SECTION B.9

RISK-BASED ANALYSIS OF ACID ROCK DRAINAGE AS IT PURPORTS TO WASTE ROCK DUMPS

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Geomega

Risk-Based Analysis of Acid Rock Drainage as it Purports to Waste Rock Dumps

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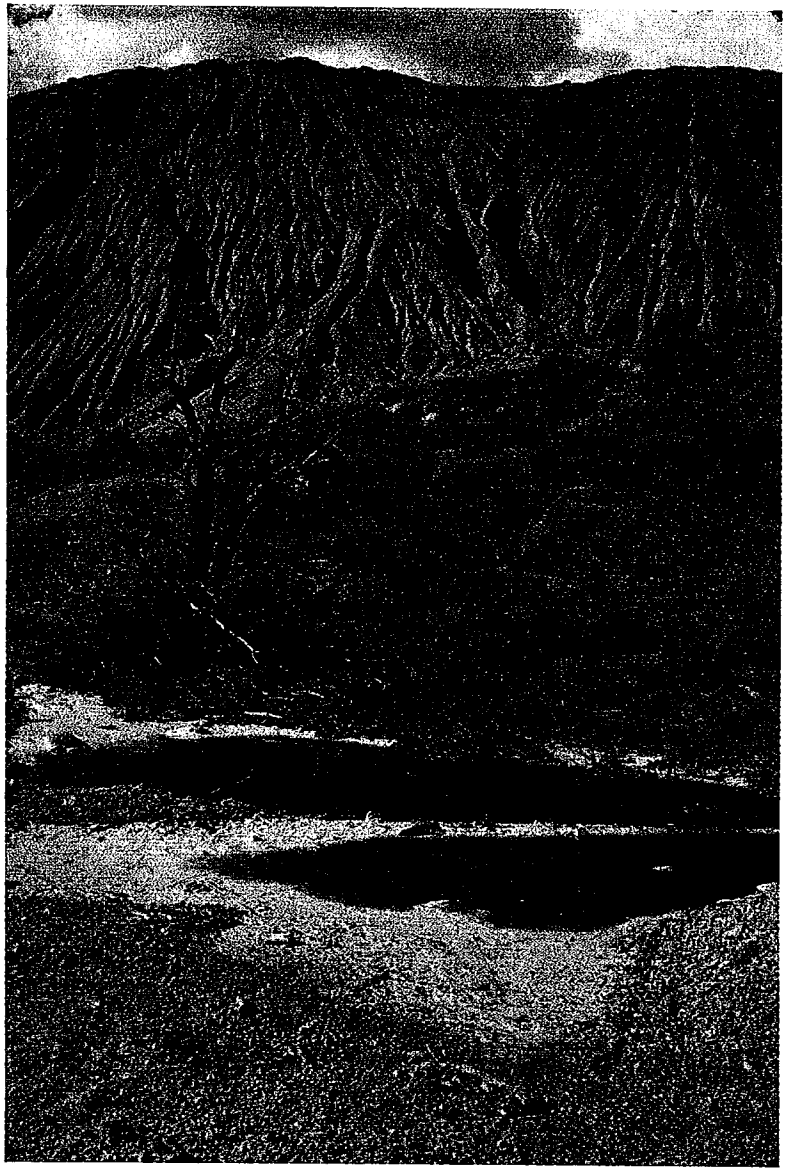


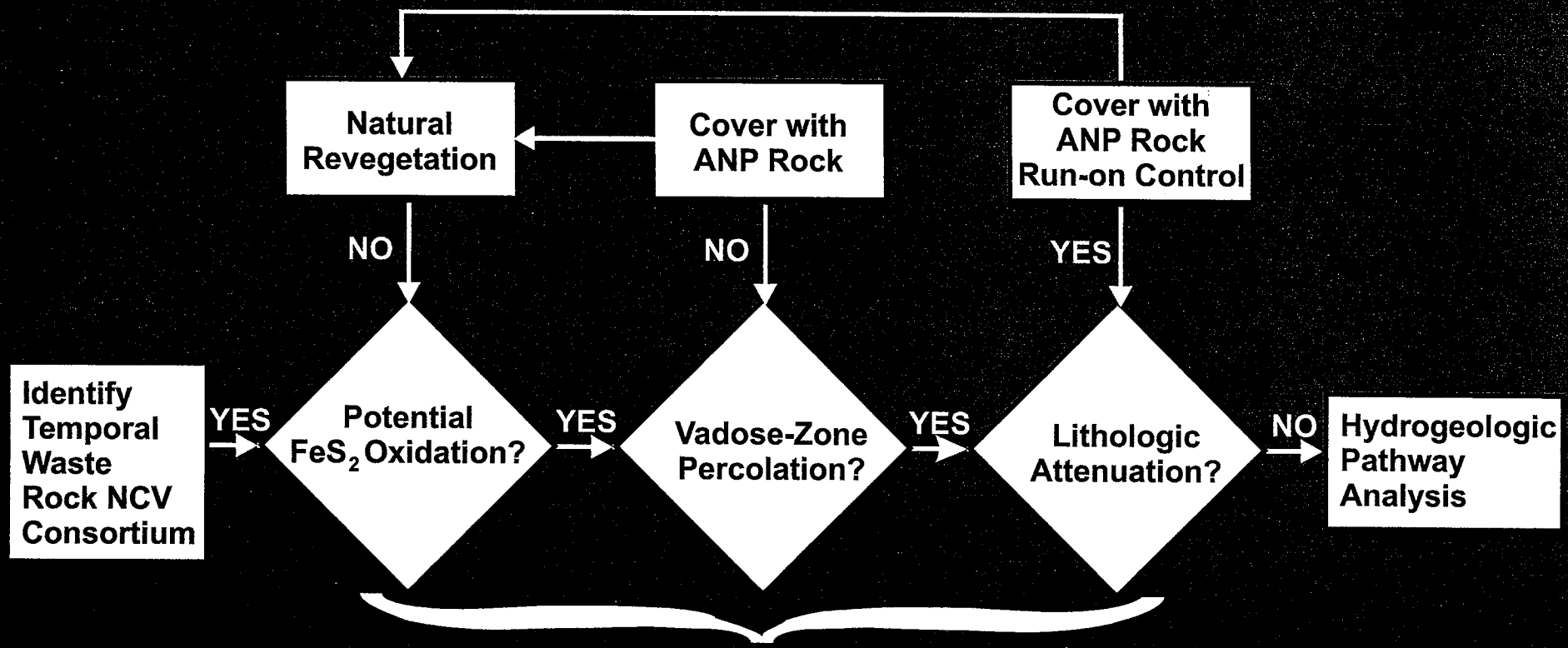
Risk-Based Analysis

Source
- Characterize Constituents of Concern
- Characterize Source Extent

Transport Pathway
- Flow Pathway
- Attenuation Mechanisms

Receptors
- Human
- Ecological
- Waters of the State
- Future Use

Risk-Based Remedial Strategy
Historical Dumps



Extrapolate to Future Waste Rock Reactivity

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Waste Rock Program Data Needs

Historical
Emplacement Era
Leached?
Topography
Vegetation Cover

Geological
Lithology:
In Dump
Substrate
Mineralogy
SCS Soil Maps

Geochemical
ANP/AGP
MWMP?
Humidity Cells
T/O_2 Profiles
Bulk Chemistry
Pore Water Chemistry
Microbial Activity
Substrate Kd

Geotechnical
Stratification
Porosity
Permeability
Bulk Density
Particle Size
Topography/ Contours
Slope Stability

Hydrologic
Precipitation
Infiltration Rate
Evaporation Rate
Moisture Profile
Spring Location
Storm Water Drainage
Surface Flows

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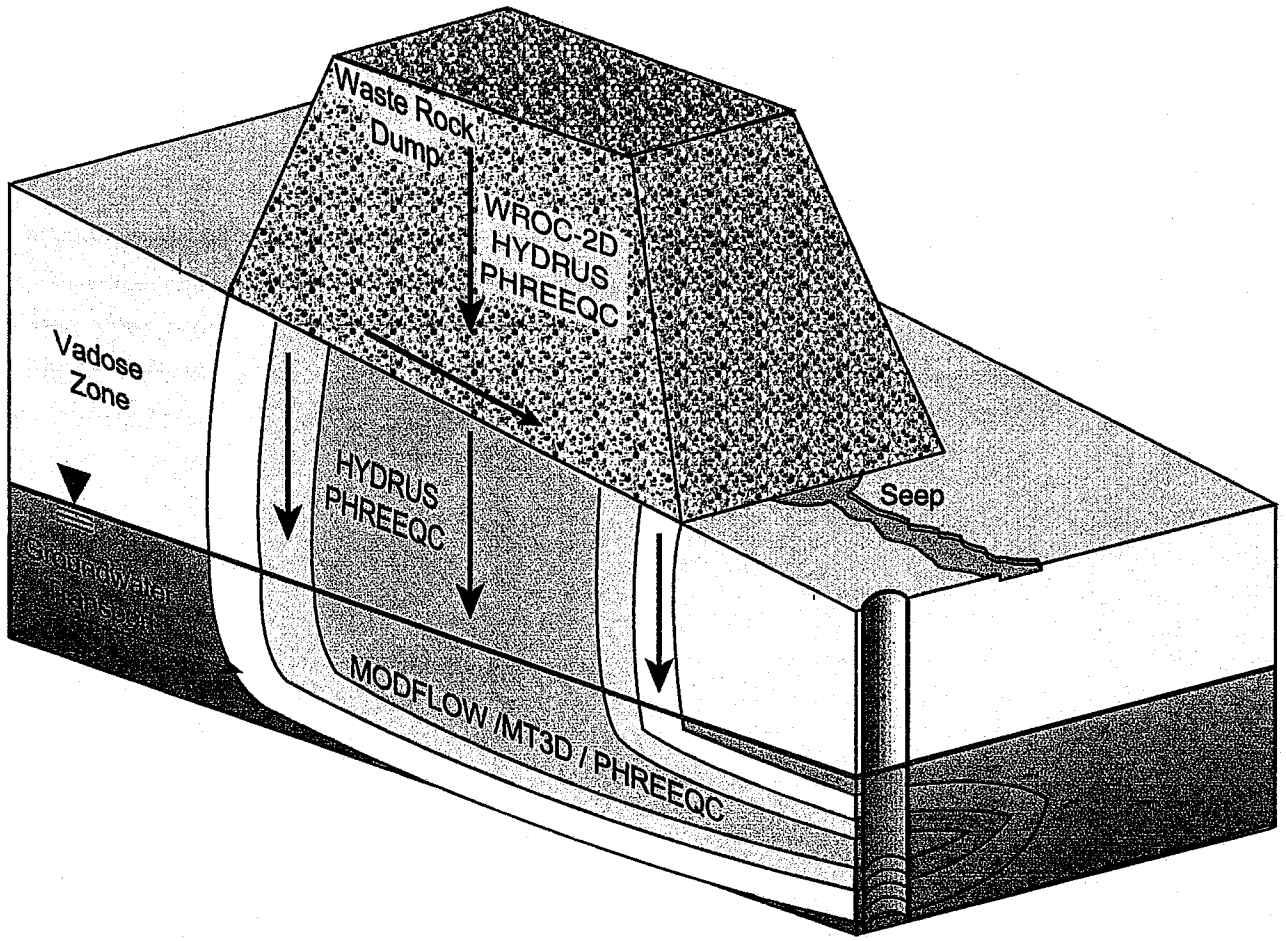
Waste Rock Oxidation, ARD Fate and Transport Model



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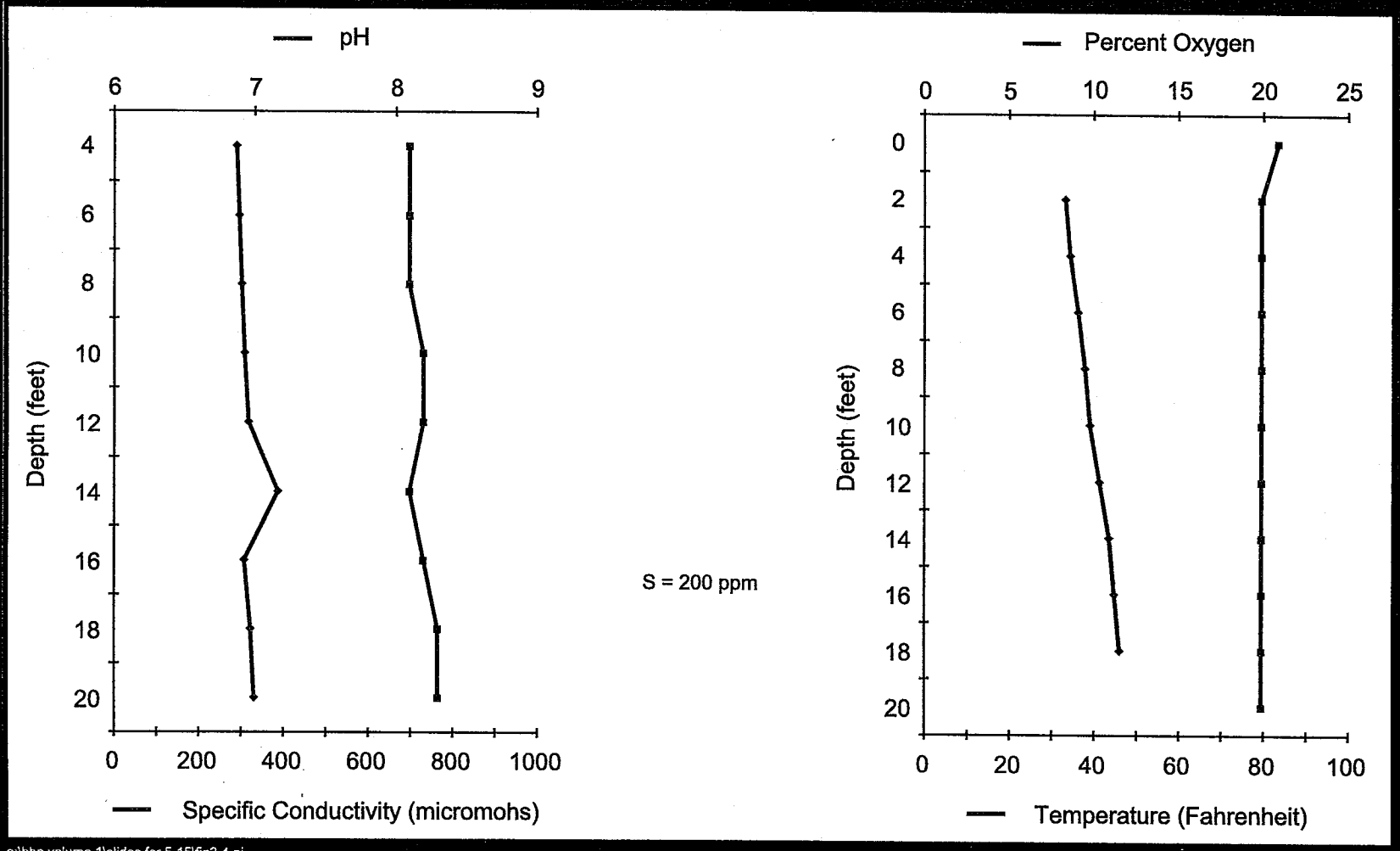
Oxide Waste Rock Dump Profiles (Boring B-24, Kimbley Oxide Waste Rock Dump)



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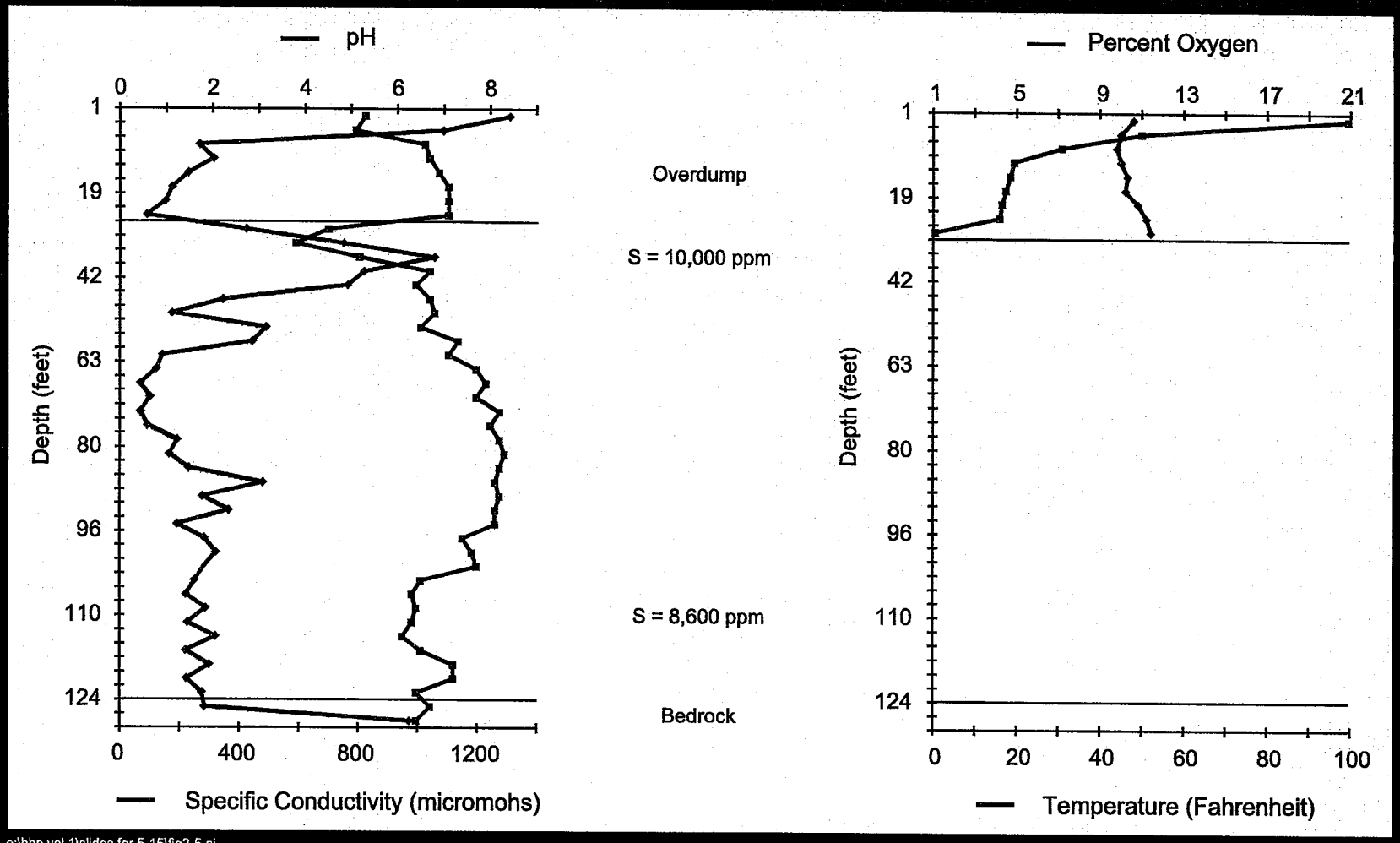
Unoxidized Sulfide Waste Rock Dump (Boring B-11, Sunshine Waste Rock Dump)



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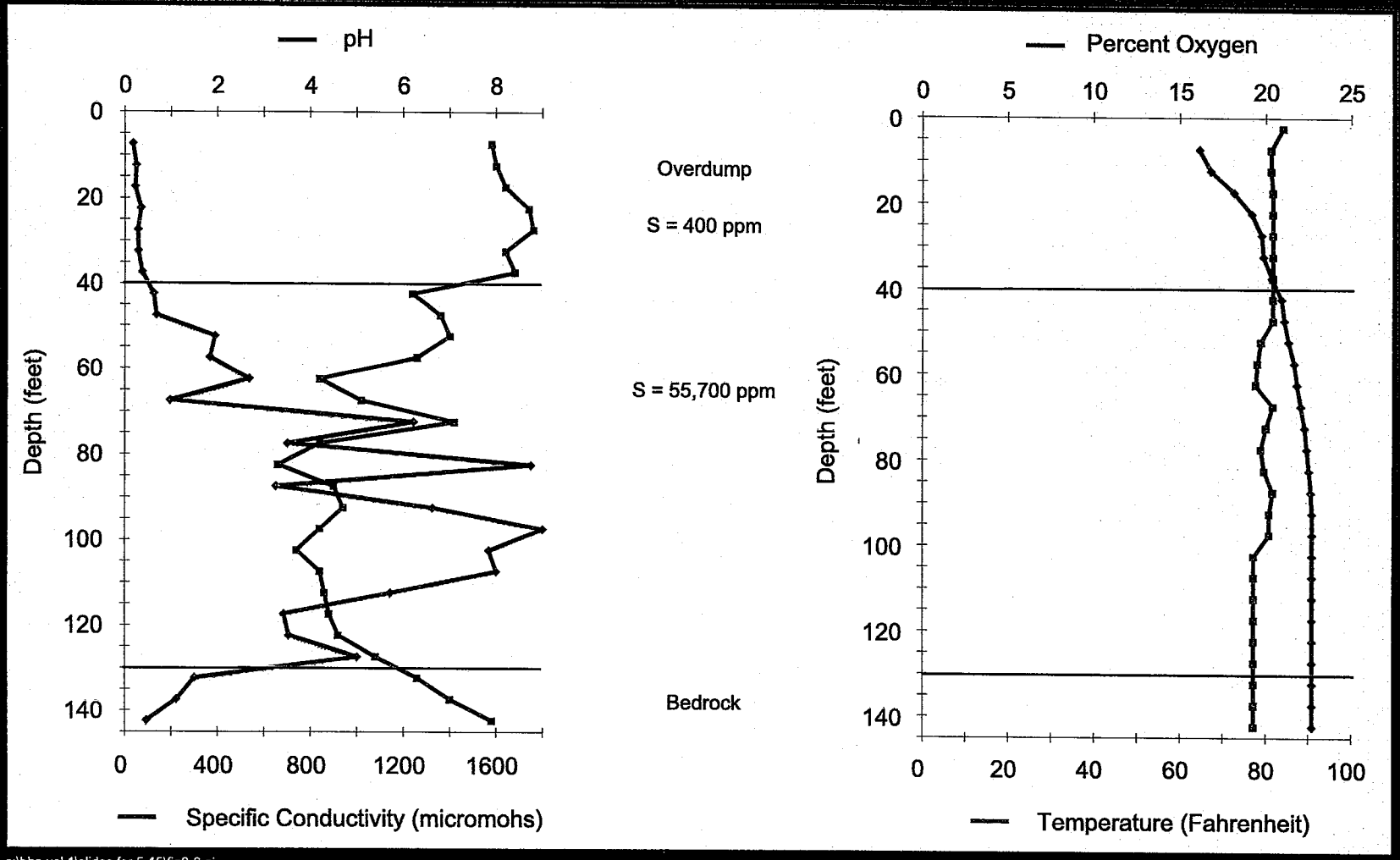
Oxidized Sulfide Waste Rock Dump (Boring B-10, Juniper Waste Rock Dump)



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Infiltration Basins in Waste Rock Dumps

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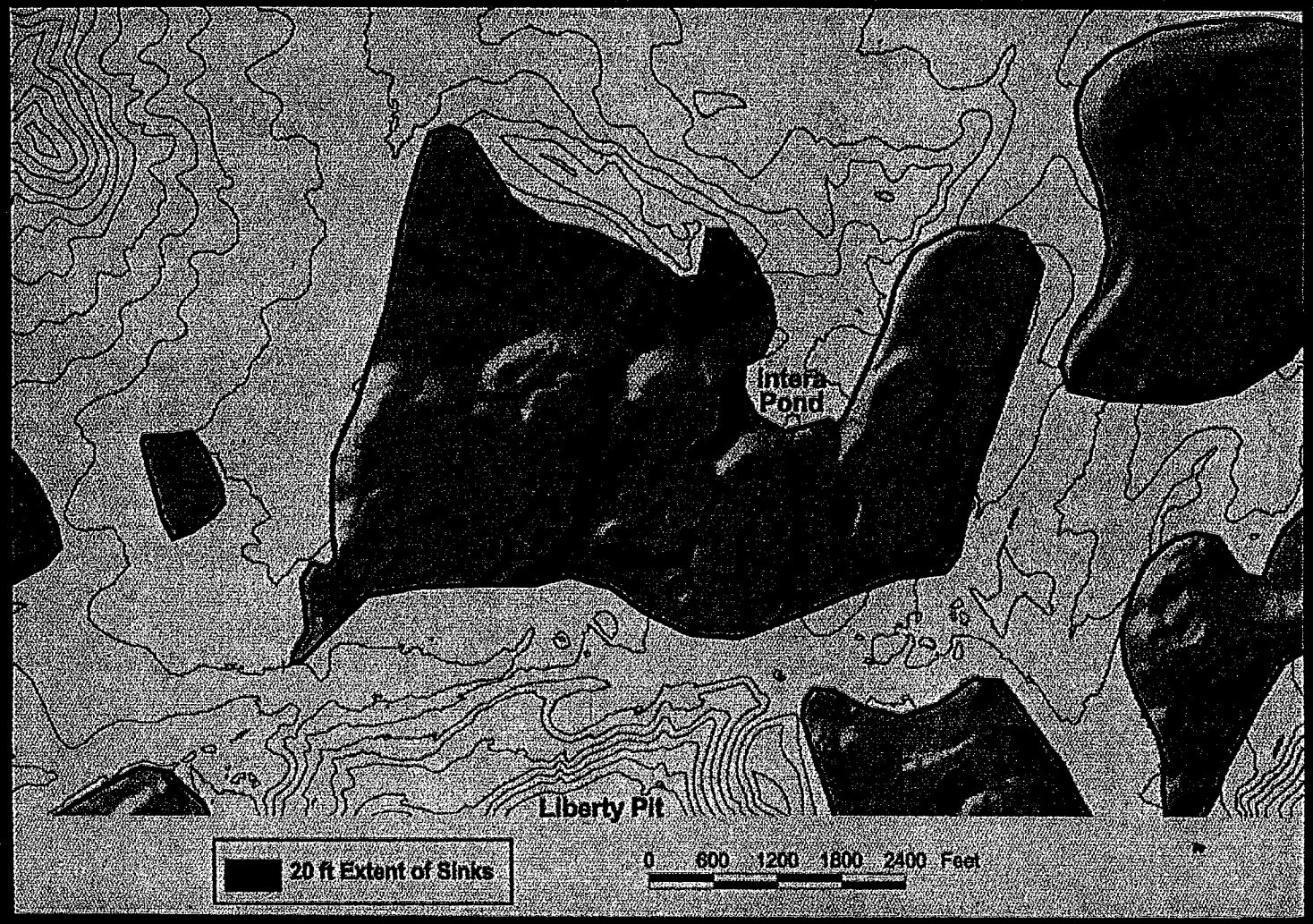
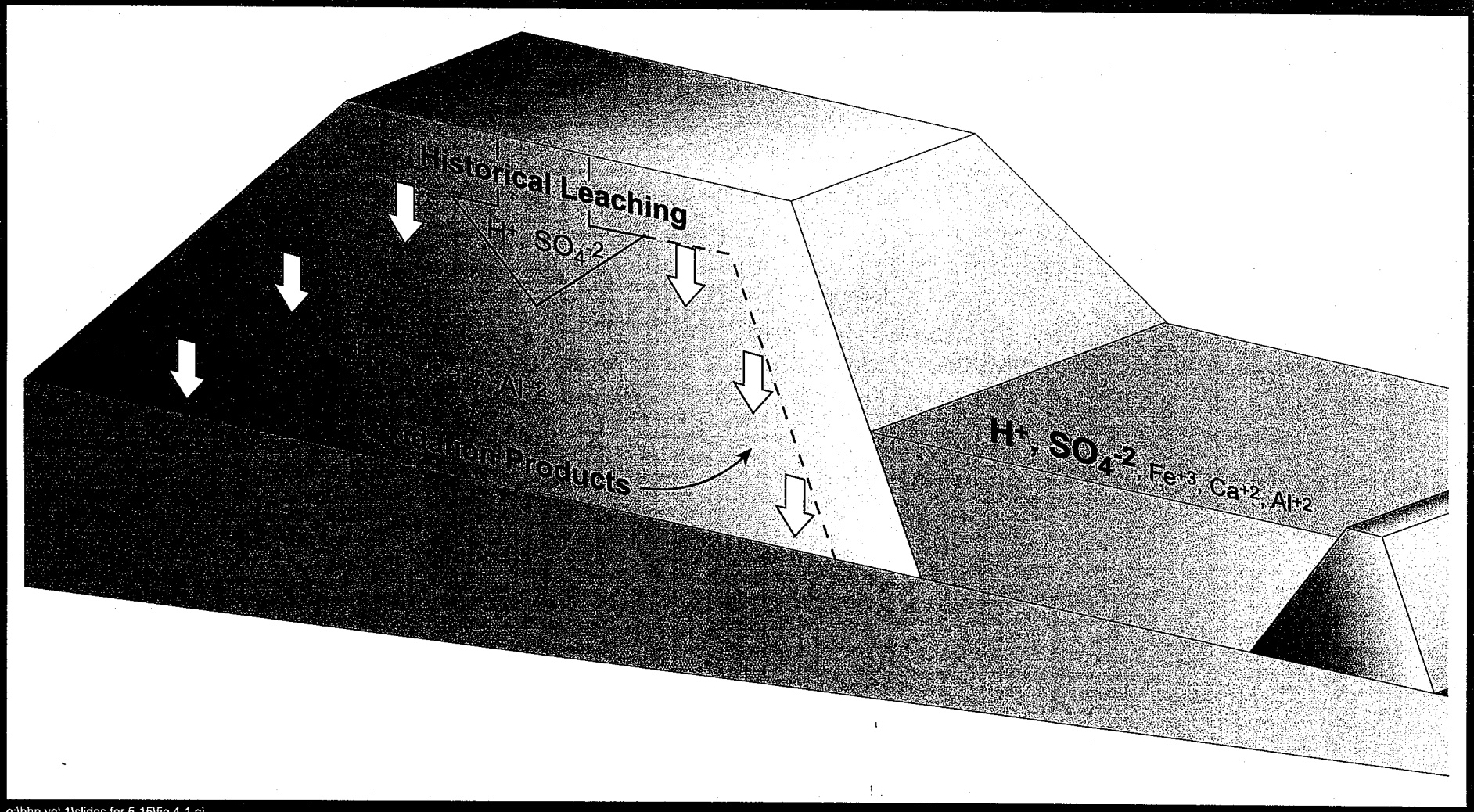
Extent of Sinks on North Liberty - Juniper Dump Complex -- Level 20 ft



Pyrite Oxidation and Seep Chemistry



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Case Study: Jupiter Dump

Construction:	1931 - 1970
Height:	150 feet
Volume:	13 million cubic yards
Footprint:	2.3 million square feet (53 acres)
Elevation:	6670 feet (at top)

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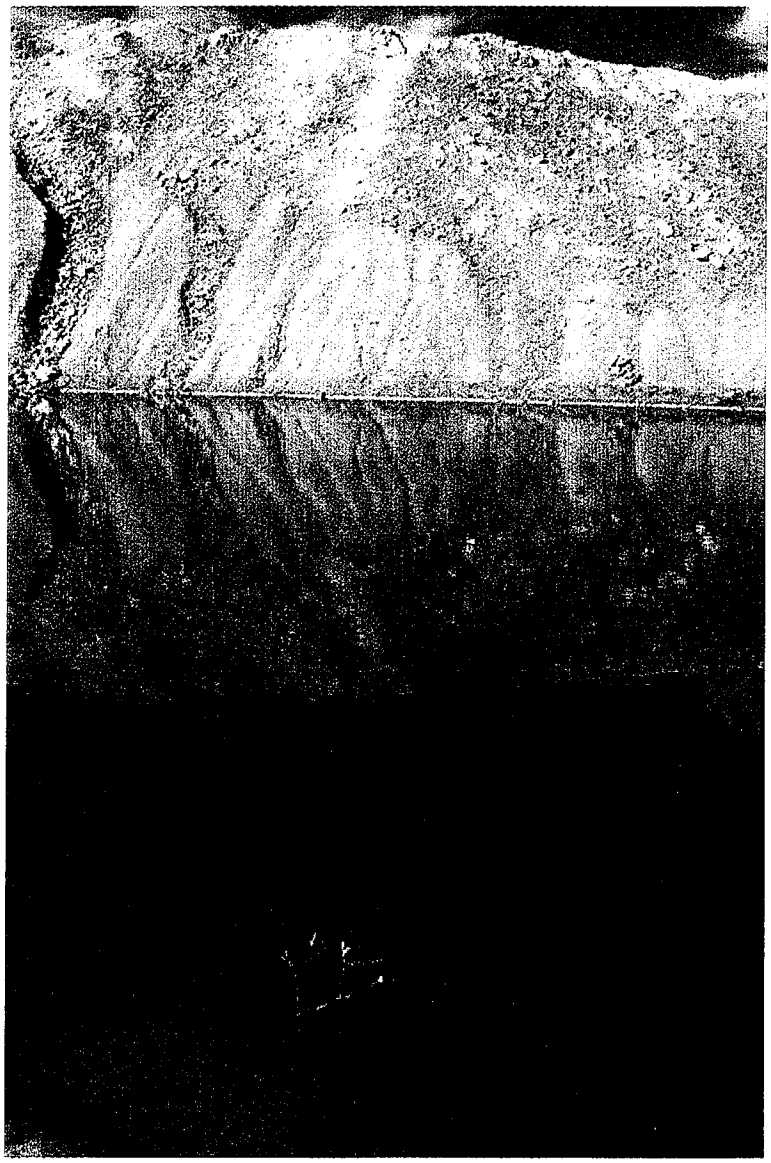


Pyrite Oxidation

Two-dimensional diffusion-reaction model based on the Davis-Ritchie Approach

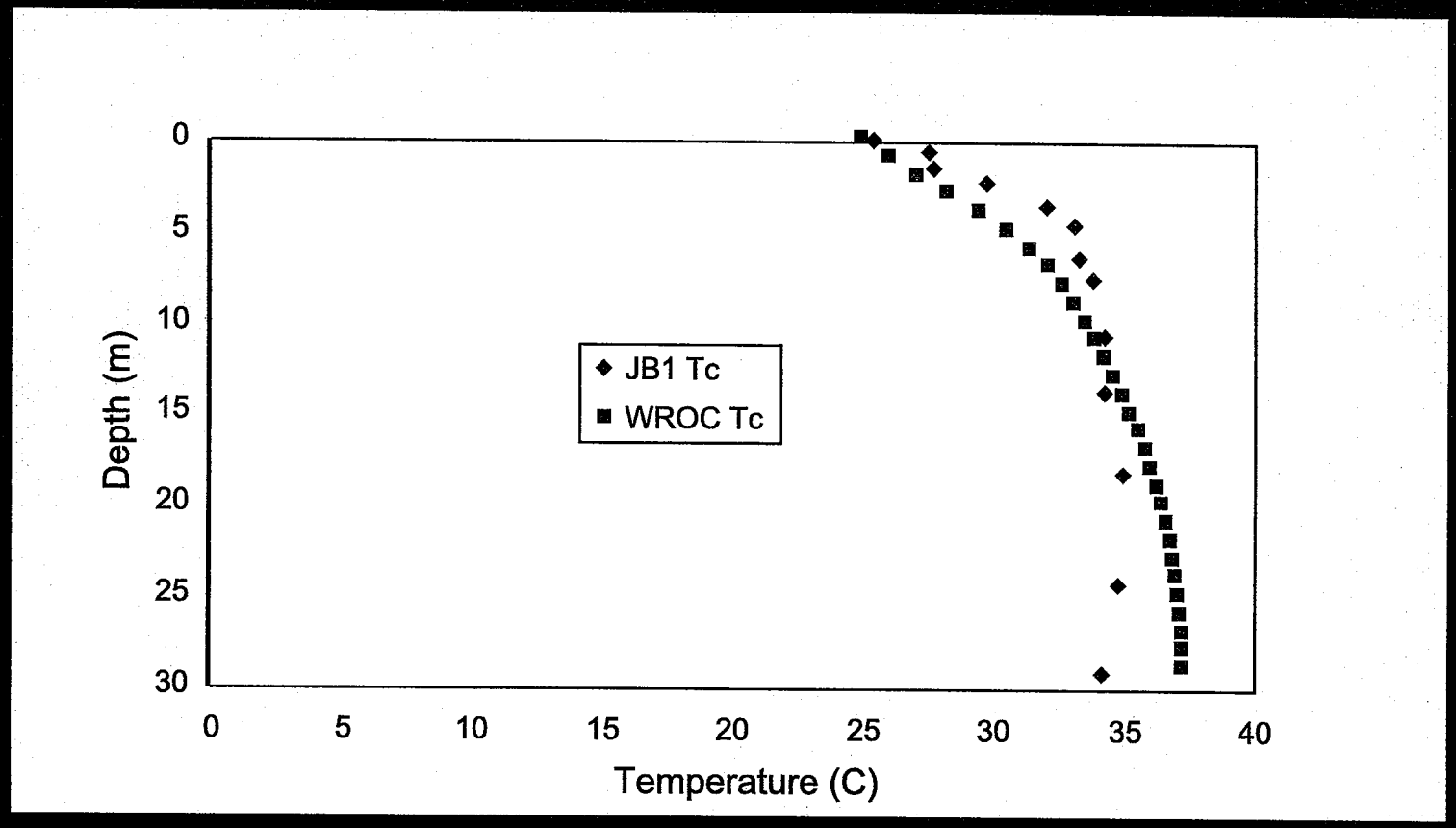
Model Parameters

Dimensions	
Porosity	0.30
Particle Size	3 mm
Pyrite Content	9%

Calibration Parameters

Diffusion Rate

Calibration of Pyrite Oxidation Model to Waste Rock Profiles



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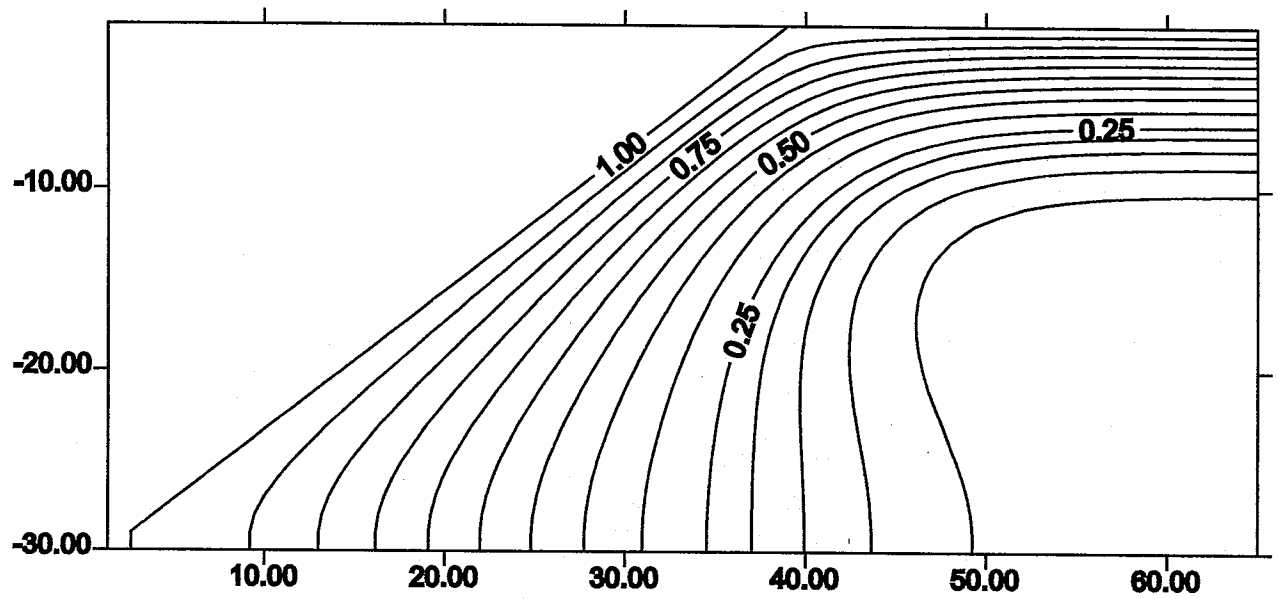
Predicted Oxidation in Jupiter Dump After 60 Years



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Waste Rock Chemistry

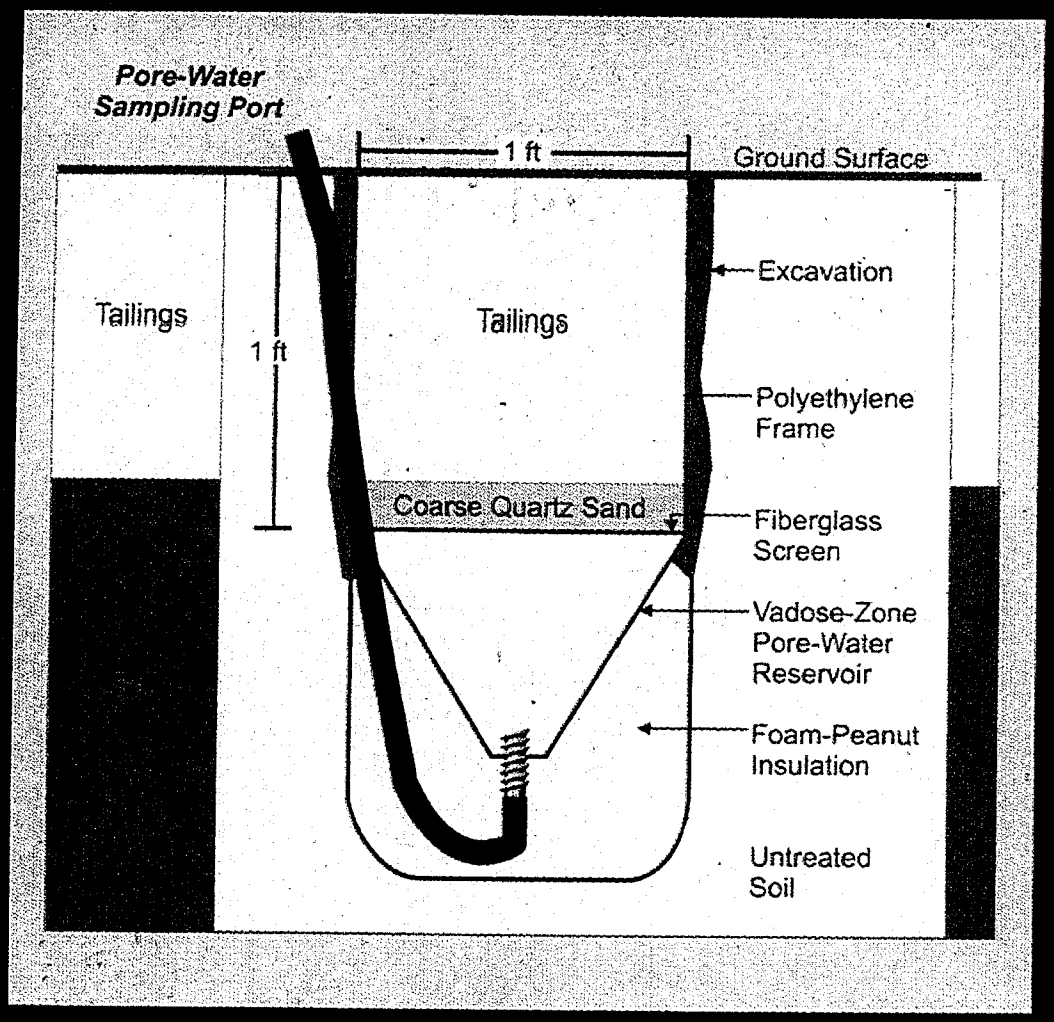
Bulk Chemistry (in mg/kg)

Al	11,900
Ca	1,510
Cu	2,550
Fe	112,000
Zn	764

Mineral Phases

Quartz, Pyrite, Gypsum, Albite, Sphalerite, ...

Schematic of Proposed Waste Rock *in situ* Percolation Sampling Equipment



Predicted Versus Measured Dissolved Concentrations

Analyte	Measured	Predicted
pH	1.9	1.8
Al	1570	2000
As	2	5
Cd	0.5	0.8
Ca	500	394
Cr	2	8
Cu	141	253
F	62	56
Fe	10500	10120
Mg	149	24
Mn	164	220
Ni	3	5
Ag	9	8
SO_4	37800	40500
Zn	255	306

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Fate and Transport

Transport Properties
- Rate
- Direction

Aquifer Properties
- Lithology
- Groundwater Chemistry

Reactions
- Hypothetical
- Observed


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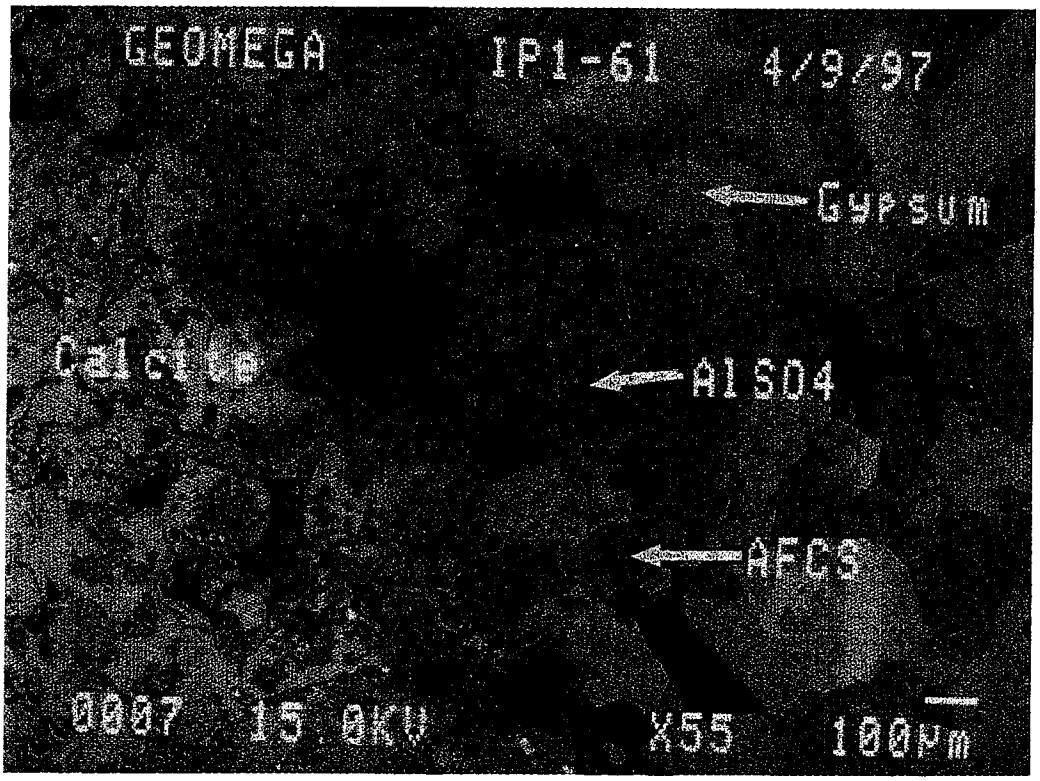
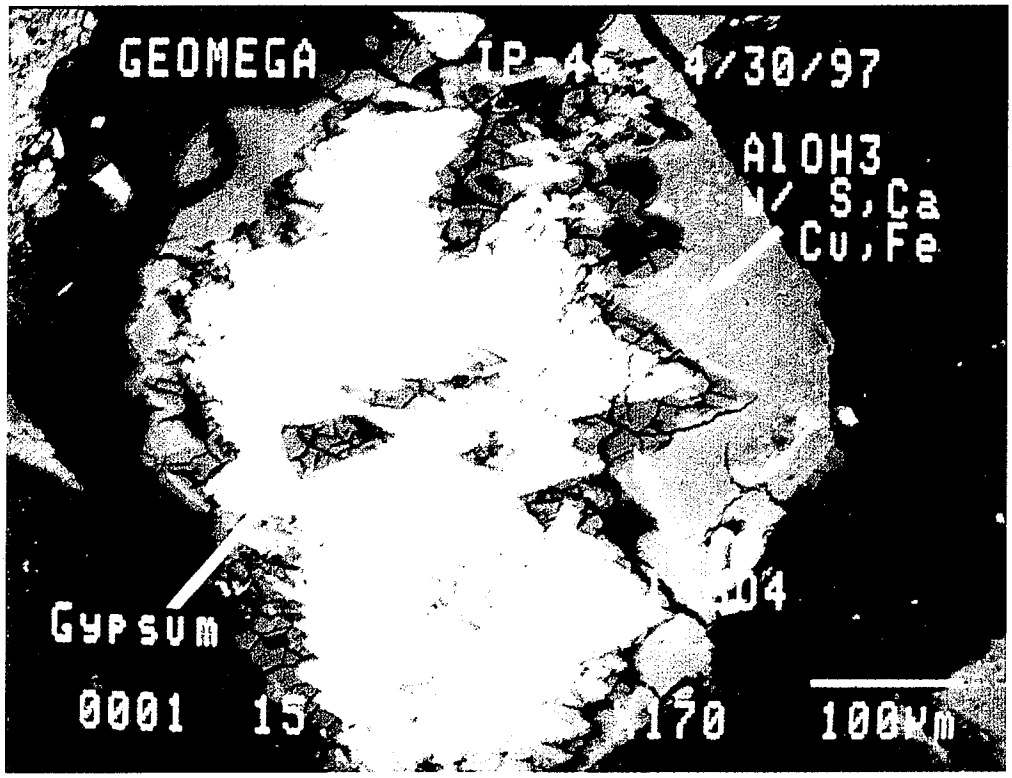

GEOMEGA
IP1-61
4/9/97
Gypsum
Calcite
AlSO4
AFCS
0007
15.0KV
X55
100µm


GEOMEGA
4/30/97
AlOH3
w/ S,Ca
Cu,Fe
Gypsum
0001 15
170
100µm

Predicted versus Observed Water Quality

Analyte	Standard	Source	Predicted	W1-b
	6.5-8.5	2.67	7.1	6.14
	0.05-0.2	893	0.25	0.229
	0.005	0.328	0.25	0.11
	125-150	741	624	863
	0.05-0.1	226	182	183
	0.1	2.35	1.76	0.16
	250-500	12,800	5,777	3,210
	5	116	58	53

Analyte	Predicted at 1600 feet	Background
	1960	1860
	970	970
	0.001	0.002
	3	0.147

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Conclusions

Coupling of reactive transport models resulted in simulations verified by field data. Simulations were used to represent and predict the extent of potential risks associated with acid rock drainage.

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Comments

Issue	Remedy
Accurate prediction of pyrite oxidation	Borehole logging for calibration profiles
Accurate prediction of drainage water quality	Solid waste rock chemistry, mineralogy
Accurate prediction of fate and transport	Calibrated flow model, site-specific observation of attenuation mechanisms