Reclamation Strategies for Waste Rock and Tailings Piles at the Greens Creek Mine

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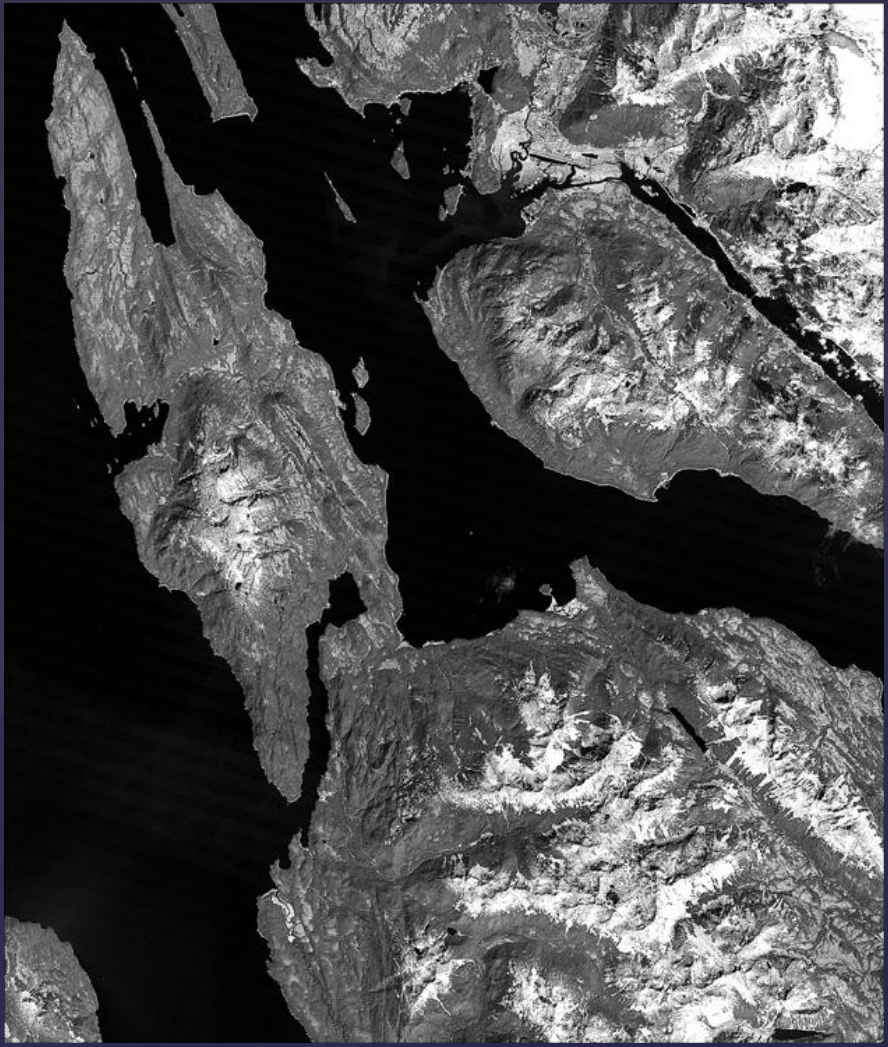
Outline

- Overview
- Consolidation of waste rock sites
- Co-disposal (waste rock & tailings)
- In situ treatment (sulfate reduction)
- Cover design
- Conclusions



(Greens Creek file)

View of northern Admiralty Island, Juneau (upper right)
Greens Creek Valley (lower center)

Overview

- Underground Ag, Zn, Au, Pb mine
- Admiralty Island near Juneau, AK
- Production since 1989
- 7+ years remaining (exploration continues)
- 6.0 million tons surface tailings
- 1.7 million tons surface waste rock

View of Greens Creek valley and mine area

Satellite view of Greens Creek waste rock pile (left), mill complex (top) and mine portals (right)

Consolidation of waste sites

- Reduces area of environmental risk
- Minimizes impact to receiving waters
- Reduces reclamation (cover) costs
- Relocation of > 600K tons (~ 50 acres) planned


(Greens Creek file)


(Greens Creek file)

View of Greens Creek waste rock pile removal (left) and replacement of pyritic rock with non-pyritic fill (upper right)

View of waste rock removal at 960 site near mine portal.

Site 347		Before Removal	After Removal	After Removal	After Removal
Parameter	**Unit**	**9/12/95**	**9/28/06**	**8/17/09**	**6/17/10**
pH	st. units	6.1	7.6	7.5	7.3
Sulfate	mg/l (tot)	1300	161	230	136
Calcium	mg/l (diss)	412	64	102	64
Magnesium	mg/l (diss)	164	21	28	21
Iron	mg/l (diss)	5.5	0.2	ND	0.61
Manganese	mg/l (diss)	7.1	0.4	0.272	0.196
Zinc	mg/l (diss)	11	0.1	0.054	0.035
Lead	mg/l (diss)	0.004	ND	0.00008	ND
Nickel	mg/l (diss)	0.3	0.005	0.007	0.0015

Improvement in drainage quality after removal of waste rock from the 960 site near the mine portal (HGCMC, 2011)

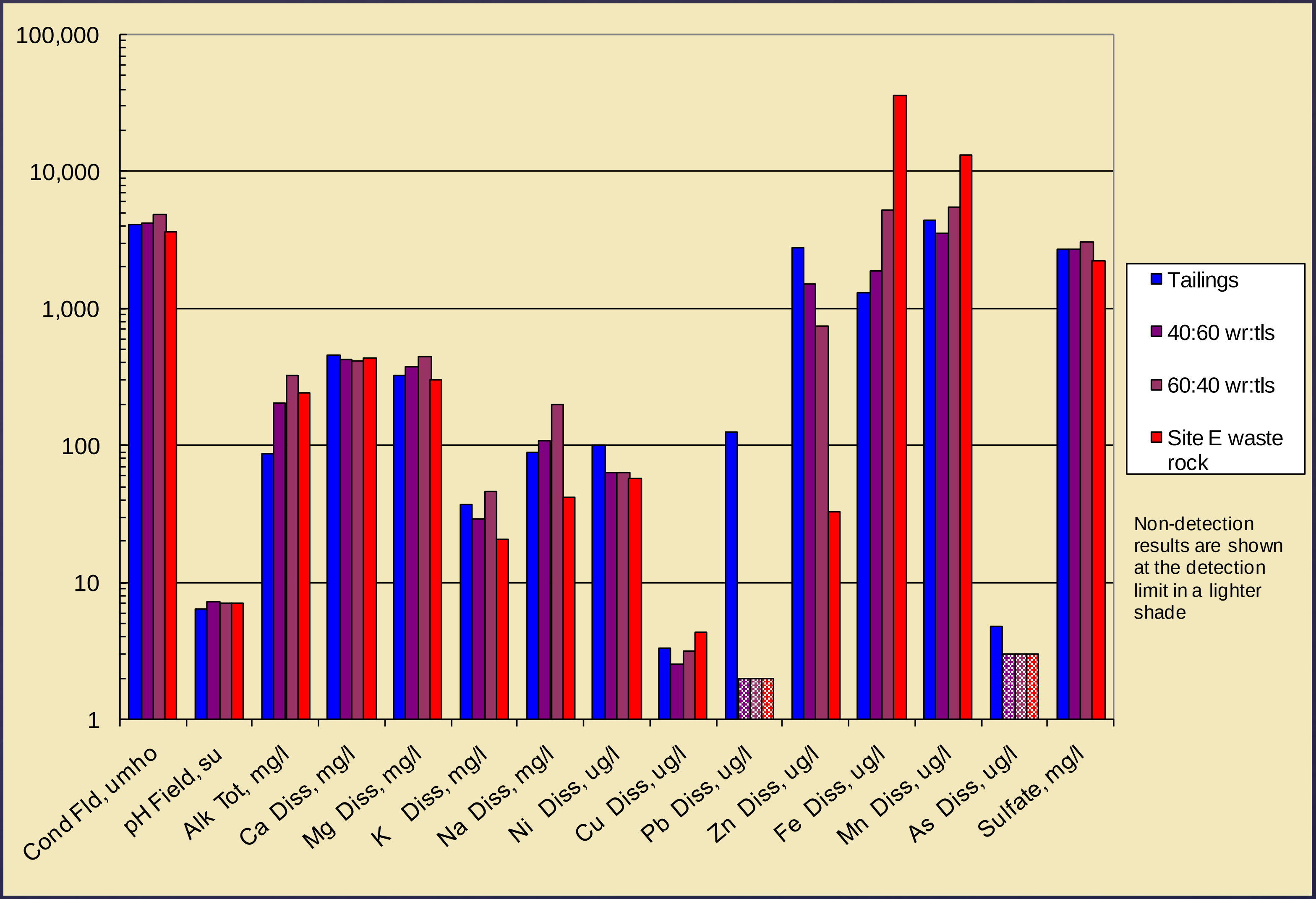
Co-disposal of waste rock and tailings

- Reduces advective transport of oxygen and subsequent sulfide oxidation
- Improves tailings strength
- Reduces tailings permeability
- A 3:2 mix of waste rock and tailings had a permeability of 5×10^{-6} cm/s and friction angle of 43° versus 3.4×10^{-5} cm/s and 36°, respectively, for 100% tailings (Klohn Crippen Consultants Ltd., 2005)
- Blending is easily achieved with current placement equipment (bulldozer)

(Greens Creek file)


(R. Friedel)

Photographs of co-disposal test columns and co-disposal field trial



Results of co-disposal test columns (Greens Creek file)

Satellite view of Greens Creek tailings pile (~60 acres)

Views of tailings placement on the Greens Creek dry-stack tailings pile. Filter-pressed tailings are spread with a bulldozer and compacted to > 90% standard Proctor density with a vibratory roller.

In situ treatment (sulfate reduction)
(Lindsay and Blowes, 2011)

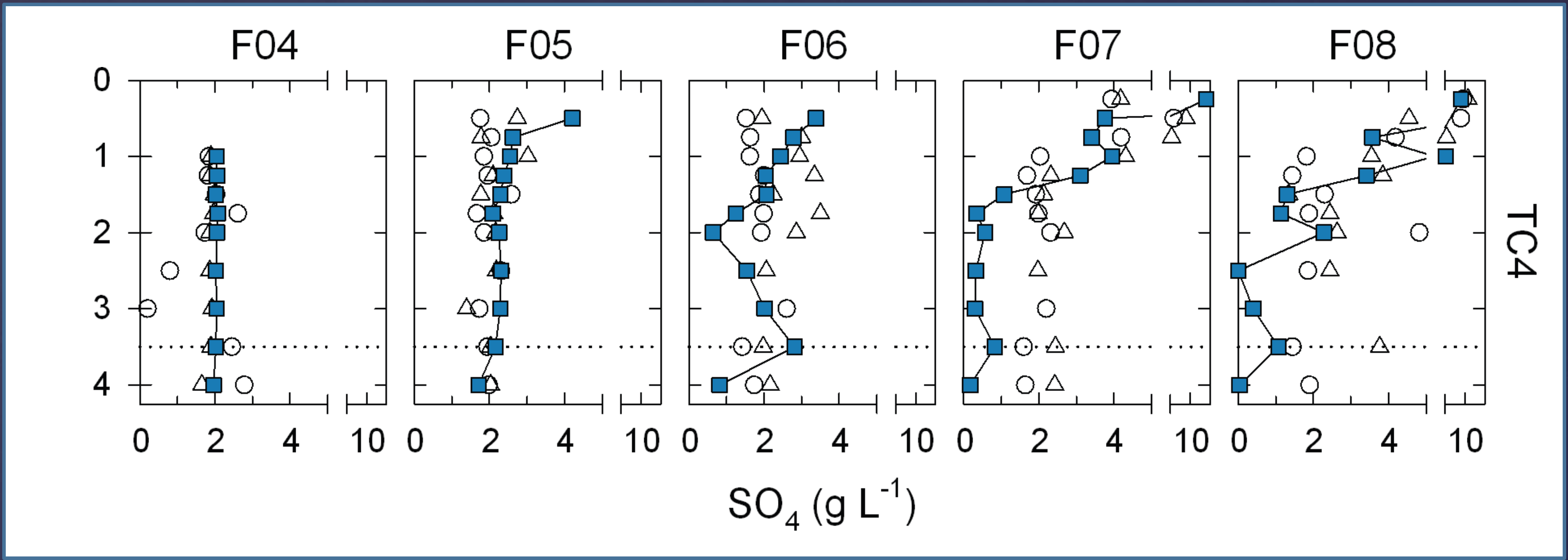
- Tested addition of peat, spent brewing grain, municipal biosolids to tailings (5-10 vol %)

- Improved pore water quality; reduced sulfate, metals and trace element concentrations; increased alkalinity

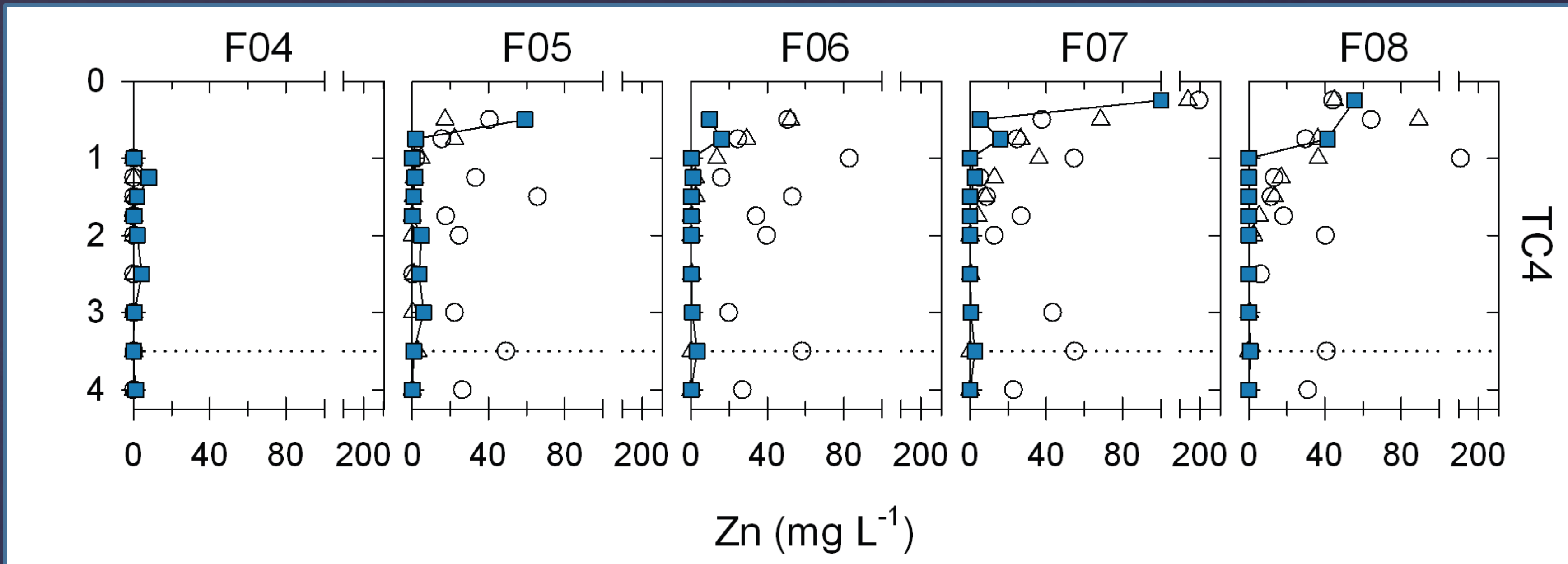
- May reduce time required to meet water quality targets

- Not recommended for oxidized materials due to reductive mobilization of Fe, As and other elements

View of carbon amendment test cells and instrumentation on the Greens Creek tailings pile



Results of addition of 2.5 vol % peat and 2.5 vol % spent brewing grain (squares), non-amended control (triangles), non-excavated control (circles), dotted line indicates lower extent of treatment, depth in meters (from Lindsay and Blowes, 2011)



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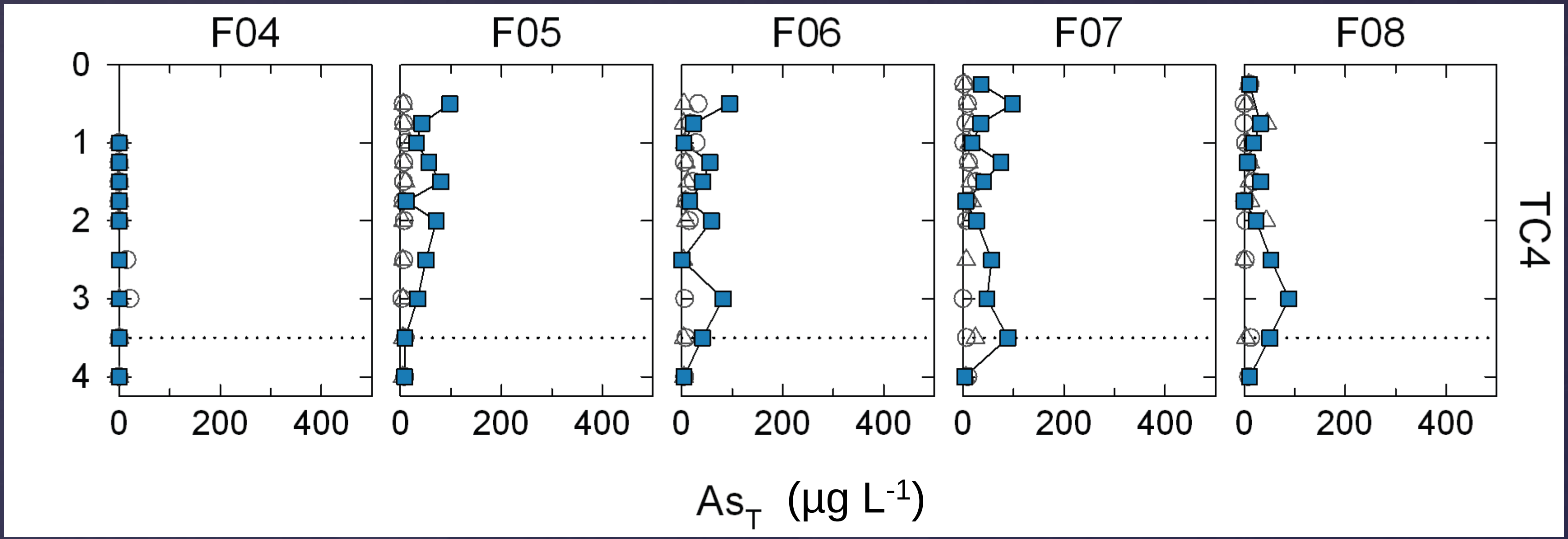

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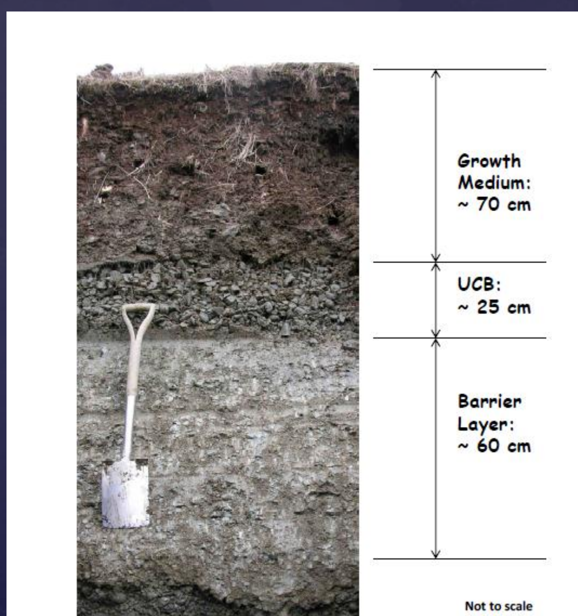
Cover design

- Reduces advective and diffusive oxygen transport and subsequent sulfide oxidation
- Prevents contact of runoff with tailings and waste rock
- Allows for re-establishment of native spruce-hemlock forest

(Greens Creek file)



(L. Hopp)

Cover Design

Cover study (Hopp et al., 2011)

- HYDRUS-2D was used to model relative importance of key cover components and alternative cover designs; agrees with field data
- At least 1 meter of growth medium is recommended to allow for re-establishment of native spruce/hemlock forest
- Upper capillary break is necessary to accommodate drainage in wet climate
- Barrier layer permeability of $< 1 \times 10^{-6}$ cm/s is necessary to achieve cover percolation rates of < 10% of annual precipitation
- Cover cost is approximately $110,000/acre, ~75% of which is for imported capillary break material

Conclusions

- Consolidation of waste rock sites reduces environmental risk and can reduce closure costs
- Co-disposal of waste rock and tailings minimizes pyrite oxidation, improves tailings strength and reduces tailings permeability
- In situ treatment of tailings with amendment of 5 vol% organic carbon (peat + spent brewing grain) improves pore water quality and may reduce the time required for drainage to meet water quality targets
- Effective cover performance is necessary to limit oxygen transport, minimize water contact with tailings and waste rock and promote re-establishment of native spruce-hemlock forest
- Reductive dissolution can lead to Fe, As and other trace element mobility

References and other resources

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http://dnr.alaska.gov/mlw/mining/largemine/greenscreek/index.htm

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