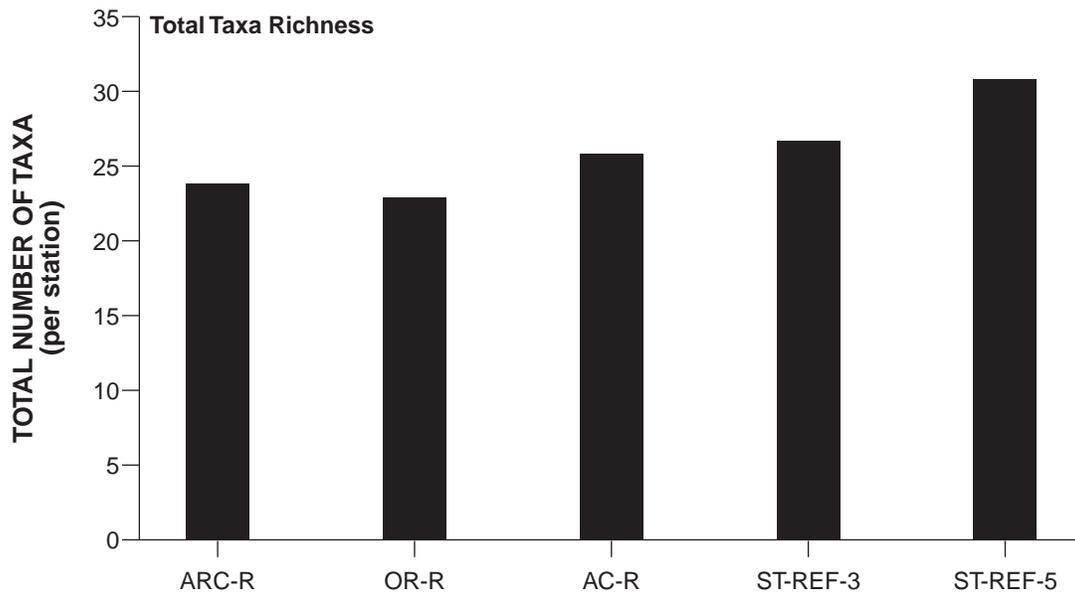
Spiders	Caterpillars
Flying insects	Slugs
Crane flies	Moths
Grasshoppers	Snails
Beetles	Other

Figure 6-7. Composition of tundra soil invertebrate samples



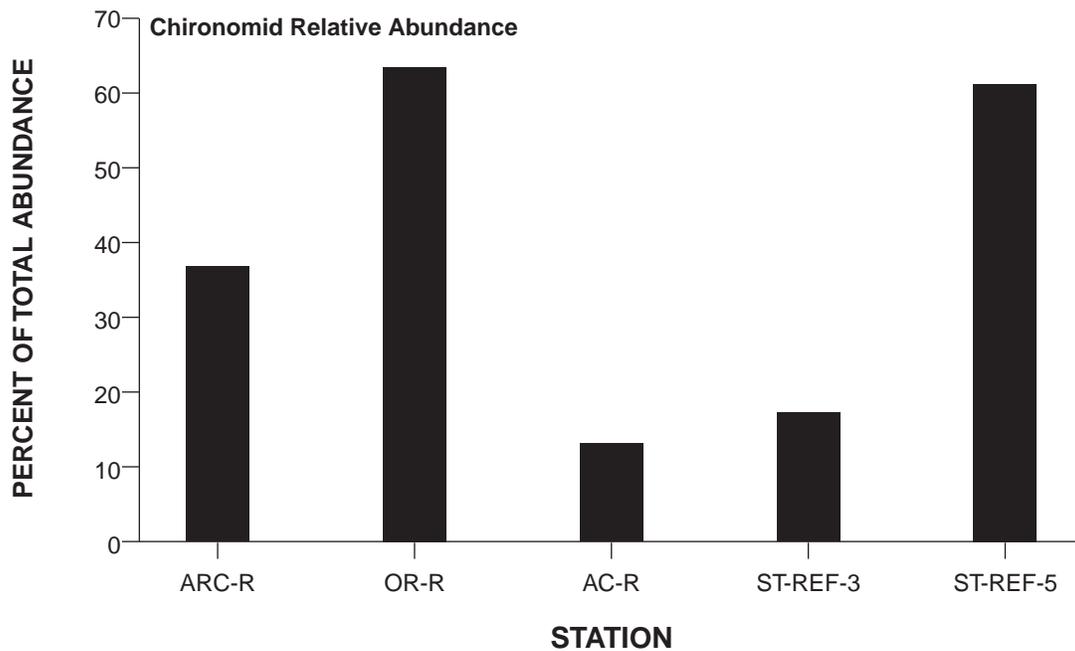
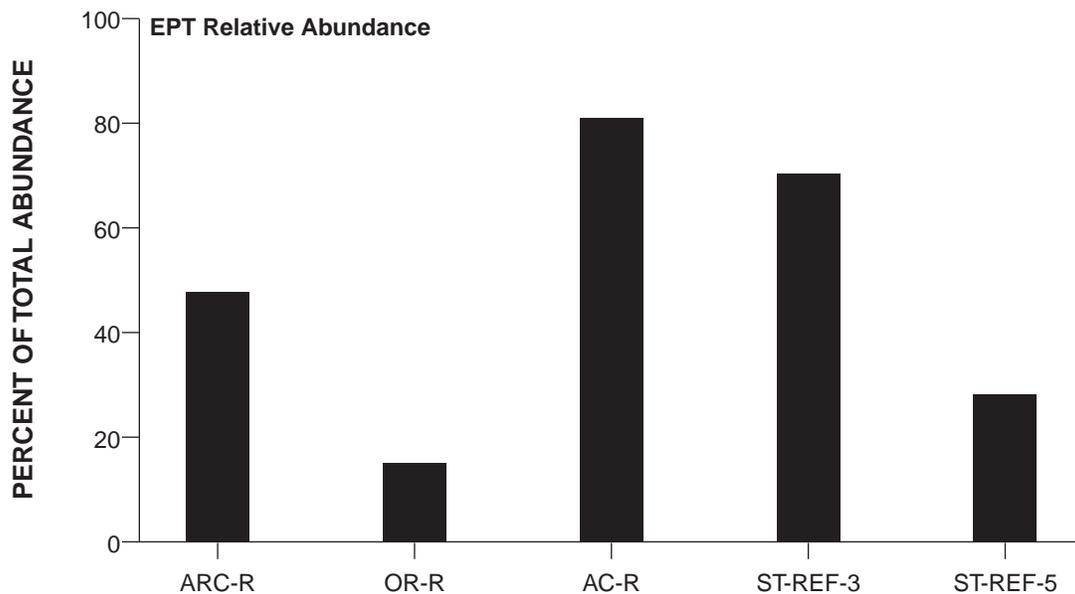
Note: Percent dominance = Percent of total abundance accounted for by the most abundant taxon

Figure 6-8. Comparison of total abundance and percent dominance between site and reference stations



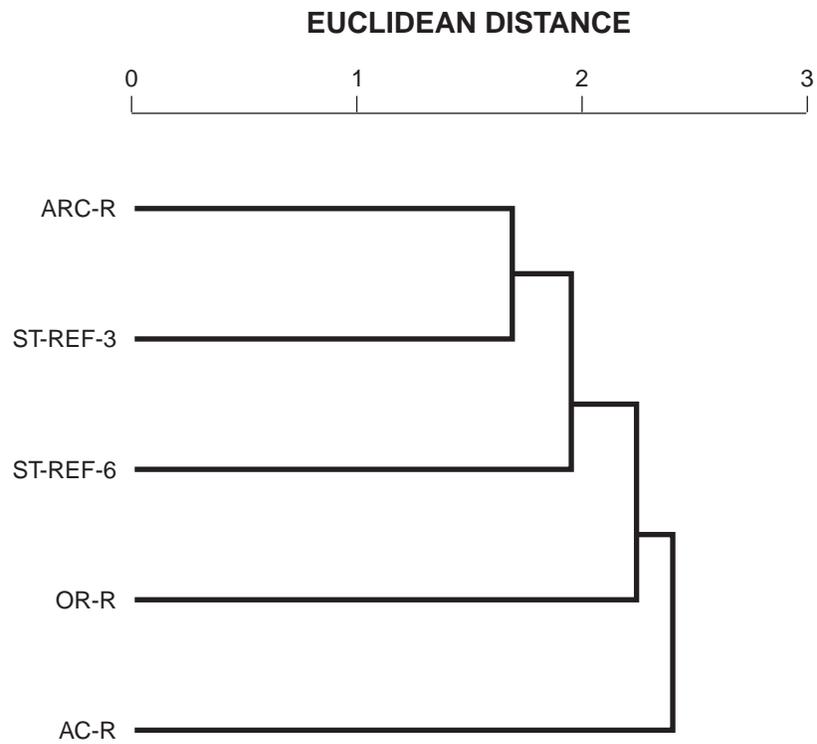
Note: EPT = Ephemeroptera, Plecoptera, and Trichoptera

Figure 6-9. Comparison of total and EPT taxa richness between site and reference stations



Note: EPT = Ephemeroptera, Plecoptera, and Trichoptera

Figure 6-10. Comparison of relative abundances of EPT taxa and chironomids between site and reference stations



Note: Classification analysis was based on the Bray-Curtis similarity index applied to log-transformed abundances of benthic macroinvertebrate taxa from each station

Figure 6-11. Results of classification analysis of benthic macroinvertebrate drift assemblages

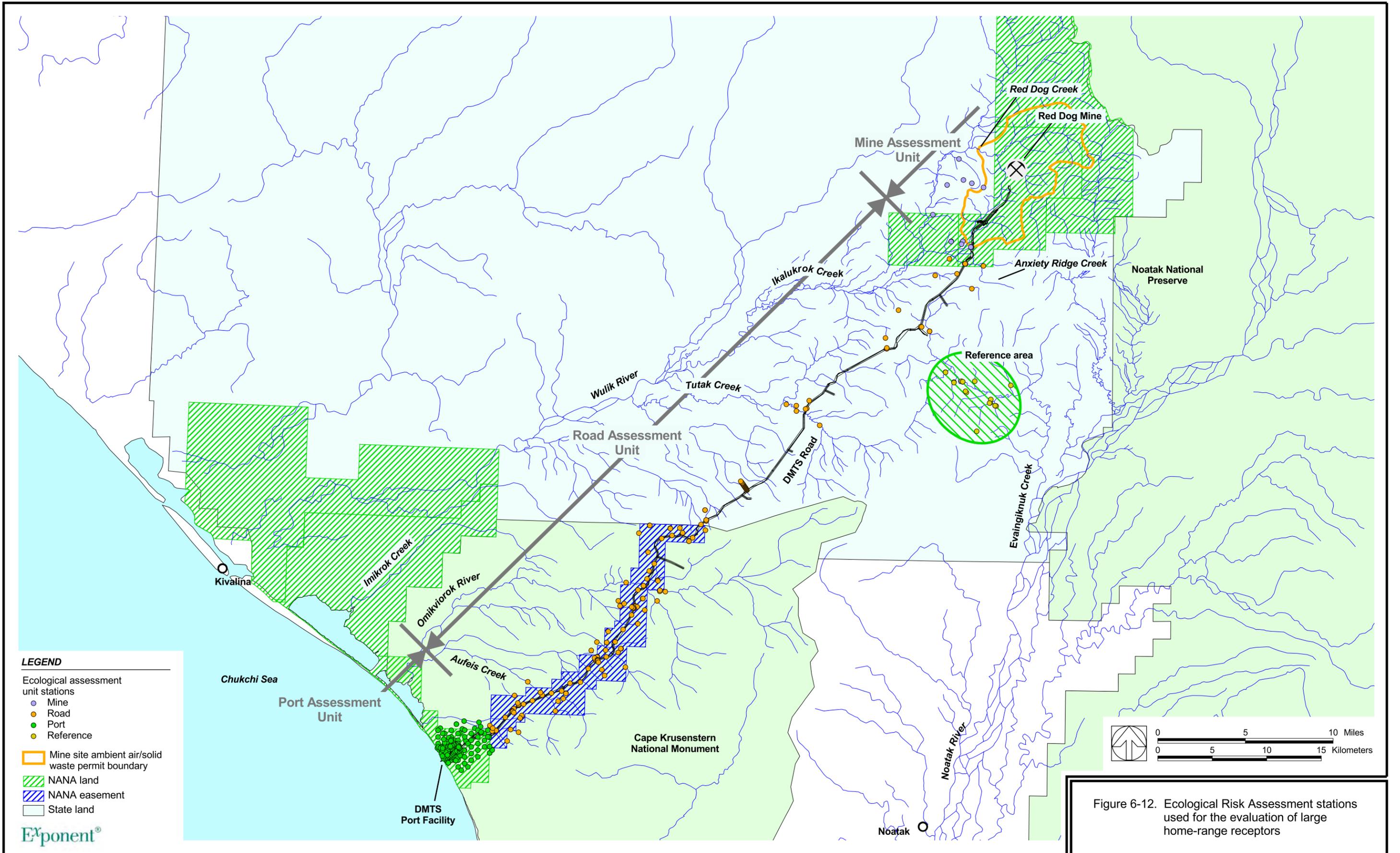
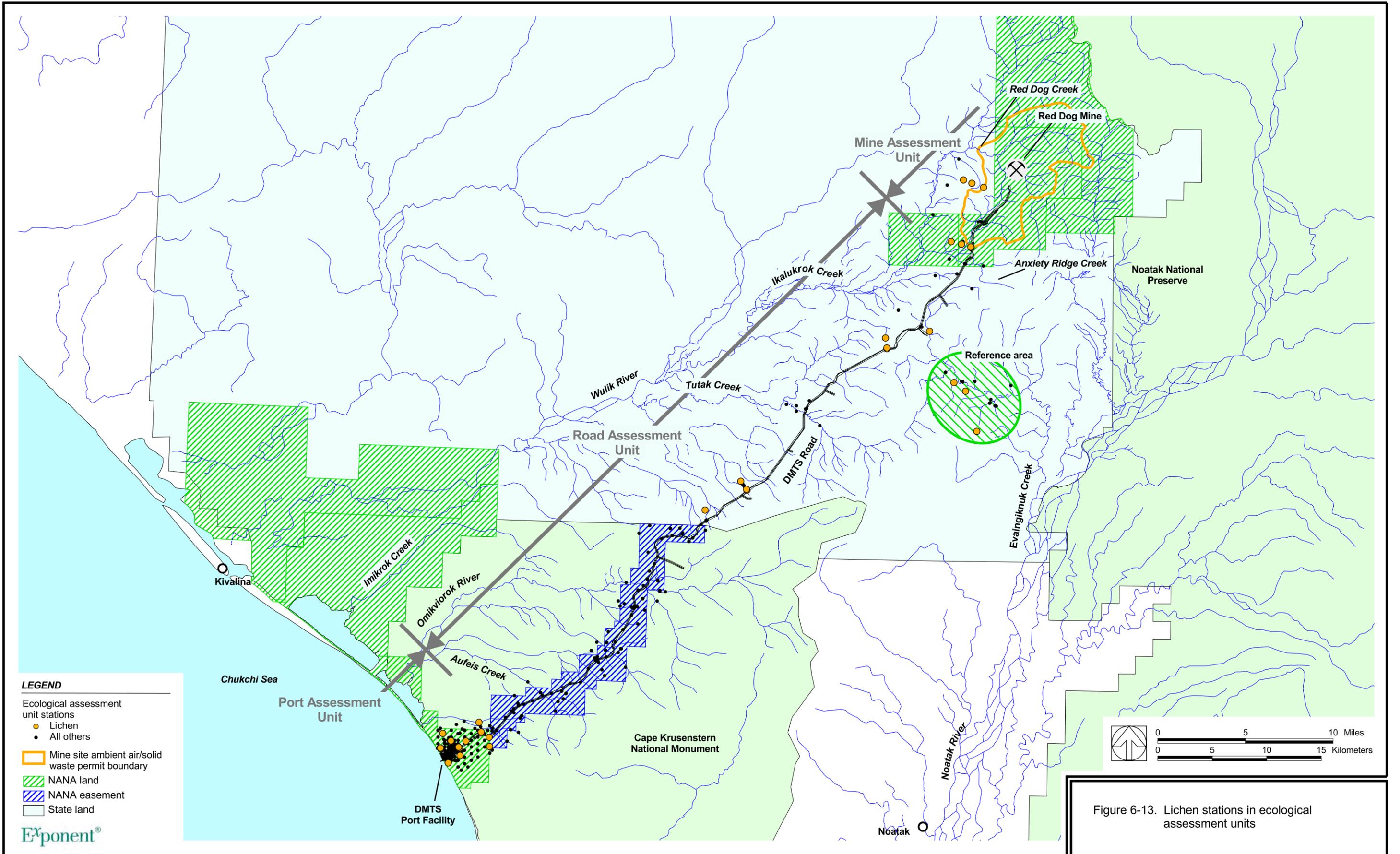


Figure 6-12. Ecological Risk Assessment stations used for the evaluation of large home-range receptors



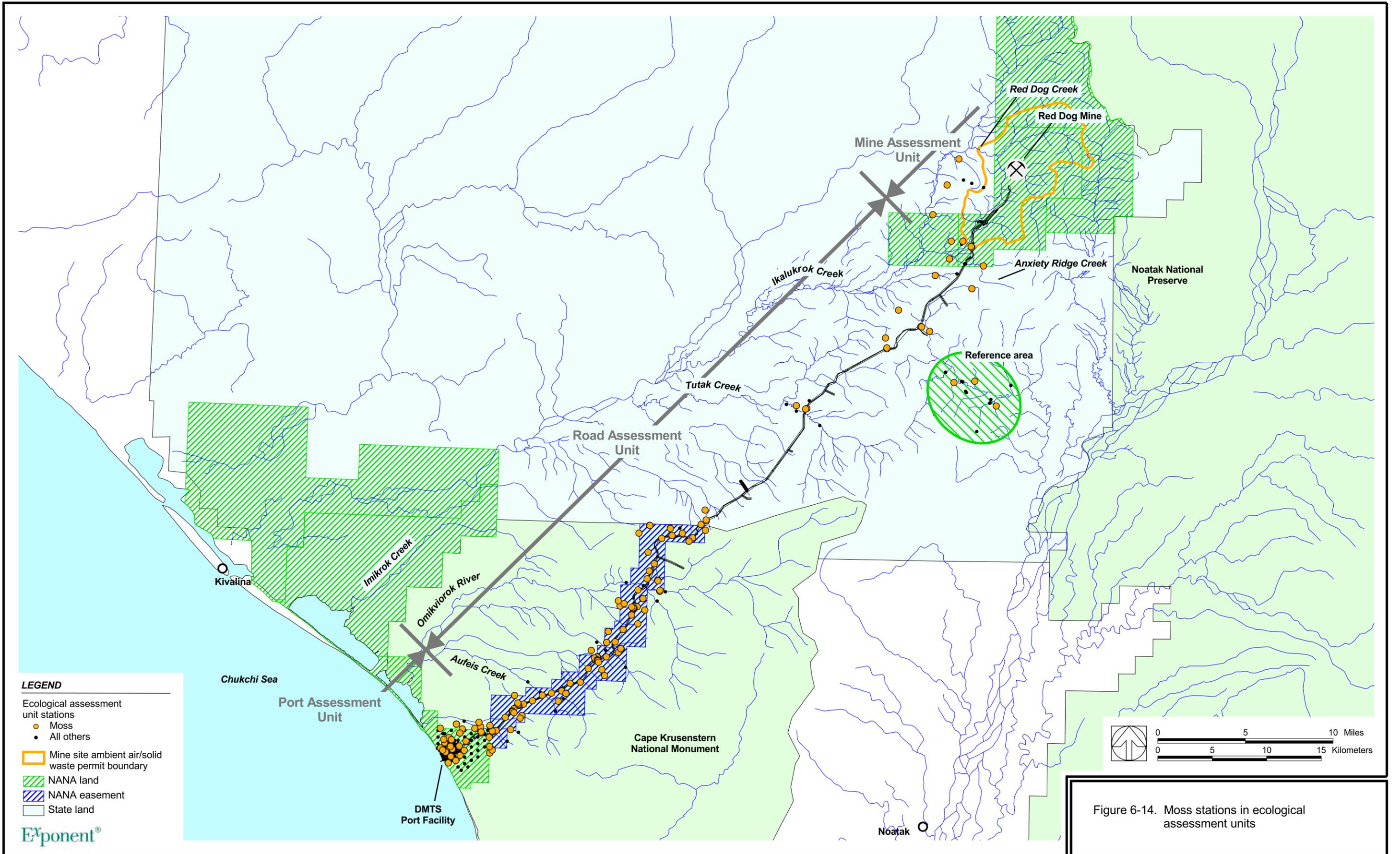


Figure 6-14. Moss stations in ecological assessment units



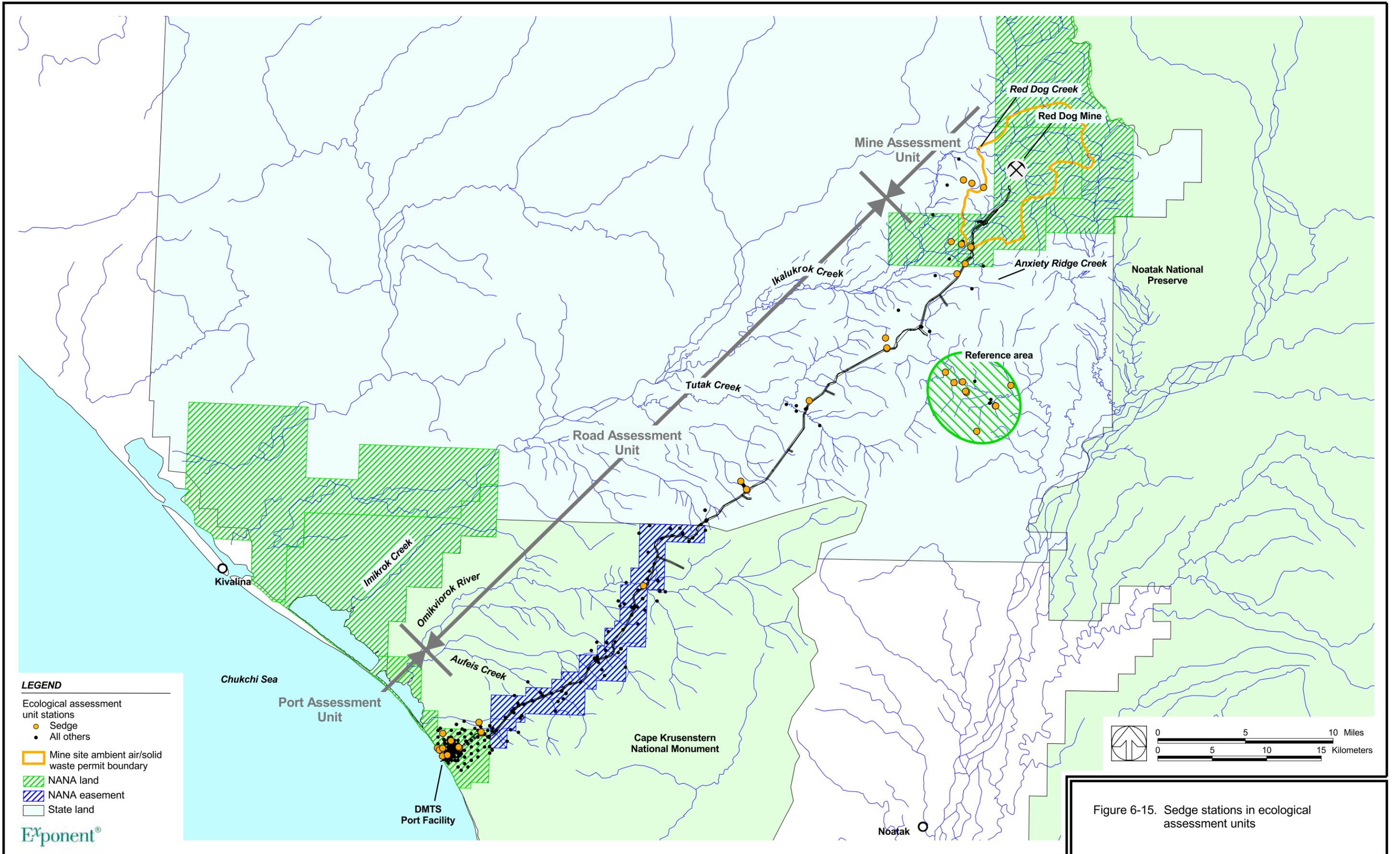
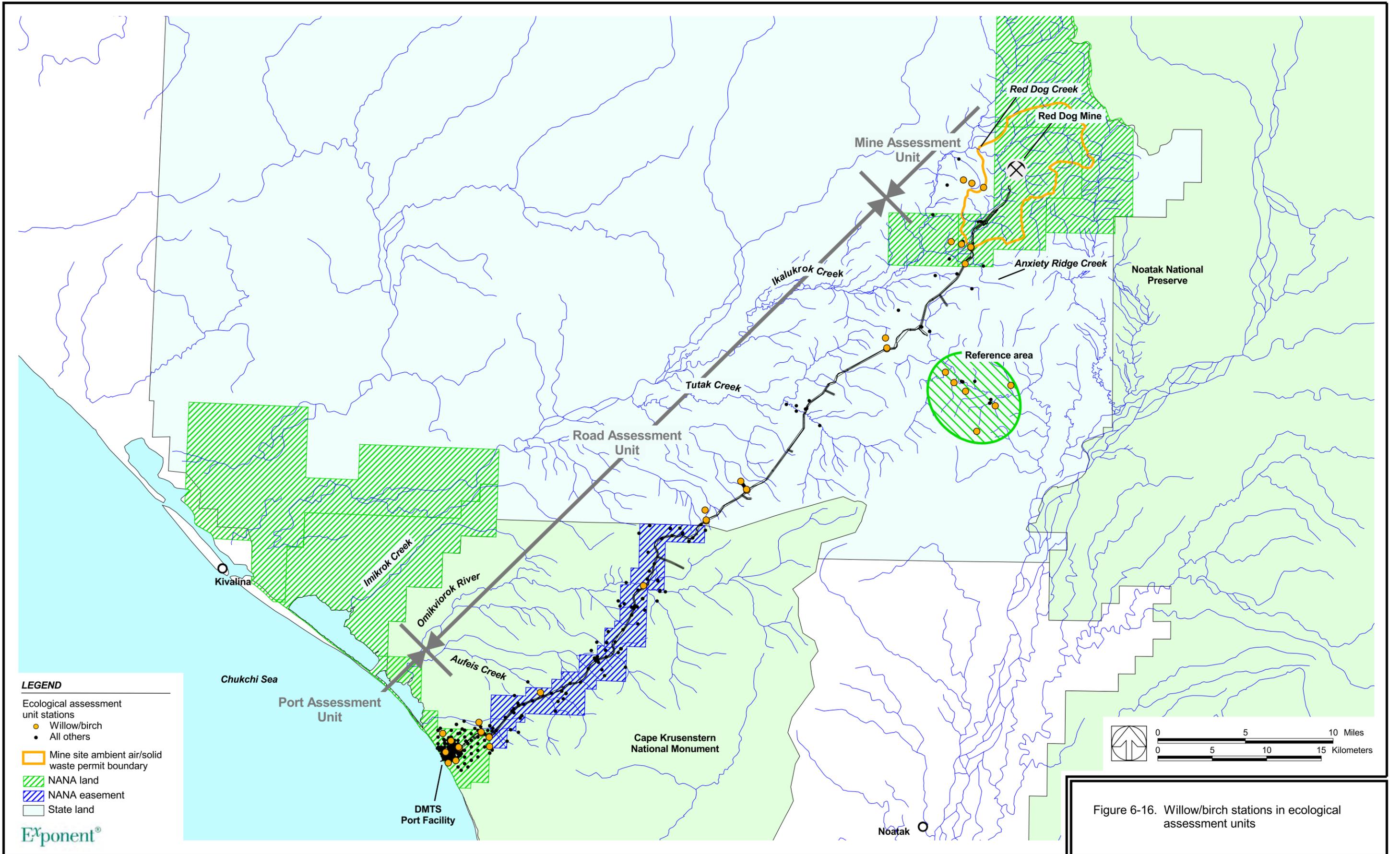


Figure 6-15. Sedge stations in ecological assessment units





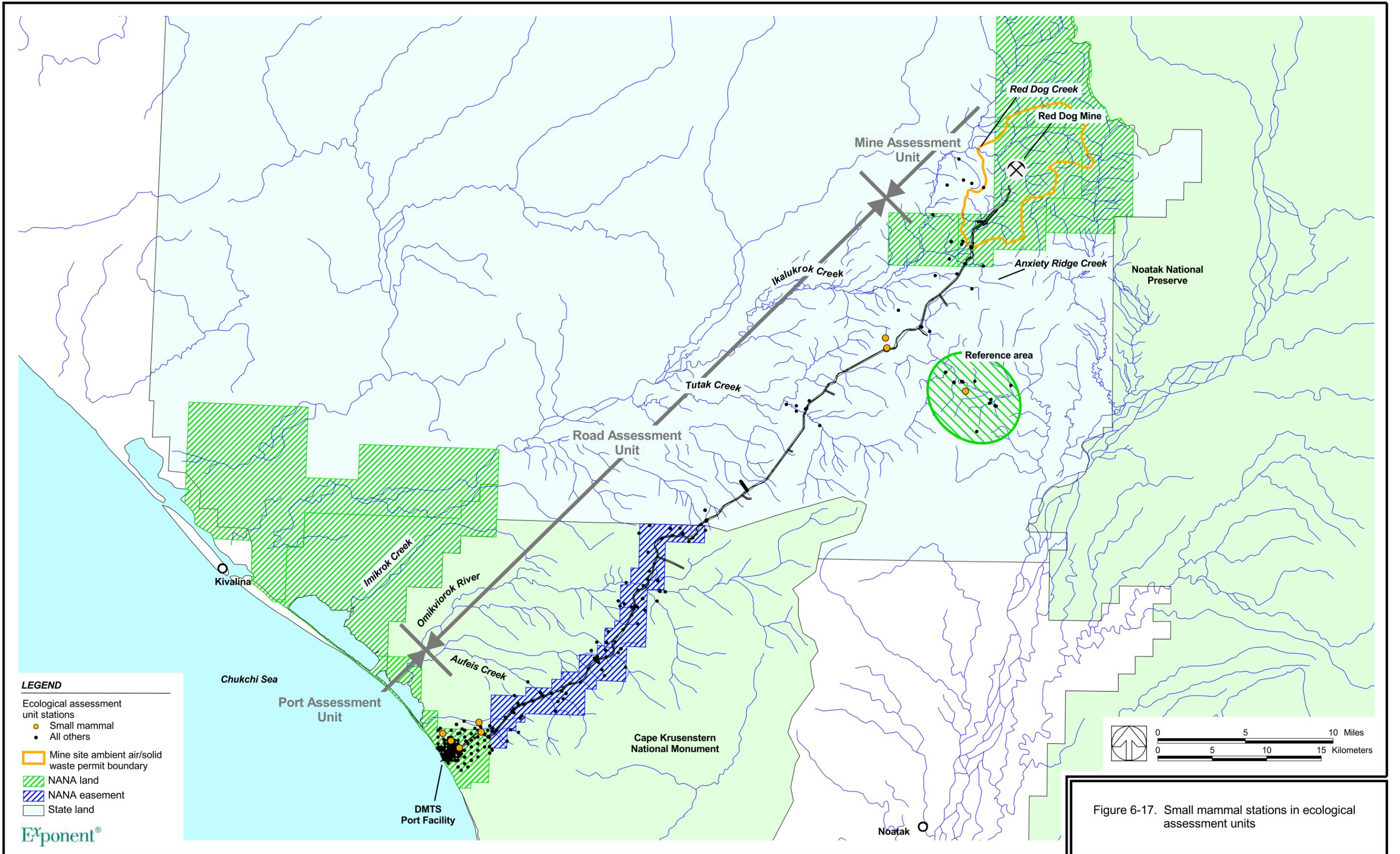
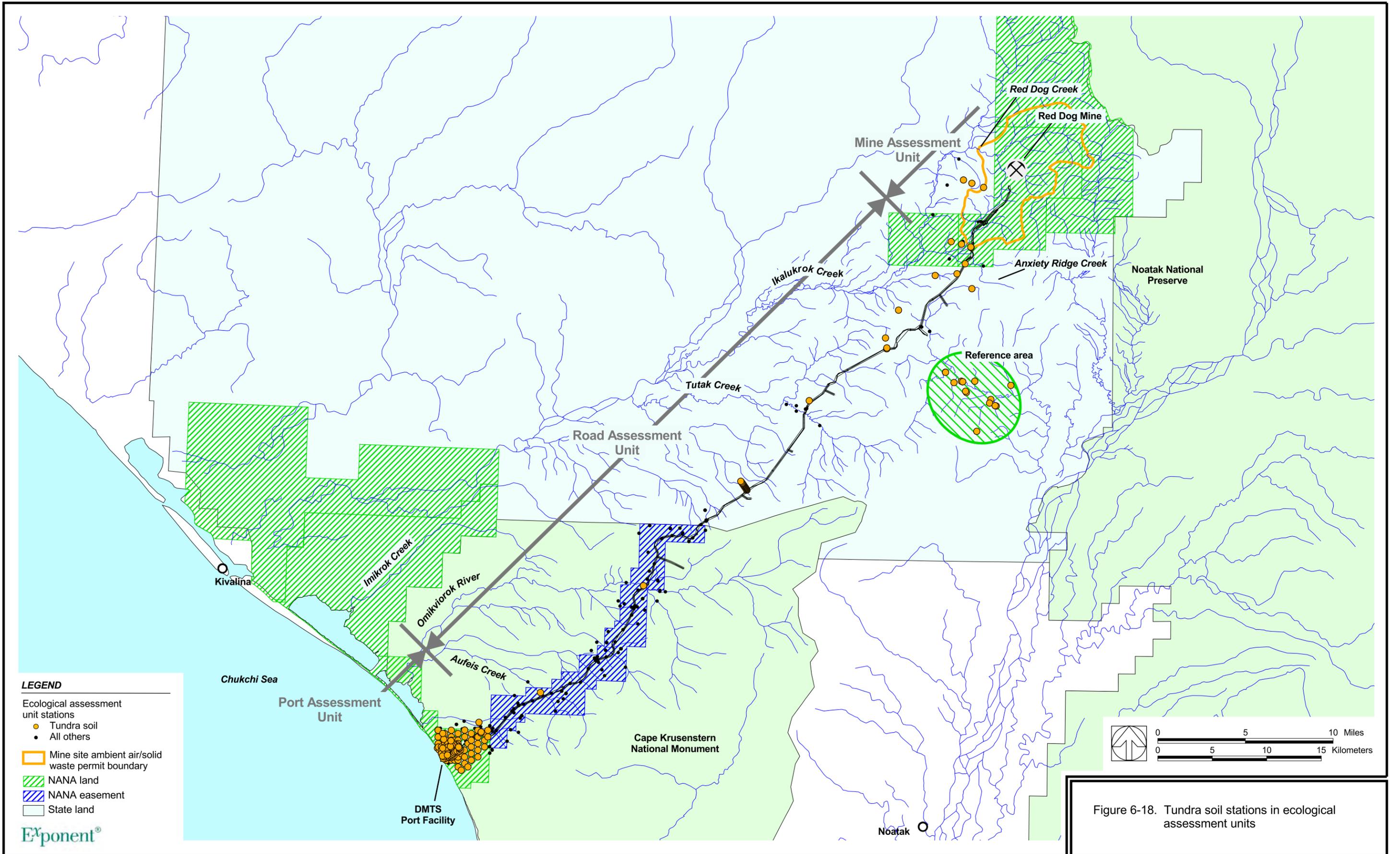
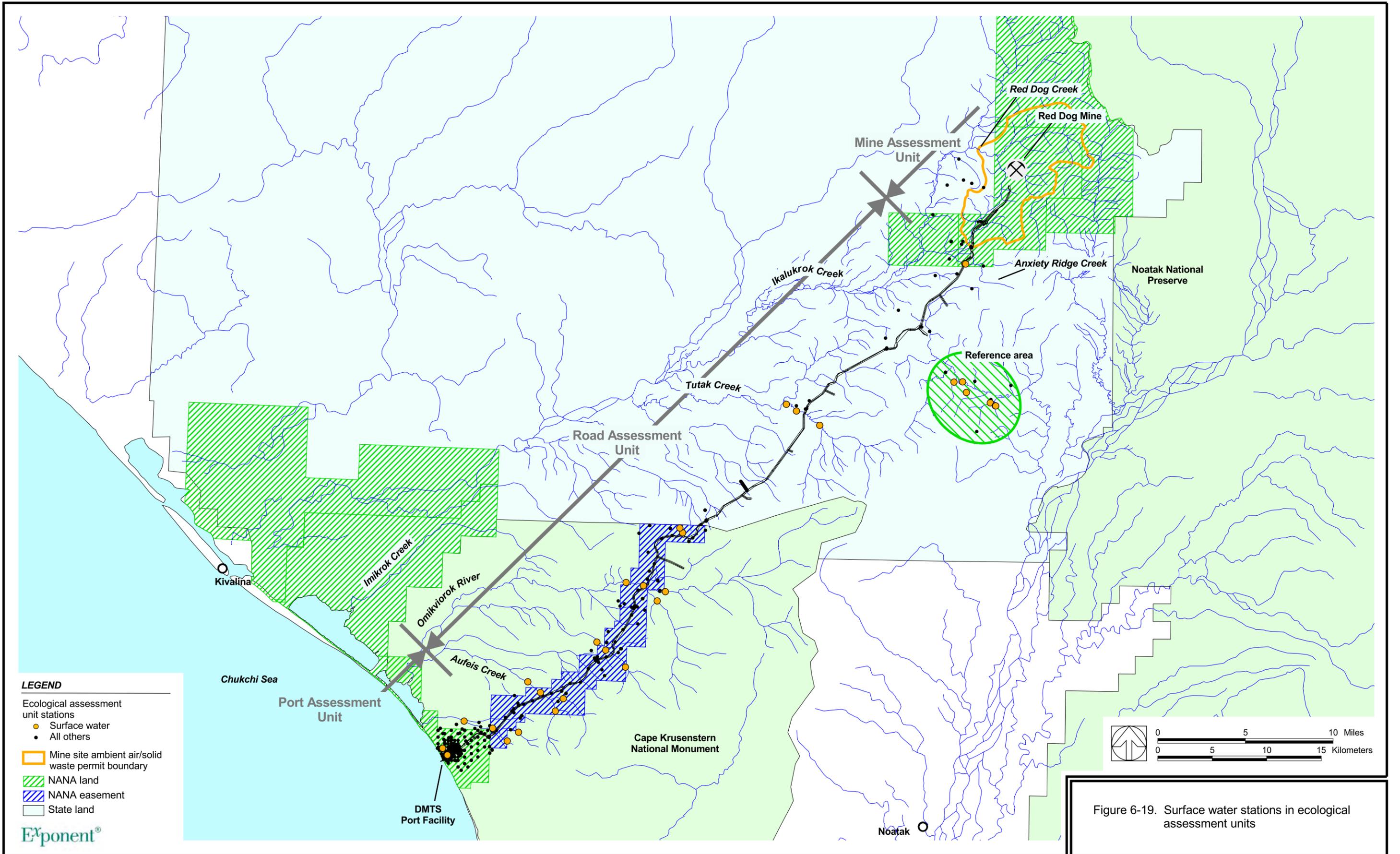
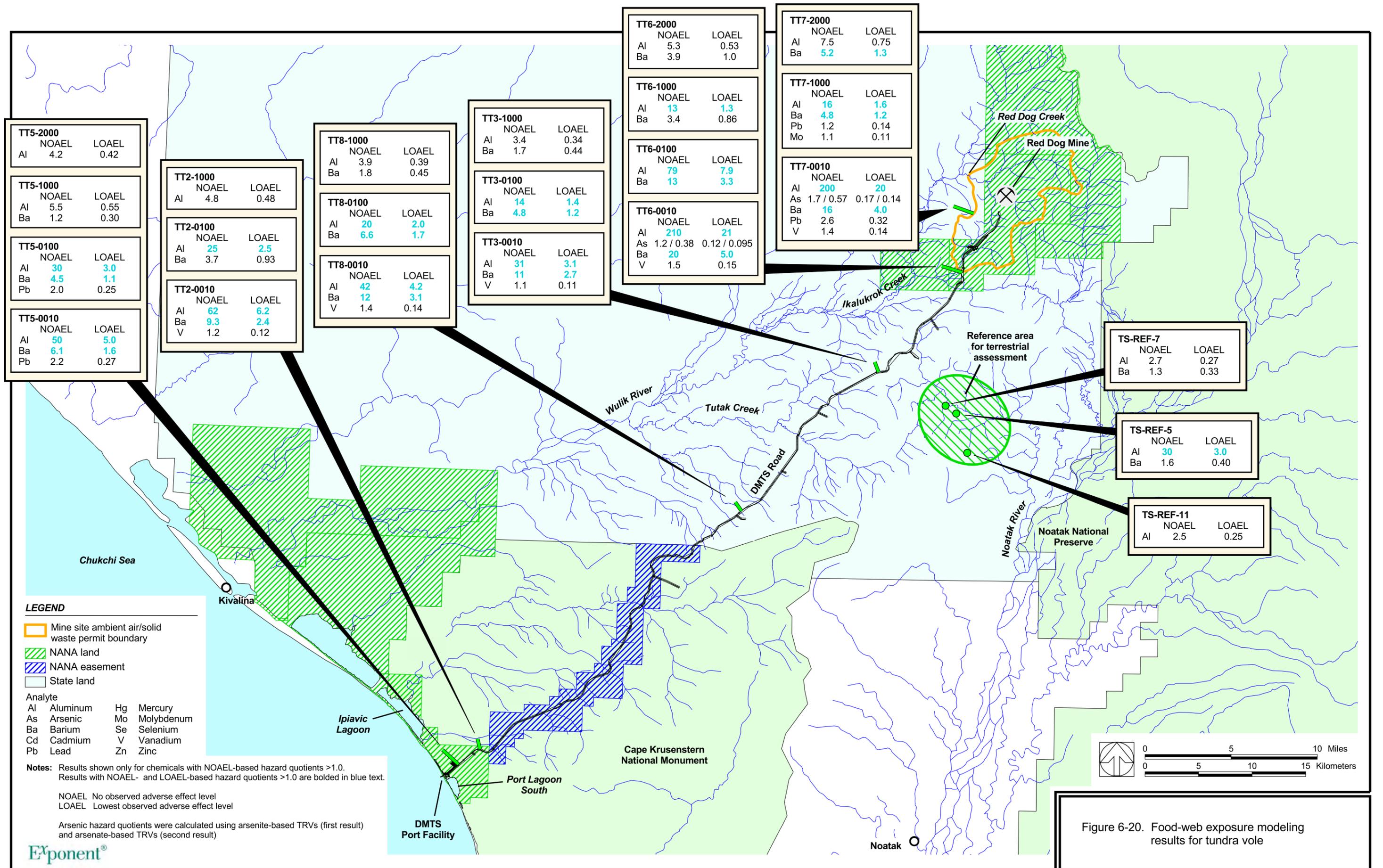


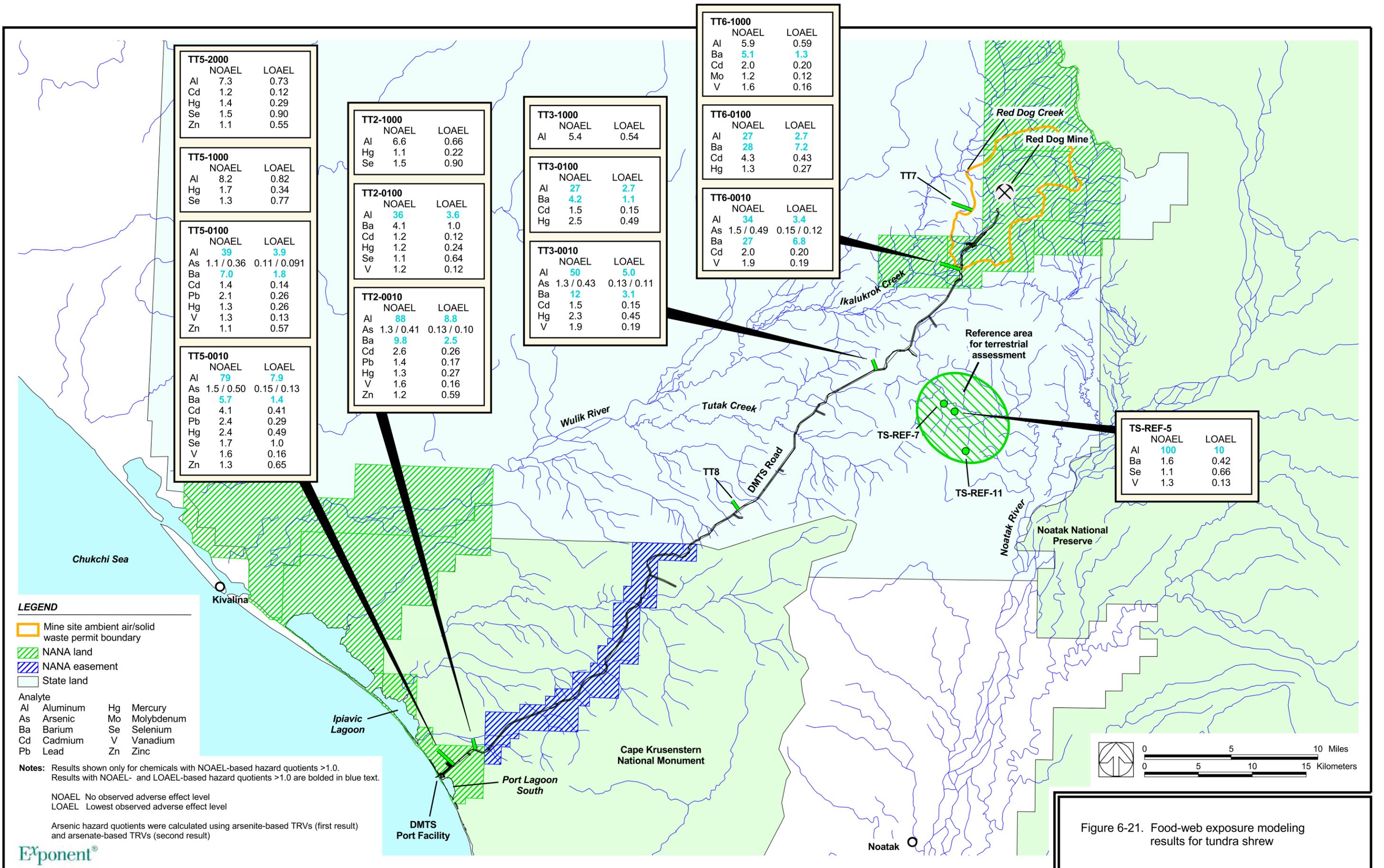
Figure 6-17. Small mammal stations in ecological assessment units











TT5-2000		
	NOAEL	LOAEL
Al	7.3	0.73
Cd	1.2	0.12
Hg	1.4	0.29
Se	1.5	0.90
Zn	1.1	0.55

TT5-1000		
	NOAEL	LOAEL
Al	8.2	0.82
Hg	1.7	0.34
Se	1.3	0.77

TT5-0100		
	NOAEL	LOAEL
Al	<b>39</b>	<b>3.9</b>
As	1.1 / 0.36	0.11 / 0.091
Ba	<b>7.0</b>	<b>1.8</b>
Cd	1.4	0.14
Pb	2.1	0.26
Hg	1.3	0.26
V	1.3	0.13
Zn	1.1	0.57

TT5-0010		
	NOAEL	LOAEL
Al	<b>79</b>	<b>7.9</b>
As	1.5 / 0.50	0.15 / 0.13
Ba	<b>5.7</b>	<b>1.4</b>
Cd	4.1	0.41
Pb	2.4	0.29
Hg	2.4	0.49
Se	1.7	1.0
V	1.6	0.16
Zn	1.3	0.65

TT2-1000		
	NOAEL	LOAEL
Al	6.6	0.66
Hg	1.1	0.22
Se	1.5	0.90

TT2-0100		
	NOAEL	LOAEL
Al	<b>36</b>	<b>3.6</b>
Ba	4.1	1.0
Cd	1.2	0.12
Hg	1.2	0.24
Se	1.1	0.64
V	1.2	0.12

TT2-0010		
	NOAEL	LOAEL
Al	<b>88</b>	<b>8.8</b>
As	1.3 / 0.41	0.13 / 0.10
Ba	<b>9.8</b>	<b>2.5</b>
Cd	2.6	0.26
Pb	1.4	0.17
Hg	1.3	0.27
V	1.6	0.16
Zn	1.2	0.59

TT3-1000		
	NOAEL	LOAEL
Al	5.4	0.54

TT3-0100		
	NOAEL	LOAEL
Al	<b>27</b>	<b>2.7</b>
Ba	<b>4.2</b>	<b>1.1</b>
Cd	1.5	0.15
Hg	2.5	0.49

TT3-0010		
	NOAEL	LOAEL
Al	<b>50</b>	<b>5.0</b>
As	1.3 / 0.43	0.13 / 0.11
Ba	<b>12</b>	<b>3.1</b>
Cd	1.5	0.15
Hg	2.3	0.45
V	1.9	0.19

TT6-1000		
	NOAEL	LOAEL
Al	5.9	0.59
Ba	<b>5.1</b>	<b>1.3</b>
Cd	2.0	0.20
Mo	1.2	0.12
V	1.6	0.16

TT6-0100		
	NOAEL	LOAEL
Al	<b>27</b>	<b>2.7</b>
Ba	<b>28</b>	<b>7.2</b>
Cd	4.3	0.43
Hg	1.3	0.27

TT6-0010		
	NOAEL	LOAEL
Al	<b>34</b>	<b>3.4</b>
As	1.5 / 0.49	0.15 / 0.12
Ba	<b>27</b>	<b>6.8</b>
Cd	2.0	0.20
V	1.9	0.19

TS-REF-5		
	NOAEL	LOAEL
Al	<b>100</b>	<b>10</b>
Ba	1.6	0.42
Se	1.1	0.66
V	1.3	0.13

Figure 6-21. Food-web exposure modeling results for tundra shrew

