

Trace Elements: 2007 Agency Update

SLR International
Corp.

November 27,
2007



Objectives

- Establish **baseline concentrations** of naturally occurring constituents (NOCs) in shallow soils, native plants (including aquatic plants), sediment, and fish tissue
- Evaluate **variability in baseline levels** of NOCs across different geochemistries, habitats, and plant species
 - Evaluate both spatial and temporal variability of trace elements in plants and soil

Target Analyses

Parameter	Method	Soil	Sediment	Plants	Fish
Ammonia	E350.3	X	X	X	
Chloride	E300.0	X	X	X ^c	
Cyanide	E335.2	X	X	X	
Fluoride	SW4500FC	X	X	X ^c	
Sulfate	E300.0	X	X	X ^c	
Mercury	SW7471A	X	X	X	X
Metals	SW6010/6020	X ^a	X ^a	X ^a	X ^b
DRO/RRO	AK102/103	X ^c			
Pesticides/PCBs	EPA 8081/8082				X ^c
Organic Carbon	ASTM D4129-82M	X			

^a 26 Metals; ^b 11 Metals; ^c Discontinued after 2005.



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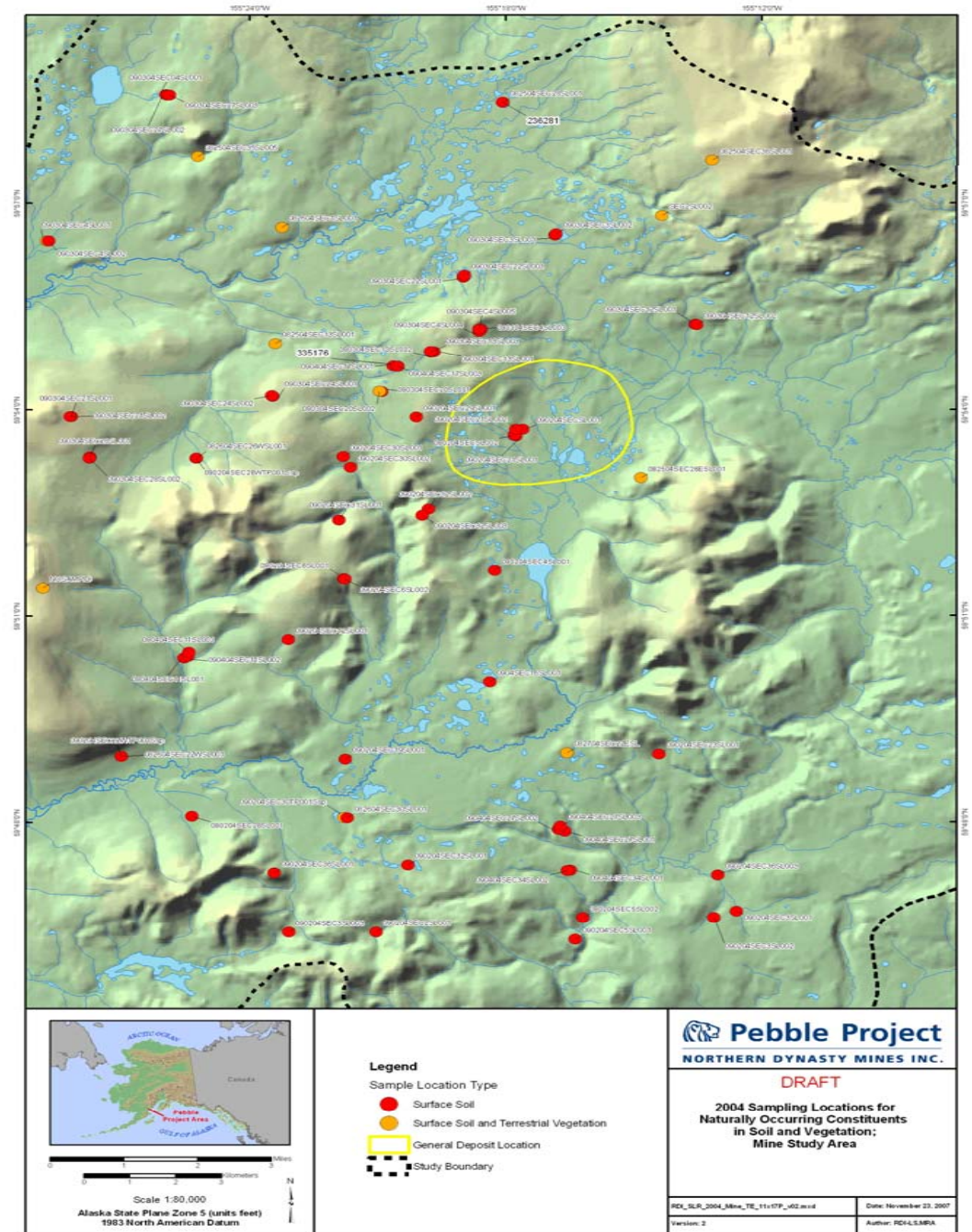
Where Has the Program Been So Far?

- Plant/soil/fish/sediment sampling began in 2004
- Plant/soil sampling program updated in 2005:
 - Sampling locations and density modified to be proportional to habitat abundance
 - All plant and soil sampling collocated
 - Two sampling events per season
 - Early season browse
 - Late season browse and berries
 - Aquatic plants and ponds added to program
 - Seep sediments sampled

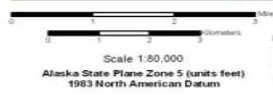
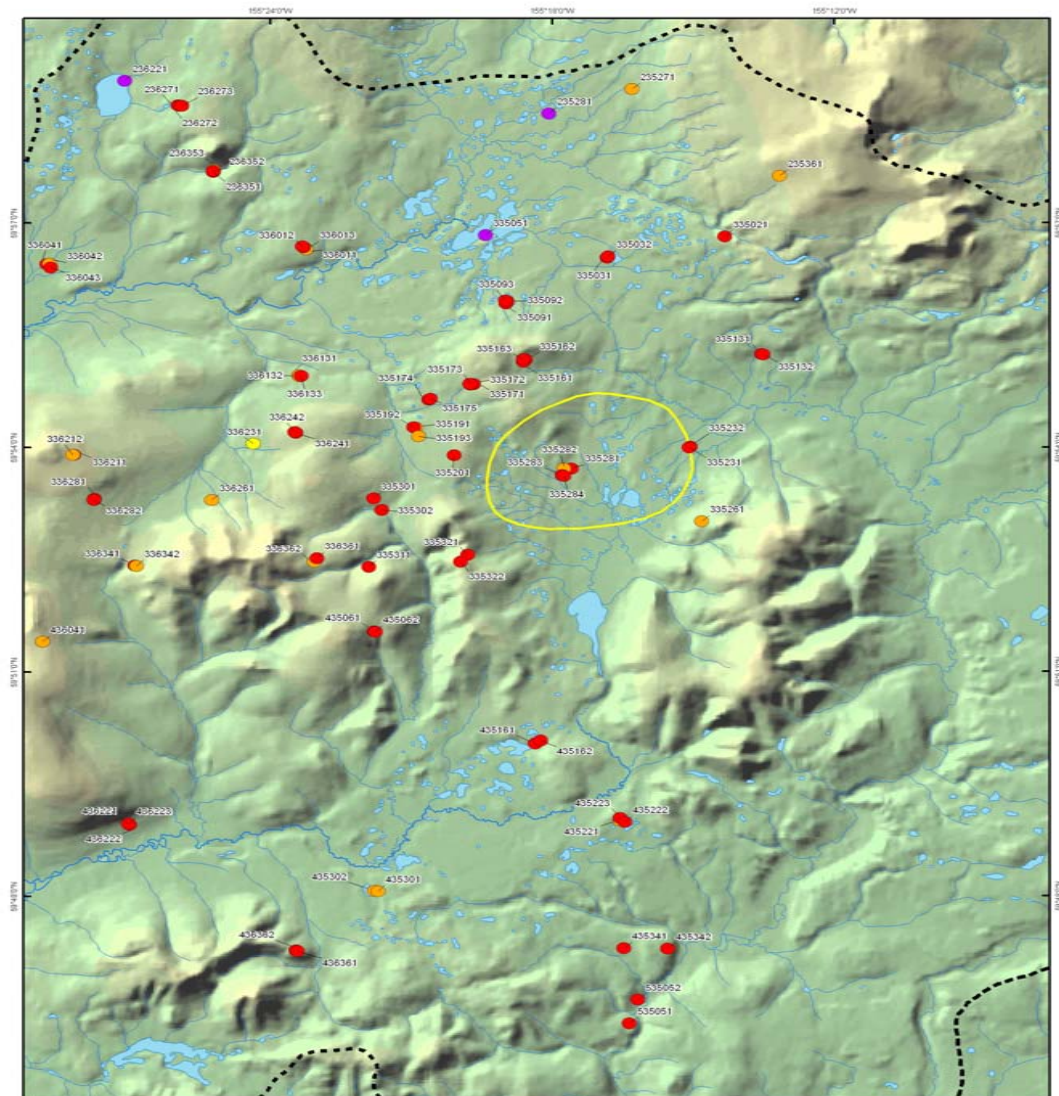


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Sampling Locations 2004



Sampling Locations 2005



Legend

Sample Location Type

- Bacteriology Soil, Surface Soil and Terrestrial Vegetation
- Surface Soil and Terrestrial Vegetation
- Surface Soil
- Aquatic Vegetation and Sediment
- General Deposit Location
- Study Boundary

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**2005 Sampling Locations for
Naturally Occurring Constituents
in Soil and Vegetation;
Mine Study Area**

RDJ_SLR_2005_Minr_TE_11x17P_002.mxd

Date: November 23, 2007

Version: 2

Author: RDJ-LSMBA



Where Has the Program Been So Far?

- Pebble East area added in 2006
- Subsurface soil sampling eliminated in 2006
- Aquatic plant/pond sampling expanded in 2006 to include:

- Groundwater-fed ponds



- Precipitation-fed ponds



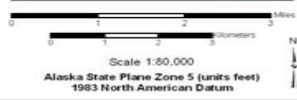
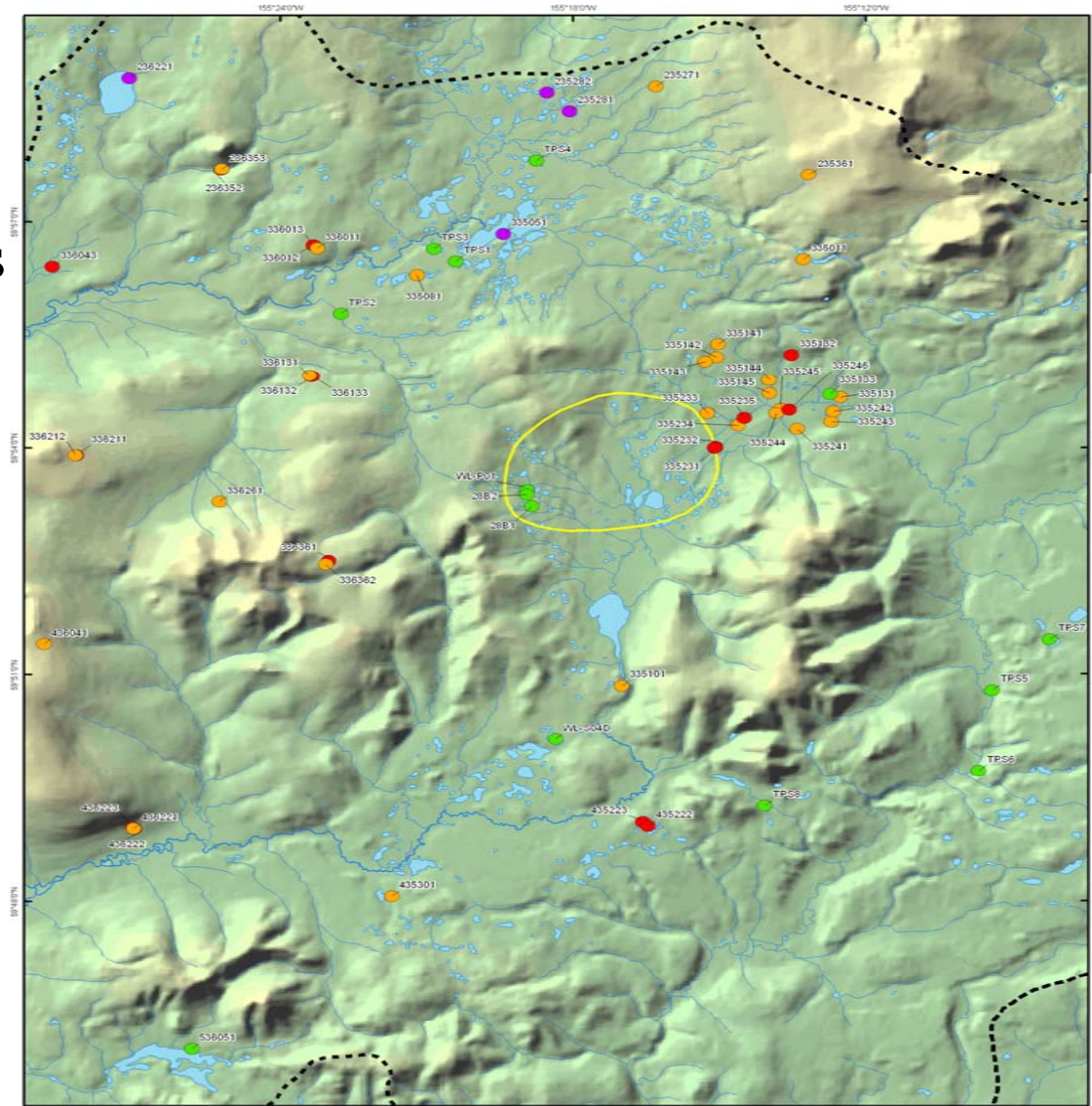
- Beaver dam impacted ponds



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Sampling Locations 2006



- Legend**
- Sample Location Type
- Surface Soil and Terrestrial Vegetation
 - Surface Soil
 - Aquatic Vegetation and Sediment
 - Aquatic Vegetation (Small Pond Study)
 - General Deposit Location
 - Study Boundary

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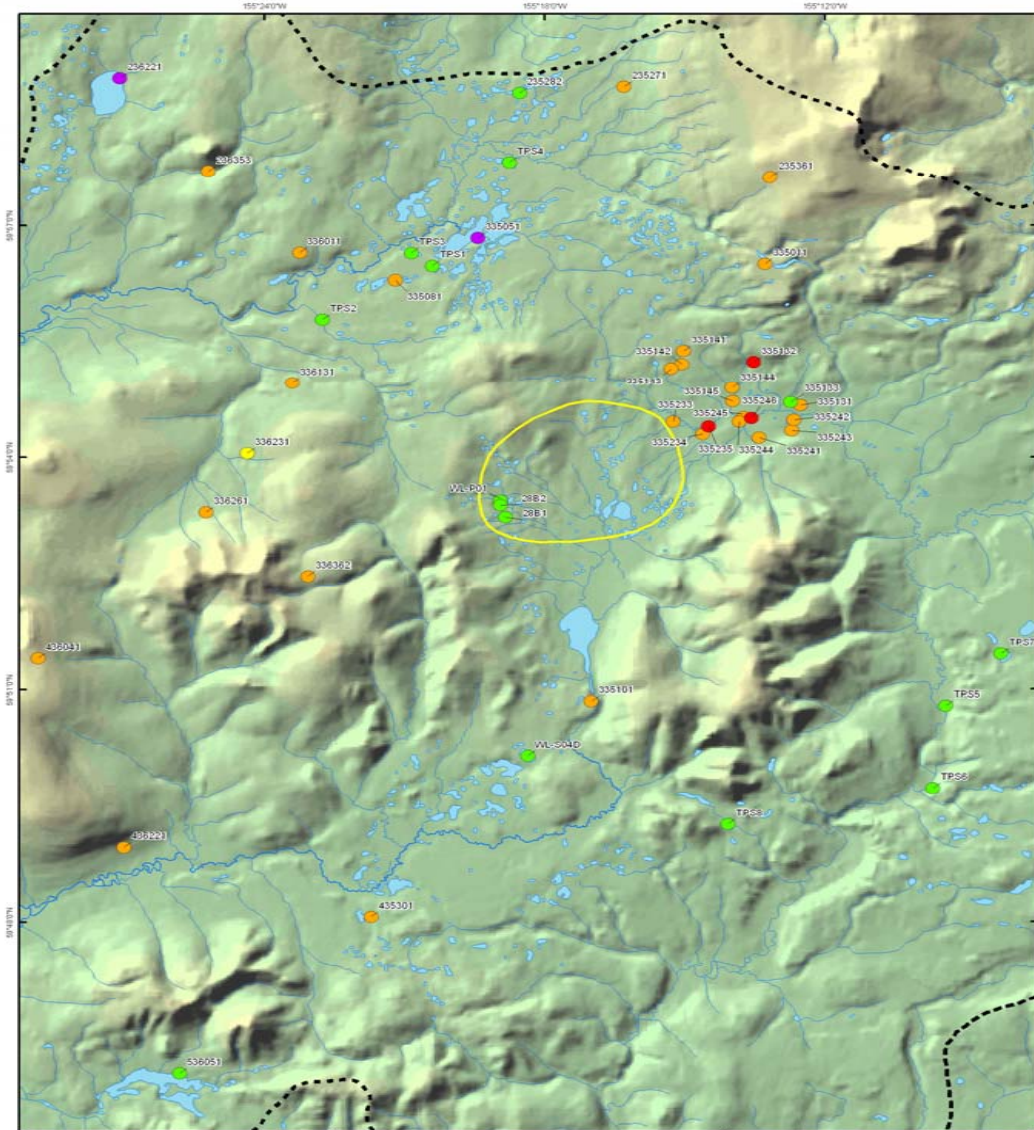
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**2006 Sampling Locations for
Naturally Occurring Constituents
in Soil and Vegetation;
Mine Study Area**

RDJ_SLR_2006_MinA_TE_11x17P_402.mxd
Version: 2

Date: November 23, 2007
Author: RDJ,LSM/RA

Sampling Locations 2007



Legend

Sample Location Type

- Bacteriology Soil, Surface Soil, and Terrestrial Vegetation
- Surface Soil and Terrestrial Vegetation
- Surface Soil
- Aquatic Vegetation and Sediment
- Aquatic Vegetation (Small Pond Study)
- General Deposit Location
- Study Boundary



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**2007 Sampling Locations for
Naturally Occurring Constituents
in Soil and Vegetation;
Mine Study Area**

RDJ_SLR_2007_Minu_TE_11x17P_02.mxd

Date: November 23, 2007

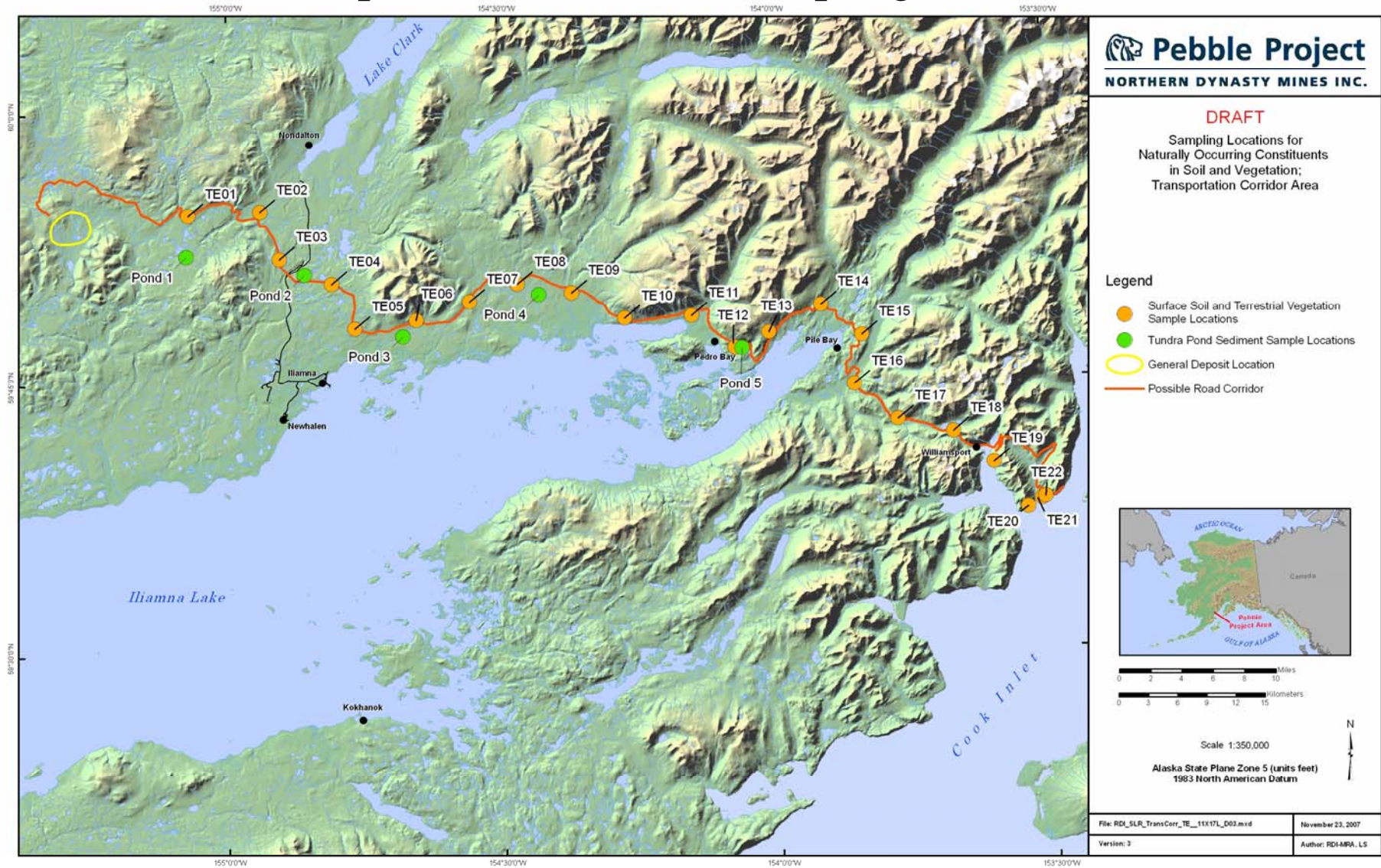
Version: 2

Author: RDJ-LEBNA

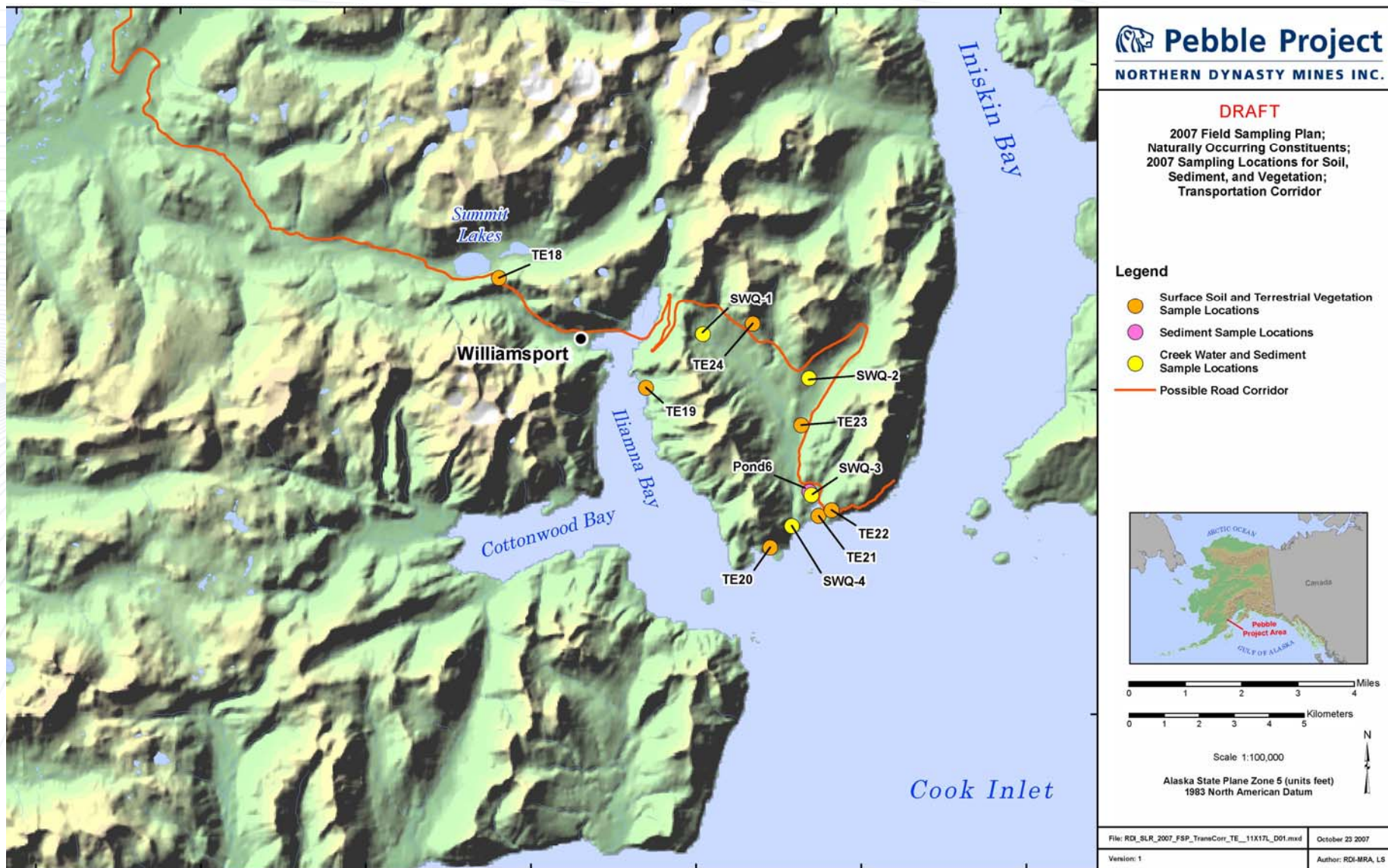
TE Sampling Locations - Transportation Corridor: Bristol Bay Drainage



Transportation Corridor Sampling Locations



Transportation Corridor Sampling Locations: Cook Inlet



Sampling Summary - Mine Site Study Area

- Sampling based on preliminary identification of seven upland habitats
- Over 50 different plant species, including:
 - trees, shrubs, forbs, moss, lichen, grasses, and sedges



- Each vegetation sampling location is visited twice per season to collect both early season browse and late season browse and berries

Current Program Status - Mine Site Study Area

- Total of 111 soil locations sampled
- Total of 38 plant locations sampled
- 17 ponds sampled; aquatic vegetation collected where available



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What Plants Have Been Sampled?

- Trees (3 species)
 - 13 samples



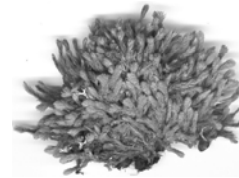
- Shrubs (16 species)
 - 188 vegetative samples
 - 78 berry samples (5 species)

- Forbs (19 species)
 - 103 samples



- Grasses and sedges (5 species)
 - 59 samples

- Mosses (5 species)
 - 60 samples



- Lichens (3 species)
 - 46 samples

Why So Many Different Plants?

- Adequate characterization of multiple habitats and species groups required
- Many different medicinal and traditional uses by natives
- Multiple food sources for wildlife
- Improves confidence in selecting indicator species



Traditional and Medicinal Plant Uses



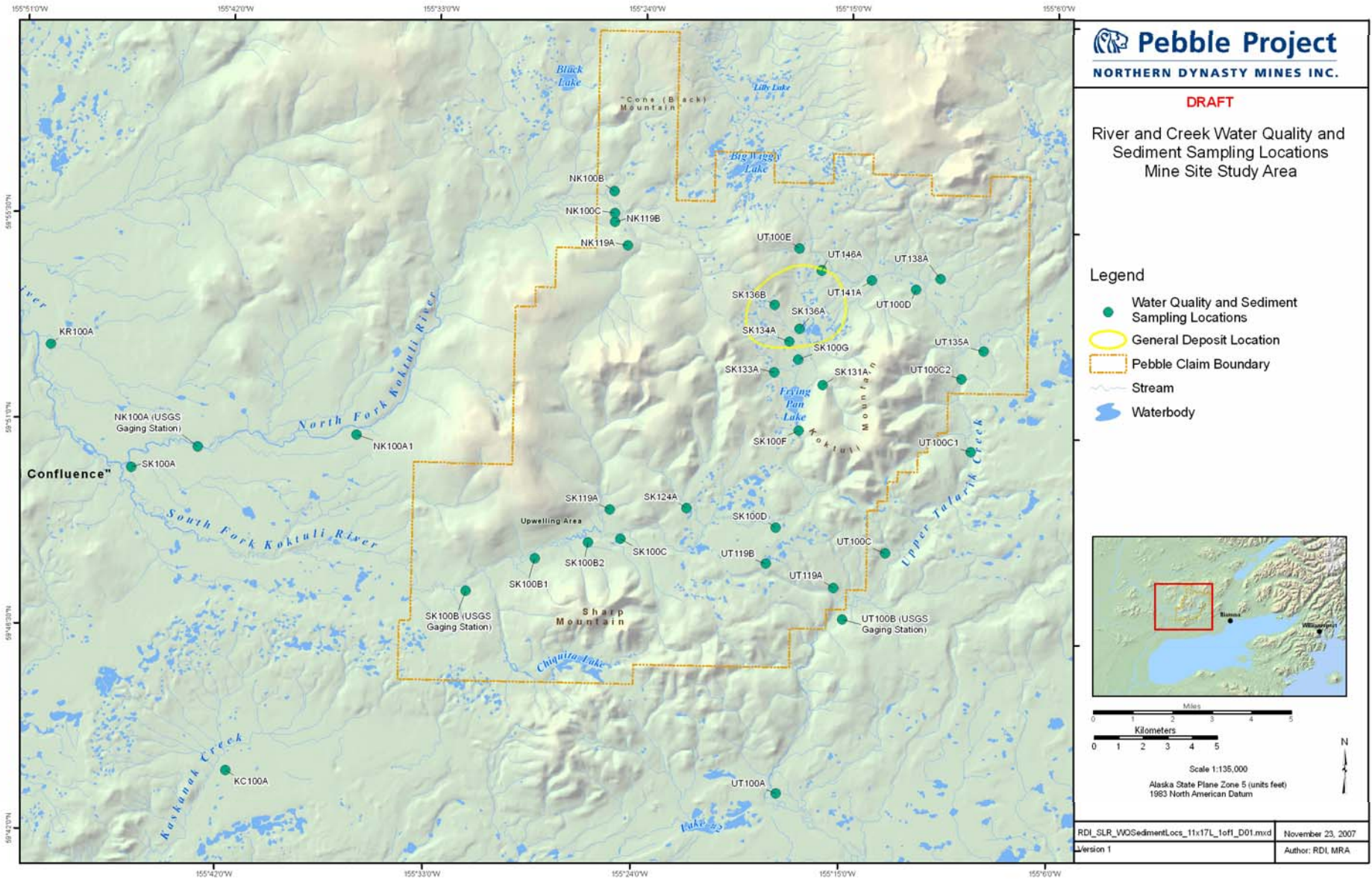
Species	Food/Drink	Medicinal	Other	Sampled at Pebble
Trees				
Black Spruce			X	X
White Spruce			X	
Shrubs				
Shrub/dwarf Birch			X	X
Paper Birch			X	
Willows			X	X
Mountain Alder		X	X	X
Bog Blueberry	X			X
Crowberry	X			X
Salmonberry	X			X
Lingonberry	X			X
Forbs				
Putchkie Cow Parsnip	X	X		
Fireweed	X	X		X
Horsetail	X	X		X
Cloudberry	X			X
Angelica		X		
Stink Weed	X			
Sweet Gale		X	X	
Devil's Club		X		
Labrador Tea	X	X		
Skunk Currant	X		X	
Alaska Spirea			X	X
Elderberry		X	X	X
Mosses				
Terrestrial Green Moss			X	X
Lichens				
Caribou Lichen	X	X		X
Ferns				
Wood Fern	X	X		
Lady Fern	X	X		
Grasses and Sedges				
Blue Joint Grass	X	X	X	X
Beach Rye	X	X	X	
Sedges			X	X

Sediment Program






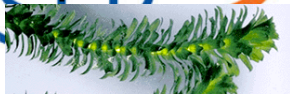


- River and Creek sampling begun in 2004
 - North Fork Kaktuli River, South Fork Kaktuli River, Upper Talarik Creek, Kaskanak Creek
 - 24 Locations, 56 samples in 2004
 - 18 Locations, 33 samples in 2005
 - 13 Locations, 13 samples in 2006
 - 14 Locations, 14 samples in 2007
- Minor drainages sampled in 2004 only
 - 17 locations, 21 samples
- Pond and seep sampling begun in 2005
 - 6 Ponds, 14 samples in 2005
 - 16 Ponds, samples in 2006
 - 19 Ponds, 20 samples in 2007
 - 9 Seeps, 12 samples in 2005



Sediment Sampling Locations



Sampling Summary: Trace Elements 2004-2007

<u>Medium</u>	<u>2004</u>	<u>2005</u>	<u>2006</u>	<u>2007</u>
Sediment 	77	59	25	34
Surface Soil 	78	85	45	27
Subsurface Soil 	9	7	0	0
Plant Tissues 	66	180	169	203
Berries 	11	25	17	25
Aquatic Plants 	0	15		

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Results: Soil Elements

- Total of 251 samples
- Results for elements generally consistent in surface and shallow samples
- Several metals (Bi, Se, Ag, Sn, CN, and ammonia) present in surface samples at 2-3x concentration in subsurface samples
- Subsurface sampling discontinued based on these results



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Results: Key Soil Findings

- Biogenic sources of petroleum-range hydrocarbons present in shallow soil
 - RRO = 1,286 mg/kg average concentration in surface (n=20)
 - DRO = 137 mg/kg
- DRO/RRO soil concentrations much greater in moraine samples than in other landforms (5-20x higher)
 - RRO average of 2,000 mg/kg in moraines, 100 mg/kg in outwash plains
 - Appropriate to identify a background concentration for DRO and RRO
 - Landform-specific background may be appropriate

Results: Key Soil Findings (cont)

- Element soil concentrations highest in talus slope samples for more than half (16 of 26) of the metals
 - Particularly for As, Cu, Pb, and Ag
- Concentrations highest in moraine samples for 9 metals
 - Particularly for Ba
- CN highest in talus slope samples (0.25 mg/kg)



Results: Key Sediment Findings

- 195 Total samples
- Several metals (Al, Be, Cd, Cr, K, Tl, V) had consistent concentrations across all sediment types
 - Five metals had higher concentrations (Ba, Co, Fe, Mg, Mn, Ni) in river sediments than in pond or seep sediments
 - Two metals had lower concentrations (Ca, Hg) in river sediments than in pond or seep sediments

Results: Key Sediment Findings (cont)

- Pond sediments had higher concentrations of only three metals (B, Se, Sn), and lowest concentrations for six metals (Al, Bi, Fe, Mn, Ag, V)
- Seep sediments were enriched relative to other sediments for five metals (Sb, As, Ca, Cr, Ag)
- Several metals had higher concentrations in the South Fork Kaktuli River than other river sediments (Bi, Cd, Cu, Pb, Mo, Zn)
 - 56 mg/kg Cu vs. <20 mg/kg in all other river sediments
- For CN, ponds and seeps had the lowest average concentrations, while samples from minor drainages had the highest concentrations

Results: Key Plant Findings

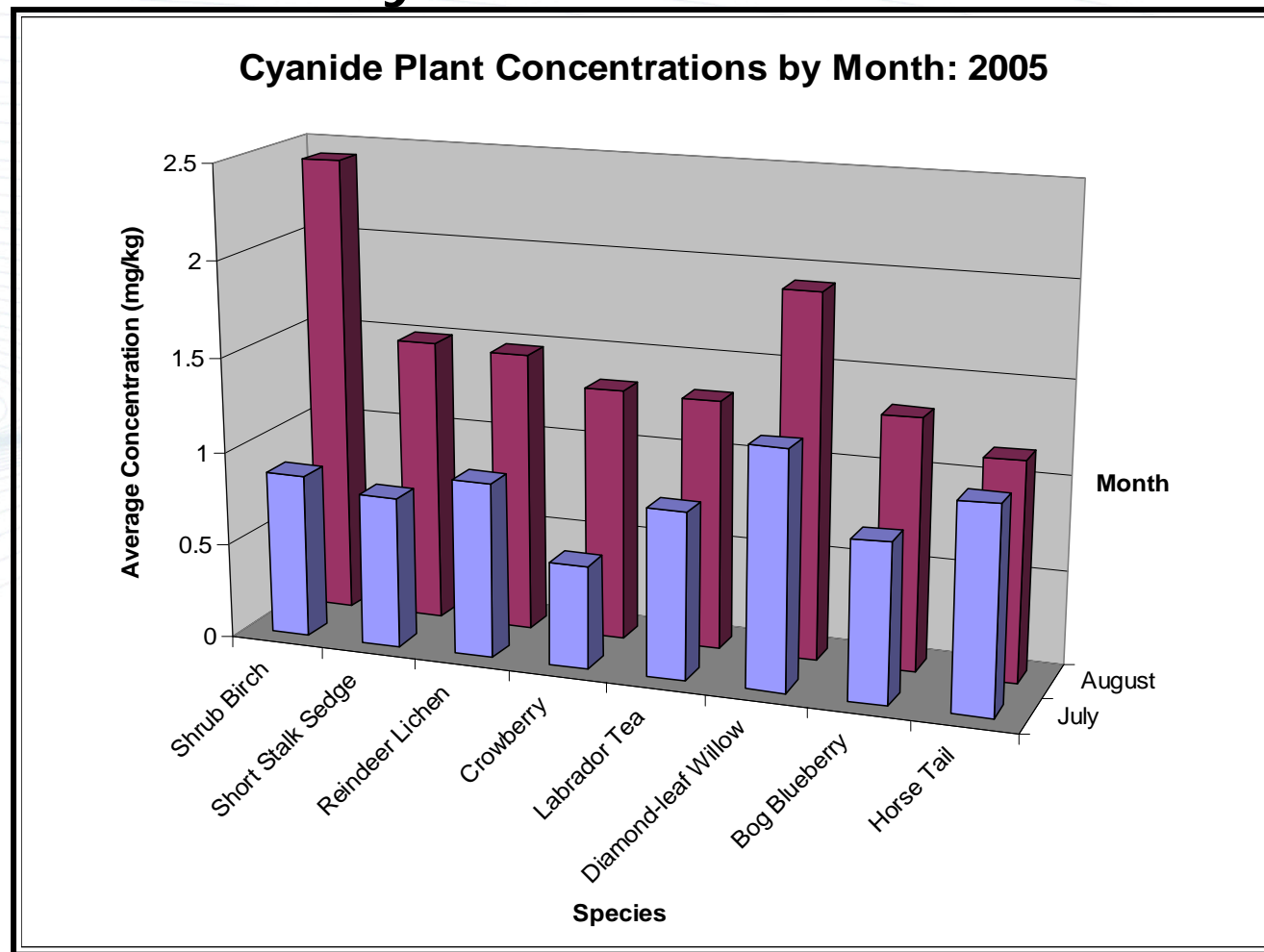
- 618 Vegetation samples
- 78 Berry samples
- 91 Aquatic plant samples
- Most abundant plants sampled:
 - short-stalk sedge (39)
 - reindeer lichen (34)
 - bog blueberry (33)
 - diamond-leaf willow (33)
 - dwarf (shrub) birch (27)
 - sphagnum moss (19)
 - Crowberry (19)



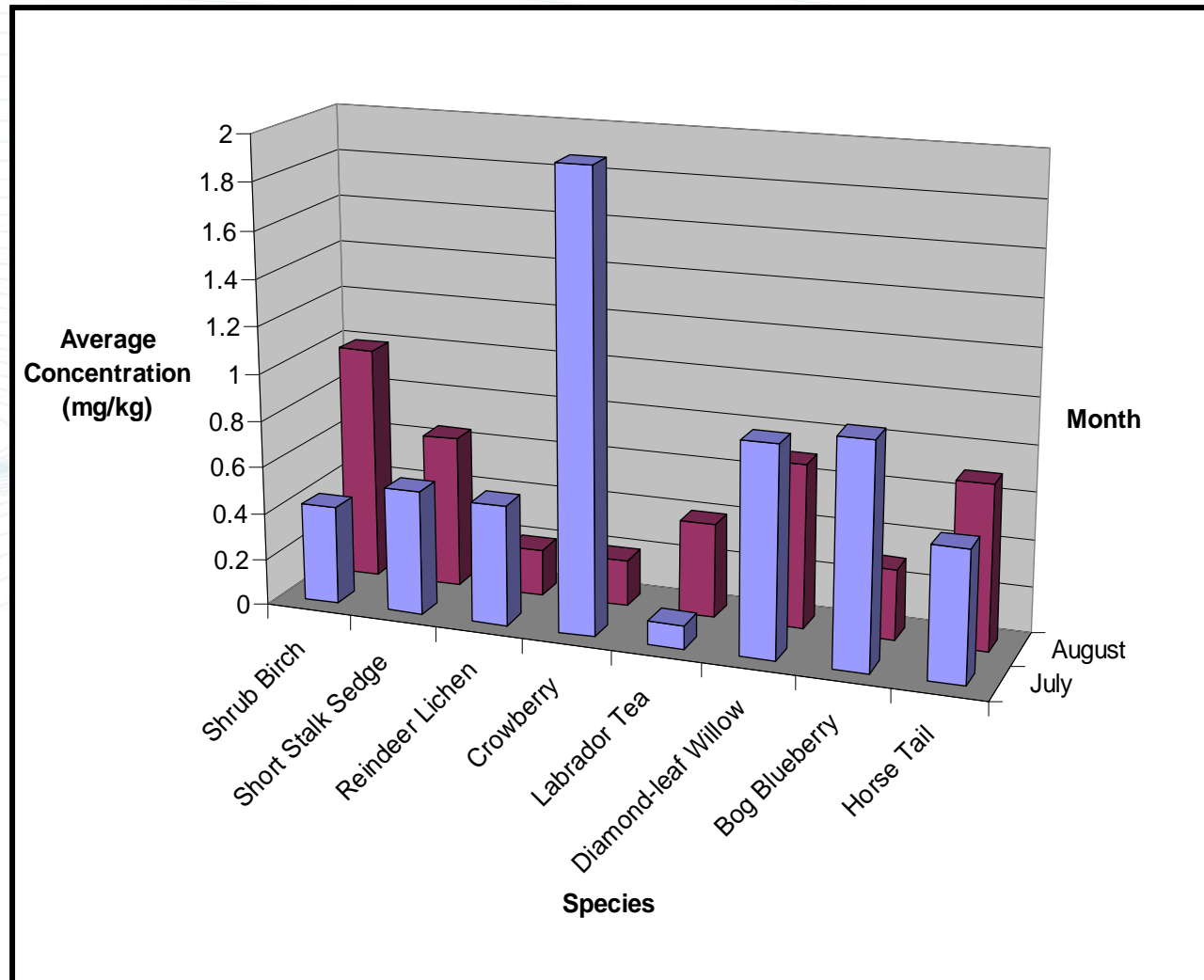
Results: Key Plant Findings (cont.)

- Elemental concentrations generally lower in berries than vegetative samples
- Higher concentrations of elements in talus slope soils not evident in plants
- Most metal concentrations lower in August than July samples
- CN higher in August samples (all plants in 2005, variable in 2006)
 - Cyanogenic bacteria may be contributing to seasonal differences in plant concentrations (preliminary results from 2007)
 - Supported by results from sediment sampling

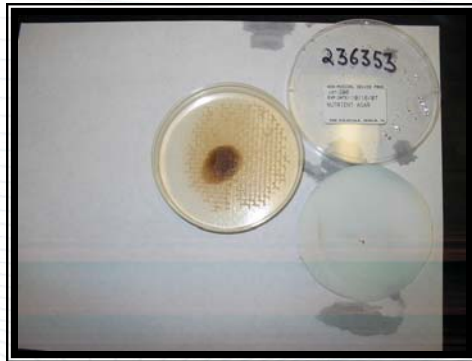
Plant Concentrations by Season: Cyanide 2005



Plant Concentrations by Season: Cyanide 2006



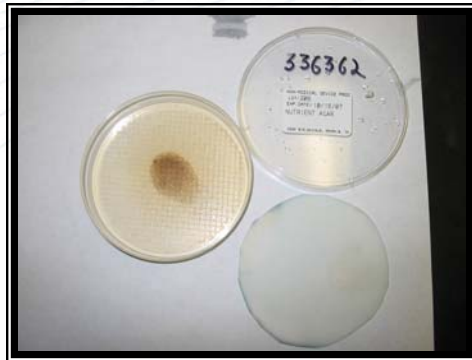
HCN Production in Soil: Results



Soil = ND; Plants = 0.16 - 1.1 mg/kg



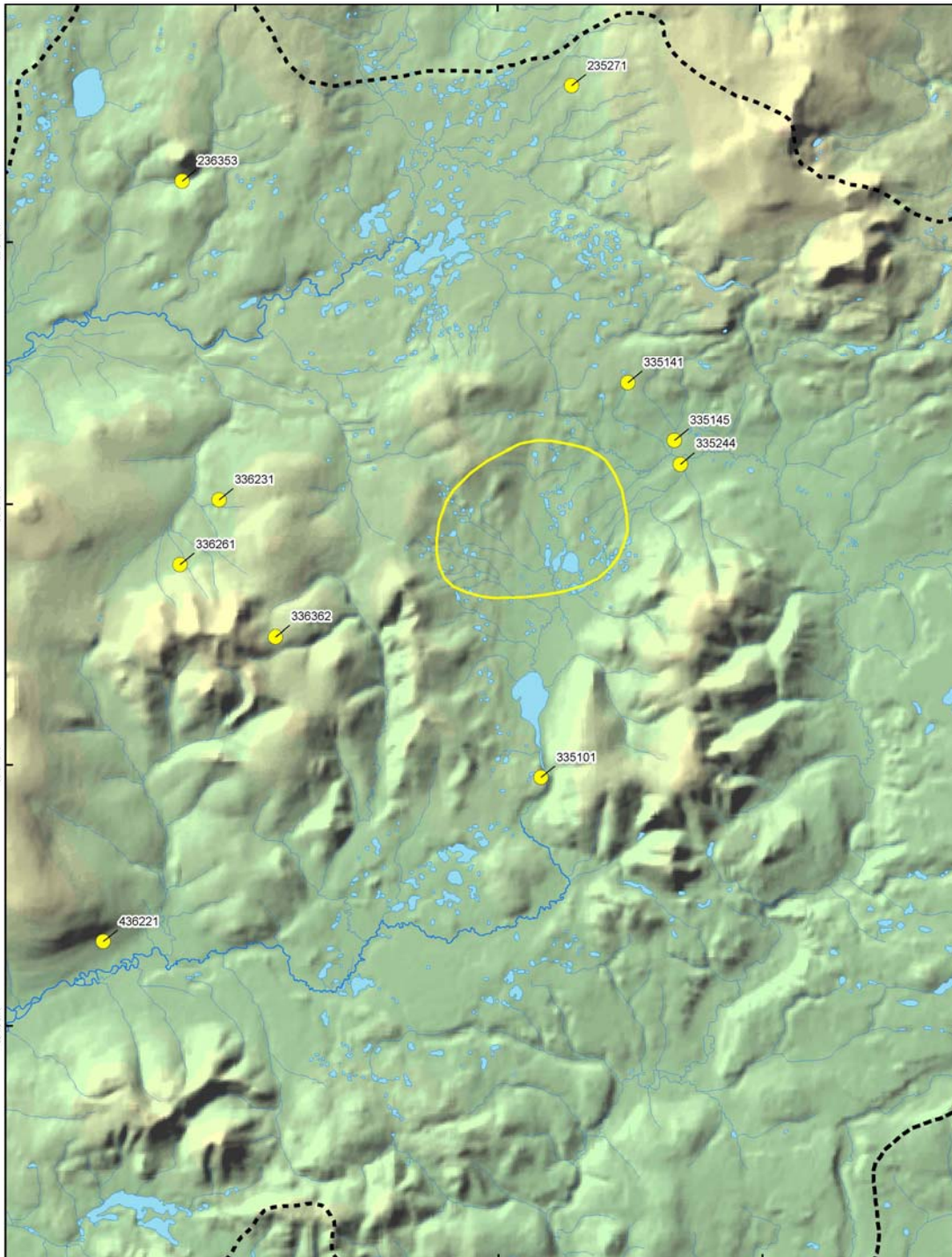
Soil = 0.08 mg/kg; Plants = 0.5 - 3.5 mg/kg



Soil = 0.21 mg/kg; Plants = 0.24 - 5.7 mg/kg



Soil = 0.14 mg/kg; Plants = 0.06 - 2.1 mg/kg



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**2008 Proposed Field Sampling Plan;
Naturally Occurring Constituents;
2008 Proposed Sampling Locations for Soil,
Sediment, and Vegetation;
Mine Study Area**

RDI_SLR_2008_Mine_TE_11x17P_v01.mxd

Date: October 23, 2007

Version: 1








Author: RDI-LS,MRA



Scale 1:80,000
Alaska State Plane Zone 5 (units feet)
1983 North American Datum

Legend

Type

-  Bacteriology Soil, Surface Soil, and Terrestrial Vegetation Sample Locations
-  Surface Soil and Terrestrial Vegetation Sample Locations
-  Surface Soil Sample Locations
-  Aquatic Vegetation and Sediment Sample Locations
-  Aquatic Vegetation (Small Pond Study) Sample Locations
-  Study Boundary
-  General Deposit Location



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Conclusions

- Over 1,200 samples from soil, sediment, plants, and berries across the mine site study area
 - Mine site area adequately characterized for baseline conditions
 - 2007 data still to be evaluated
- 122 soil and plant samples from the Transportation Corridor collected in 2004
- 124 soil and plant samples from Cook Inlet portion of Transportation Corridor collected in 2006 and 2007
 - 2007 data still to be evaluated
 - Data completeness depends on final plans for Corridor



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Thank You!!