3.7.4 ACID GENERATING POTENTIAL

The potential of material to generate acid is important in terms of the proposed rock piles, and to assess potential chemistry of waters recharging the groundwater after contact with the walls of the open pits.

A total of 274 samples were collected over consecutive ten-foot depth intervals from twelve exploration drill holes and analyzed for total sulfur and acid neutralizing potential or ANP (WMCI, 2000). From these data, the acid generating potential, or AGP (total sulfur concentration in weight percent times 31.25), and net neutralizing potential, or NNP (acid neutralizing potential minus the acid generating potential) were calculated. The total sulfur content, ANP, and NNP, are plotted versus depth in Figures 3.7-5, 3.7-6 and 3.7-7. The results of the acid/base accounting analyses are summarized in Table 3.7-7 over depth intervals of 0 – 100 ft, 100 – 200 ft, 200 – 300 ft, 300 – 400 ft and 400 - 495 ft.

Total sulfur analyses show that the bedrock profile across the project site is stratified with low total sulfur concentrations in the upper 200 ft, with increasing sulfur concentrations with depth (Fig. 3.7-8). Sulfur concentrations reported in Table 3.7-7 show that roughly half of the analyses in the upper 200 feet of the drill holes were below the machine detection limit (MDL) of 0.01 weight percent. The proportions of samples with total sulfur concentrations below the MDL decreases with depth. The total sulfur concentrations in the upper 200 feet ranged from below the MDL to 0.051 weight percent and increase with depth from below the MDL to maximums of 0.65, 3.23, and 4.34 weight percent, respectively, for the intervals of 200 to 300 ft, 300 to 400 ft and 400 to 495 ft. The average total sulfur concentration for the upper 200 feet was less than 0.1 weight percent. The average total sulfur concentrations for the deeper intervals 200 to 300 ft, 300 to 400 ft and 400 to 495 ft, were 0.2, 0.7, and 2.5 weight percent, respectively. Assuming the total sulfur concentration of the bedrock was fairly uniform, the sulfur profile suggests that the bedrock is strongly weathered and oxidized at least to a depth of approximately 200 ft.

The acid neutralizing potential also shows a change in character below roughly 200 ft depth (Fig. 3.7-6). Below 300 ft depth, the ANP ranges from 170 to 240 tons $CaCO_3$/Kton rock, and averages 220 tons $CaCO_3$/Kton rock. Between 200 and 300 ft, the range in ANP varies between just below 40 to 240 tons $CaCO_3$/Kton rock, and averages 175 tons $CaCO_3$/Kton rock. Above 200 ft depth, the ANP has a much larger range, from roughly 2 tons $CaCO_3$/Kton rock to over 500 tons $CaCO_3$/Kton rock, and averages approximately 150 tons $CaCO_3$/Kton rock. The shallow analyses were distributed in roughly three populations. A group of analyses with values:

- Near 240 tons $CaCO_3$/Kton rock.
- Above roughly 400 tons $CaCO_3$/Kton rock.
- Gradational between near zero and 240 tons $CaCO_3$/Kton rock.

Assuming the stratigraphic section is roughly uniform vertically through the deposit, and the pre-weathered bedrock ANP is near 240 tons $CaCO_3$/Kton rock, the first group of analyses may represent weakly to unweathered relict bedrock with ANP equivalent to the deeper bedrock. The high ANP samples may represent a second bedrock type with higher carbonate concentration or more abundant carbonate veining. The third group of analyses may represent the weathered equivalents of either group one or two that have undergone acid leaching following weathering and oxidation of the primary, hydrothermal sulfide mineralization.

Owing to the relatively low total sulfur content of the samples, the distribution of NNP values mimics the pattern of ANP with depth (Fig. 3.7-7). Above 200 ft depth, the NNP values vary widely from less then 1 ton $CaCO_3$/Kton rock to over 530 tons $CaCO_3$/Kton rock, with three poorly defined groups: over 500 tons $CaCO_3$/Kton rock, roughly 200 tons $CaCO_3$/Kton rock, and less then 50 tons $CaCO_3$/Kton rock. Below 200 ft, the NNP varies between 30 tons $CaCO_3$/Kton rock and 250 tons $CaCO_3$/Kton rock, and averages between 150 and 200 tons $CaCO_3$/Kton rock.

The NNP is a measure of the acid generating potential of the rock mass as a whole. None of the samples were acid generating based on the standard criterion for the prediction of acid generation of NNP less than -20 tons $CaCO_3$/Kton rock. Samples with NNP values greater than 20 tons are considered nonacid generating. Roughly 70 percent of the samples in the top 200 ft of the drill holes were nonacid generating (64 percent in the upper 100 ft and 82 percent between 100 and 200 ft). Samples below 200 ft were all nonacid generating. The acid generating potential for the remaining samples fall within the uncertain range (between –20 and 20 tons $CaCO_3$/Kton rock).

Figure 3.7-8 is a plot of the total sulfur analyses versus NNP. The figure indicates that values with NNP less then 20 tons $CaCO_3$/Kton rock also have total sulfur concentrations that are very low. Of the 65 samples with NNP values less then 20 tons, half (32 samples) have total sulfur concentrations below the MDL (0.01 weight percent). The remaining samples are less then 0.16 weight percent. Using one half the detection limit for values reported as below the MDL, the average total sulfur concentration of the samples with NNP less then 20 tons was 0.02 weight percent. Based on this analysis, the rock material that would be generated from the pit area is not considered to be acid generating.

The results of ore and development rock characterizations were evaluated by a third-party consultant for the State of Alaska (SRK Consulting, Solid Waste Disposal Permit 0031-BA008-Fort Knox Mine Review of Requirements for Geochemical Characterization of True North Project Tailings, July 24, 2000). The evaluation showed minimum potential for any adverse impacts to any surface or ground waters of the state. The report characterized the deposit as having very low sulphur concentrations and elevated neutralization potential.

Table 3.7-6 Summary of groundwater chemistry from nine groundwater monitoring wells

Analytes	Units	No. of analyses	No. of detects	No. of MDLs	Min	Max	Average(1)	EPA drinking water standards	Human health standards	No. of exceedences
Alkalinity as CaCO5	mg/L	16	16	0	153	405	281	*	none (2)	0
Ammonia-N	mg/L	16	4	12	-0.05	1	0.35	*		0
Antimony	mg/L	15	12	3	-0.0013	0.031	0.006	0.006	0.014 (3)	5
Antimony	mg/L	16	14	2	-0.0013	0.221	0.040	*		0
Arsenic	mg/L	15	14	1	-0.005	0.43	0.117	0.05	0.000018	14
Arsenic	mg/L	16	16	0	0.015	1.54	0.324	*		0
Barium	mg/L	14	13	1	-0.005	0.119	0.023	2	1.0 (2)	0
Barium	mg/L	14	13	1	-0.005	0.72	0.139	*		0
Bismuth	mg/L	14	1	13	-0.02	0.2	0.04	*		0
Bismuth	mg/L	14	2	12	-0.02	0.3	0.06	*		0
Cadmium	mg/L	16	1	15	-0.0001	0.0001	0.0001	0.005	none (3)	0
Cadmium	mg/L	16	4	12	-0.0001	0.0006	0.0002	*		0
Calcium	mg/L	16	16	0	43.4	474	156	*		0
Calcium	mg/L	16	16	0	37.6	476	165	*		0
Calcium Hardness	mg/L	5	5	0	194	2090	952.2	*		0
Chloride	mg/L	16	13	3	-0.05	22.3	1.95	250 (2)	none (2)	0
Chromium	mg/L	16	3	13	-0.002	0.009	0.002	0.1		0
Chromium	mg/L	16	12	4	-0.005	0.128	0.023	*		0
Conductance	umhos	12	12	0	350	2880	1145	*		0
Copper	mg/L	16	4	12	-0.003	0.02	0.006	1.3	1.3	0
Copper	mg/L	16	9	7	-0.006	0.231	0.034	*		0
Cyanate	mg/L	2	0	2	-0.01	-0.01	0.005	*		0
Cyanide, Total	mg/L	16	0	16	-0.01	-0.01	0.01	*		0
Cyanide, WAD	mg/L	16	0	16	-0.01	-0.01	0.01	*		0
Field temperature	Deg C	6	0	0	-1	1	0.0	*		na
Fluoride	mg/L	16	14	2	-0.05	1.3	0.35	4		0
Hydrogen Sulfide	mg/L	6	0	6	-0.04	-0.04	0.02	*		0
Iron	mg/L	16	8	8	-0.01	1.51	0.24	0.3 (2)	0.3 (2)	3
Iron	mg/L	16	16	0	0.003	111	15.0	*		0
Lead	mg/L	16	2	14	-0.002	0.003	0.001	0.015	none	0

Table 3.7-6 Summary of groundwater chemistry from nine groundwater monitoring wells (cont'd)

Analytes	Units	No. of analyses	No. of detects	No. of MDLs	Min	Max	Average(1)	EPA drinking water standards	Human health standards	No. of exceedences
Lead	mg/L	16	9	7	-0.002	0.242	0.027	*		0
Magnesium	mg/L	16	16	0	13.9	227	69.6	*		0
Magnesium	mg/L	16	16	0	17.8	229	73.8	*		0
Manganese	mg/L	16	15	1	-0.012	1.93	0.366	0.05 (2)	0.05 (2)	11
Manganese	mg/L	15	15	0	0.023	2.52	0.636	*		0
Mercury	mg/L	15	0	15	-0.0002	-0.0002	0.0001	0.002	0.00005	0
Mercury	mg/L	15	1	14	-0.0002	0.0003	0.0001	*		0
Nickel	mg/L	10	2	8	-0.005	0.013	0.011	*	0.61	0
Nickel	mg/L	10	3	7	-0.019	0.137	0.028	*		0
Nitrate-N	mg/L	16	9	7	-0.01	0.33	0.06	10	10 (2)	0
Nitrite-N	mg/L	16	2	14	-0.01	0.1	0.02	1		0
pH	Unit	14	14	0	7	7.7	7.41	6.5-8.5 (2)	5 – 9 (2)	0
Potassium	mg/L	16	15	1	-1	16.8	5.38	*		0
Potassium	mg/L	16	15	1	-1	32.2	9.35	*		0
Selenium	mg/L	16	6	10	-0.002	0.009	0.003	0.05	0.17 (3)	0
Selenium	mg/L	16	5	11	-0.002	0.018	0.004	*		0
Silicon	mg/L	14	14	0	2.5	7.2	4.4	*		0
Silicon	mg/L	14	14	0	2.4	484	51.6	*		0
Silver	mg/L	16	6	10	-0.0001	0.0003	0.002	0.1 (2)	none	0
Silver	mg/L	16	9	7	-0.0001	0.01	0.002	*		0
Sodium	mg/L	16	16	0	1.3	26.7	4.04	*		0
Sodium	mg/L	16	16	0	1.61	23.1	4.16	*		0
Sulfate	mg/L	16	16	0	27.8	1600	383	250 (2)		7
Total Dissolved Solids	mg/L	16	16	0	212	2930	890	500 (2)	250 (2)	13
Total Phosphate-P	mg/L	14	7	7	-0.04	1.51	0.21	*		0
Total Solids	mg/L	8	8	0	500	2100	1151	*		0
Total Suspended Solids	mg/L	14	11	3	-5	1500	300	*	none (2)	0
Turbidity	NTU	8	8	0	0.55	600	168	*		0
Zinc	mg/L	16	9	7	-0.003	0.1	0.019	5 (2)	9.1	0

Table 3.7-6 Summary of groundwater chemistry from nine groundwater monitoring wells (cont'd)

Analytes	Units	No. of analyses	No. of detects	No. of MDLs	Min	Max	Average(1)	EPA drinking water standards	Human health standards	No. of exceedences
Zinc	mg/L	16	10	6	-0.009	0.211	0.045	*		0
Benzene	ug/L	4	0	4	-0.2	-0.2	0.1	5	1.2	0
Chlorobenzene	ug/L	4	0	4	-0.2	-0.2	0.1	100	680 (3)	0
1,2-Dichlorobenzene	ug/L	4	0	4	-0.2	-0.2	0.1	*	2700 (3)	0
1,3-Dichlorobenzene	ug/L	4	0	4	-0.2	-0.2	0.1	*	400	0
1,4-Dichlorobenzene	ug/L	4	0	4	-0.2	-0.2	0.1	*	400	0
Ethylbenzene	ug/L	4	0	4	-0.2	-0.2	0.1	700	3100 (3)	0
Toluene	ug/L	4	1	3	-0.3	0.44	0.22	1000	6800 (3)	0
Xylenes	ug/L	4	1	3	-0.4	0.65	0.31	10000		0
Surrogate Recovery	%Recovery	4	4	0	95	107	100	*		0
Total Petroleum Hydrocarbons	mg/L	8	0	8	-0.4	-0.4	0.2	*		0

(1)Averages use one half the detection limit for the concentrations reported as below the machine detection limit (MDL)

(2) indicate secondary water quality standards

(3) Human health criteria site more stringent standards under 40 CFR 141 and Safe Drinking water Standards

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Figure 3.7-5 Total sulfate content from ABA samples

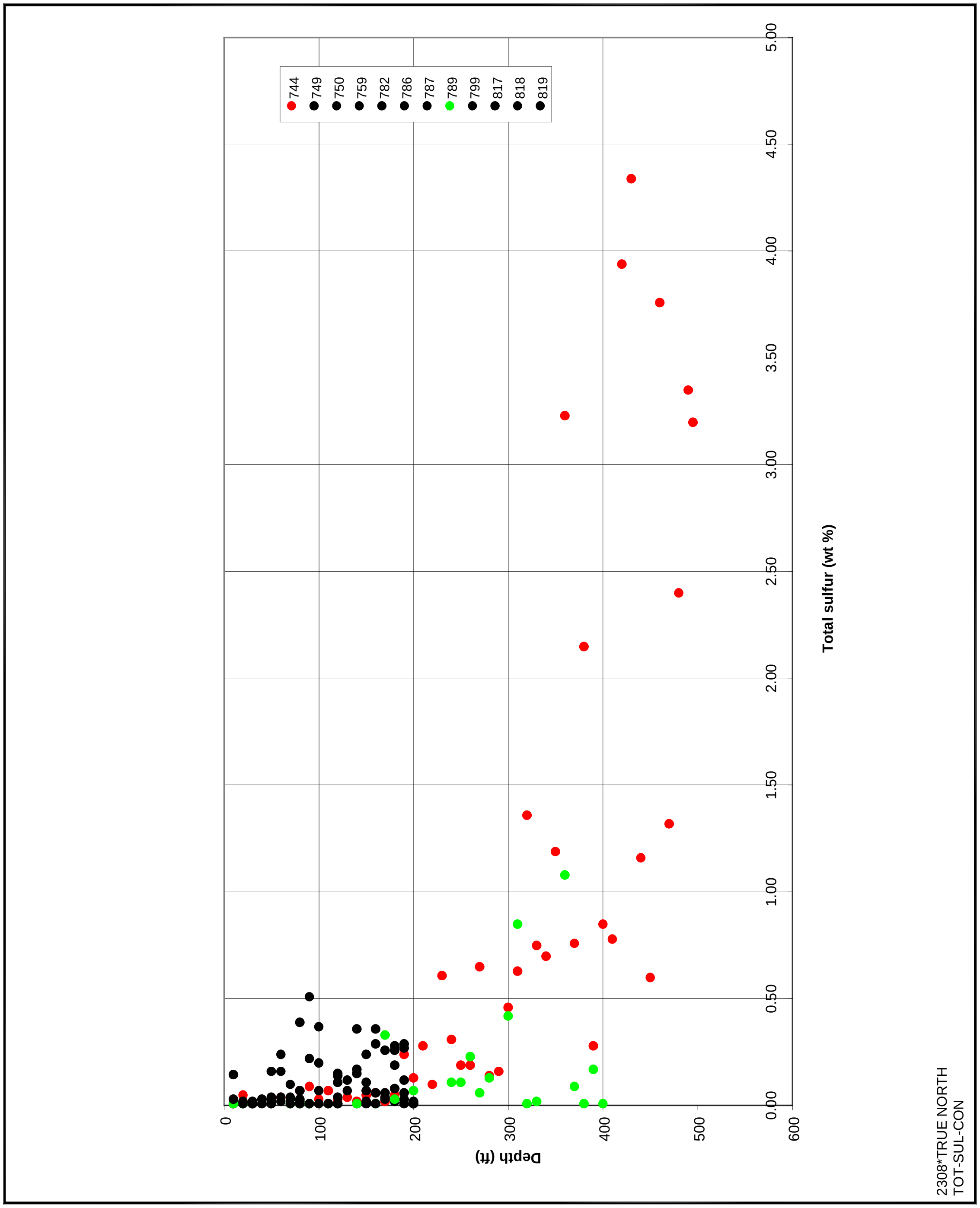

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Figure 3.7-6 Acid neutralizing potential from ABA samples

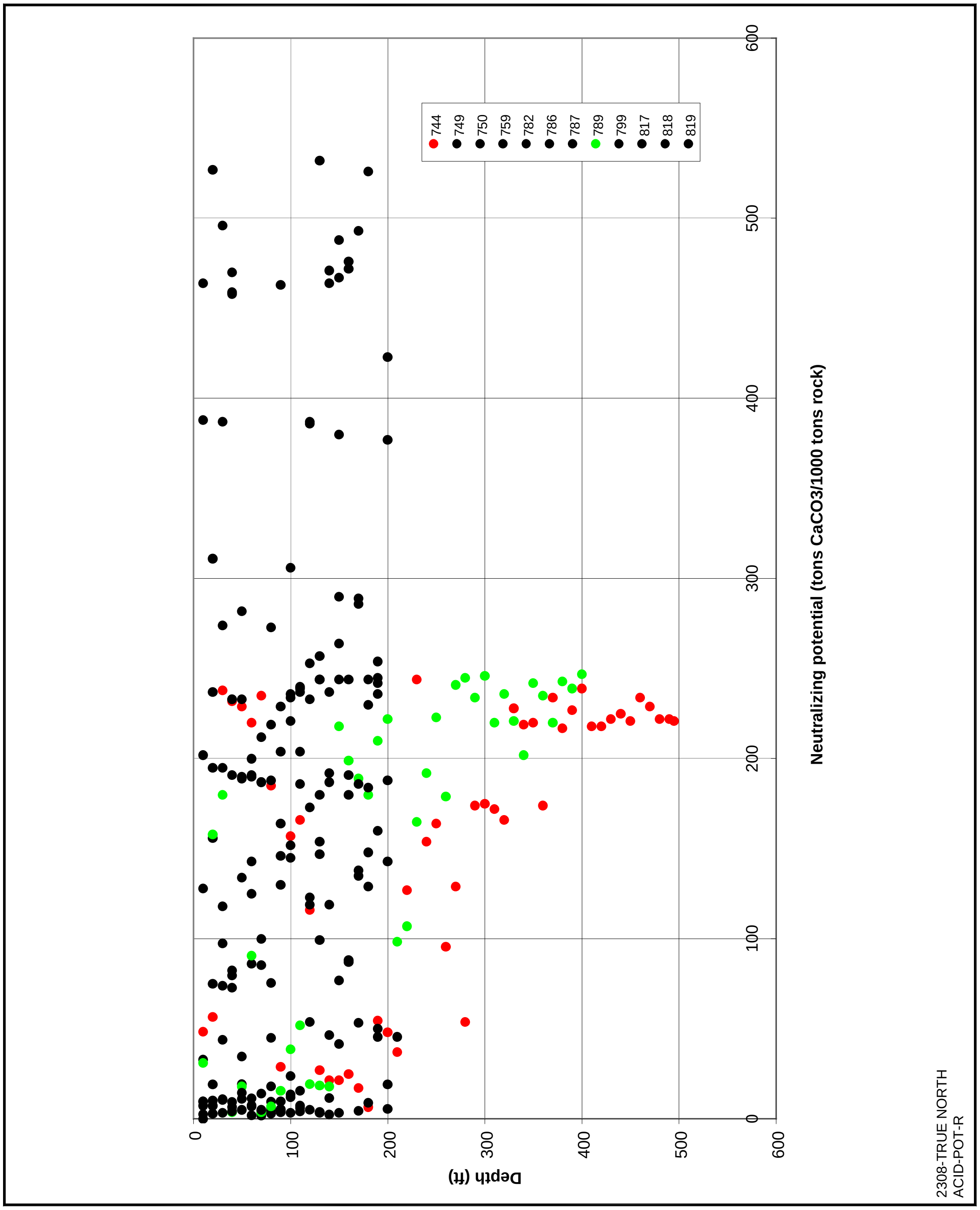

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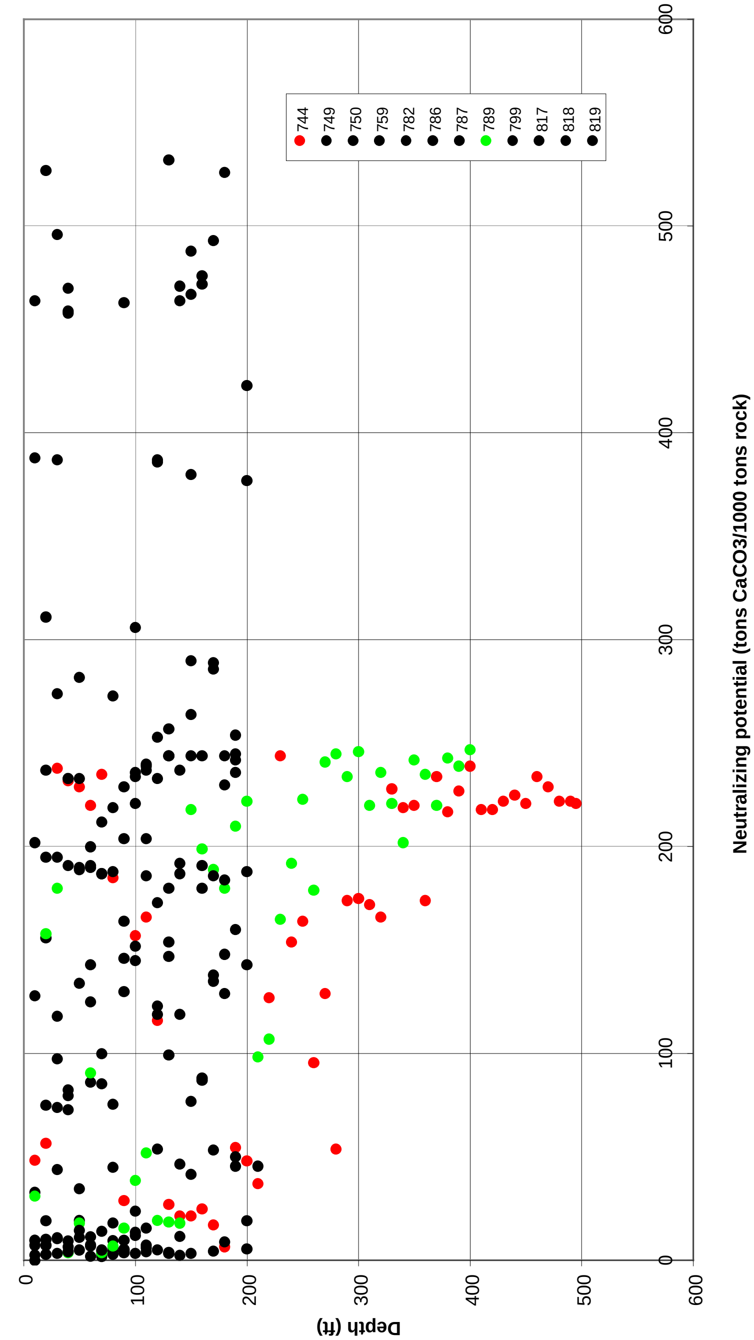
Figure 3.7-6 Acid neutralizing potential from ABA samples



2308-TRUE NORTH
ACID-POT-R

Table 3.7-7
Summary of acid/base accounting analyses from True North

	Units	0–100 ft	100-200 ft	200–300 ft	300-400 ft	400–495 ft
Total sulfur						
Number of samples		122	102	20	20	10
Number below MDL		68	42	4	2	0
Minimum	wt %	<0.01	<0.01	<0.01	<0.01	0.6
Maximum	wt %	0.51	0.36	0.65	3.23	4.34
Average	wt %	0.032	0.062	0.208	0.708	2.485
Neutralizing potential						
Number of samples		122	102	20	20	10
Number below MDL		0	0	0	0	0
Minimum	tons CaCO3/Kton rock	1.85	2.41	37.1	166	218
Maximum	tons CaCO3/Kton rock	527	532	246	243	234
Average	tons CaCO3/Kton rock	126.2	174.3	164.2	220.1	223.2
Net neutralizing potential						
Number of samples		122	102	20	20	10
Number below MDL		0	0	0	0	0
Minimum	tons CaCO3/Kton rock	0.74	2.41	28.4	73	86
Maximum	tons CaCO3/Kton rock	527	530	240.9	246.7	202.3
Average	tons CaCO3/Kton rock	125.2	172.4	157.7	198.0	145.6
Number NNP > 20		78	82	20	20	10
Percent NNP > 20		63.9	80.3	100	100	100

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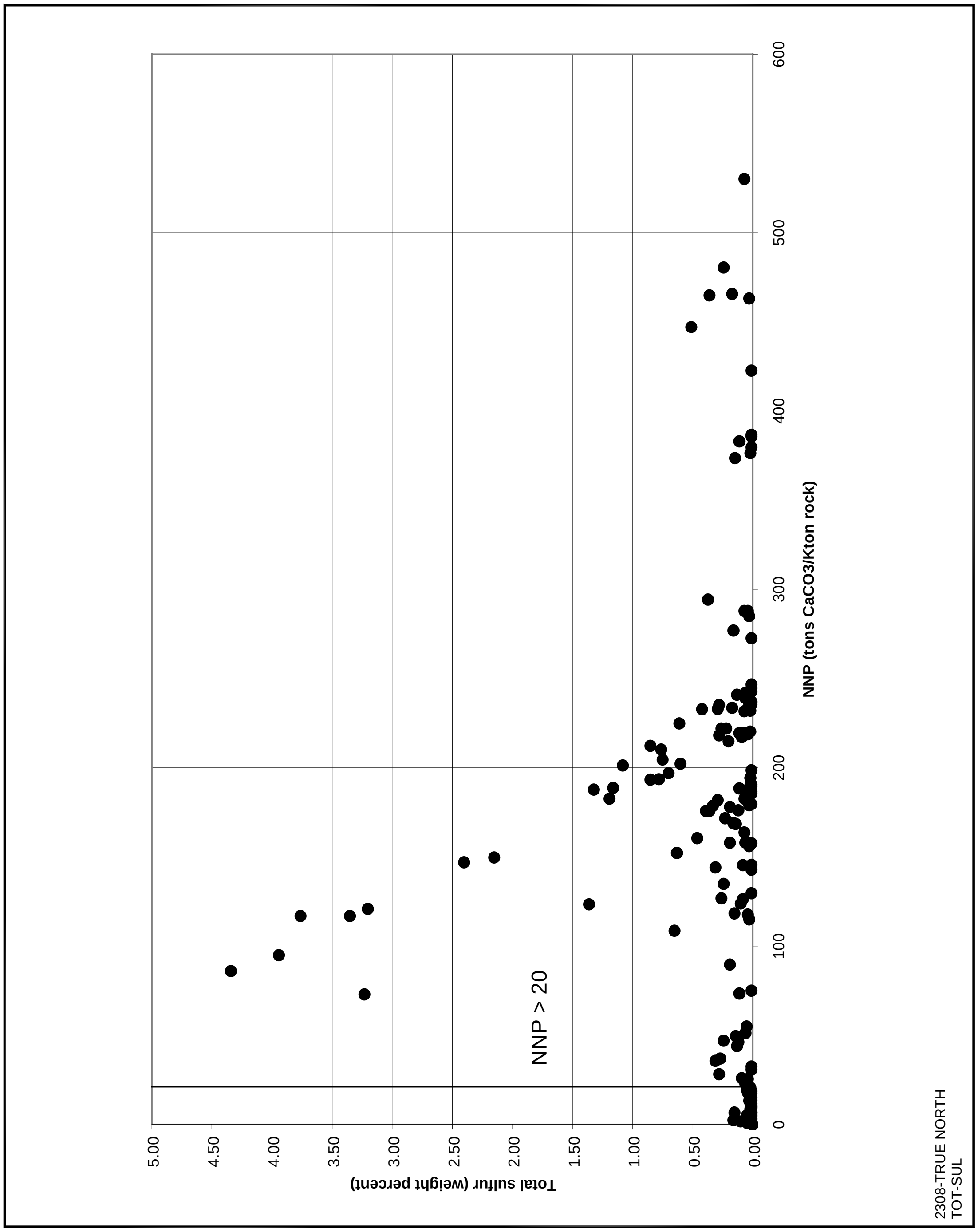
Figure 3.7-8 Total sulfur versus NNP from ABA samples



3.8 VEGETATION

The project area is predominantly forested, although at higher elevations shrub communities are more prevalent. Well-drained soils of the uplands and alluvial plains are covered mainly with white spruce (*Picea glauca*) and a mixture of broadleaf trees such as paper birch (*Betula papyrifera*) and quaking aspen (*Populus tremuloides*). The climax forest on well-drained soils in the area is white spruce (America North, Inc., 1991)

The moderately well-drained and imperfectly drained soils may support forests similar to those on well-drained soils, but more commonly black spruce (*Picea mariana*) and willows (*Salix* spp.) are found. Mosses (*Sphagnum* spp.), horsetail (*Equisetum* spp.), and grasses typically cover the ground. Shrubs such as willow, however, also are prevalent (America North, Inc., 1991).

The poorly drained soils with a high permafrost table generally support communities of black spruce, willow, and alder (*Alnus* spp.). A thick moss mat, principally *Sphagnum* spp., covers the ground. Lichens such as *Cladonia* spp. and *Peltigera* spp. are common in the moss mat also. This mat supports a dense cover of shrubs, primarily bog birch (*Betula glandulosa*), spirea (*Spirea beauverdiana*), Labrador tea (*Ledum decumbens*), cranberry (*Vaccinium vitis-idaea)*, and blueberry (*Vaccinium uliginosum*). Tussocks of cottongrass (*Eriophorum* spp.) are also common, especially along the toe slopes (America North, Inc., 1991).

Poorly drained soils with a high permafrost table may be found on the northern exposures of mountain slopes, especially those areas that are concave or broken. Spindly black spruce and a thick moss mat are typical on these sites. Permafrost is discontinuous throughout the project area, and does not exist on some north-facing mountain slopes where it normally would be expected. South-facing slopes receive much more radiation from the sun, and generally support white spruce, paper birch, and quaking aspen (America North, Inc., 1991).

3.8.1 Mine Area

Vegetation in the True North Mine area was classified by Anderson et al. (1995, 1996, 1997, 1998) from 1995 to 1998 according to an ecological land classification system developed by Jorgenson and Smith (1995) for the Fort Wainwright area near Fairbanks. This system incorporates physiographic (landscape) features with the Alaska vegetation classification developed by Viereck et al. (1992).

Table 3.8-1 and Figure 3.8-1 present the vegetation types on the approximately 17,564 acres (7,108 ha) of the True North mining claims.

The area is dominated by upland forest (58 percent), upland shrub (8 percent), lowland forest (7 percent), and lowland shrub (23 percent).

The upland forest types are dominated by open and closed needleleaf (26 percent), primarily black spruce, and open and closed broadleaf (18 percent), primarily aspen and paper birch. Mixed forests, open and closed, consisting primarily of paper birch and white spruce, cover 14 percent of the area. Tall open scrub, primarily “dwarf” spruce 5 to 10 feet (1.5 - 3 m) high, comprises 5 percent of the area.

3.8.2 Ore Haul Road

Vegetation along the proposed ore haul road corridor is dominated by open black spruce forest and black spruce woodlands. Woodland areas often have an open canopy of tall deciduous shrubs (*Betula nana, B. occidentalis, Alnus crispa, and Salix sp.*). Open deciduous forest of aspen (*Populus tremuloides*) also occur in the road corridor, but are present in small isolated patches (ABR, 2000a).

Table 3.8-1.
Vegetation types and area of each type found on the True North mining claims.

Physiography[2]	Vegetation Type[1]		Area		Percent of Total
	Level 1[3]	Levels 2–3[4]	Hectares[5]	Acres	
Upland	Forest	Needleleaf-closed	634.8	1568.6	8.9
		Needleleaf-open	1189.6	2939.5	16.7
		Broadleaf-closed	1077.2	2661.8	15.2
		Broadleaf-open	166.7	411.9	2.3
		Mixed-closed	628.9	1554.0	8.8
		Mixed-open	404.3	999.0	5.7
	Scrub	Tall-closed	104.6	258.5	1.5
		Tall-open	374.6	925.6	5.3
		Low-closed	29.3	72.4	0.4
		Low-open	56.0	138.4	0.8
Lowland	Forest	Needleleaf-closed	19.9	49.2	0.3
		Needleleaf-open	474.5	1172.5	6.7
		Broadleaf-open	1.5	3.7	<0.1
		Mixed-open	6.9	17.0	0.1
	Scrub	Tall-closed	157.0	387.9	2.2
		Tall-open	665.7	1644.9	9.4
		Low-closed	694.3	1715.6	9.8
		Low-open	134.9	333.3	1.9
Riverine	Forest	Broadleaf-closed	4.2	10.4	0.1
		Broadleaf-open	8.7	21.5	0.1
		Mixed-closed	1.7	4.2	<0.1
		Mixed-open	1.7	4.2	<0.1
	Scrub	Tall-closed	72.4	178.9	1.0
		Tall-open	30.6	75.6	0.4
		Low-closed	9.9	24.5	0.1
	Barren		0.2	0.5	<0.1
Lowland/Riverine	Meadow		38.1	94.1	0.5
Pond			10.9	26.9	0.2
Pond (impoundment)			3.1	7.7	0.0
Human Disturbed			105.5	260.7	1.5
Total Area			7,108.3	17563	

1 Vegetation types follow Viereck et al. (1992) and physiography follows Jorgenson and Smith (1995).

2 Physiography refers to the topographic and hydrologic characteristics of the site (i.e., the landscape features).

3 Forests include trees >3 m (10 ft) high and a tree canopy cover >25%. Scrub includes areas with trees <3 m high ("dwarf" trees), <25% large tree cover, and shrub cover ≥30%.

4 More than 60% of canopy cover contributed by needleleaf (conifer) trees, or broadleaf (hardwood) trees. Mixed forests are those where needleleaf and broadleaf trees contribute 25–75% canopy cover. Open refers to open tree canopy (25–59% canopy cover), closed refers to closed tree canopy (60-100% canopy cover). Tall scrub is >1.5 m high, low scrub is <1.5 m high. For scrub types, open canopy is 25–75% cover and closed canopy is >75% cover.

5 Hectare; 1 ha = 2.471 acres.